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From atoms to pebbles

HERSCHEL's view of Star and Planet Formation Symposium

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Herschel Space Observatory - Mission Update and Science Highlights

Pilbratt, Göran L.
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The Herschel Space Observatory was successfully launched on 14 May 2009, it carries a 3.5 m passively cooled telescope, and three focal plane instruments inside a superfluid helium cryostat. Herschel is the first large aperture space infrared observatory, it builds on previous infrared space missions by offering a much larger telescope and pushes towards longer wavelengths. It performs imaging photometry and spectroscopy in the far infrared and submillimetre part of the spectrum, covering approximately the $55-670\,\mu$m spectral range, providing a total of six photometric bands, imaging spectroscopy, and very high-resolution heterodyne spectroscopy. Herschel is designed to observe the 'cool universe'; the key science objectives include star and galaxy formation and evolution, and in particular the physics, dynamics, and chemistry of the interstellar medium and its molecular clouds, the wombs of the stars and planets. Herschel observations provide both a view across cosmic time, and more detailed views in individual galaxies, particularly in our own galaxy, including individual stars and their circumstellar matter and our own solar system. I will briefly describe Herschel, its mission to date, status, and achieved scientific capabilities, provide a selection if its scientific highlights across, and conclude with a look toward the future of Herschel and beyond.

Herschel and some questions on star and planet formation

Natta, Antonella
Osservatorio di Arcetri

Star and planet formation, from molecular clouds to debris disks, forms a substantial part of the Herschel observational program. In this introductory talk, I will discuss some aspects of the Herschel results and pose few questions that I hope will be answered in the future.

TOPIC 1 – **Pre-Collapse Phase**

Oral Presentations

Pre-collapse phase studies before Herschel

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The role of molecular clouds as factories of stars has been recognized for decades, but understanding how a large cloud of tens of thousands or more solar masses fragments into stellar-sized pockets with an efficiency of only a few percent and an IMF spectrum is still a puzzling mystery. In this talk, I will review how our observational understanding of the stages prior to star formation has evolved with time, from the earliest molecular studies to the pre-Herschel era. Both the large scale of clouds and the small structure of dense cores will be covered, following the results from molecular-line observation and dust emission/extinction studies. Although Herschel observations are clearly revolutionizing our view of cloud and core formation, parallel work on the kinematics of the cloud gas is also shedding new light on the pre-collapse phases. I will end my presentation showing how large-scale kinematics studies, highly complementary to the Herschel continuum data, reveal a sequence of fragmentation that seems responsible for core formation.

Herschel Observations of the Pre-Collapse Phase of Star Formation

Di Francesco, J. [1]

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Stars form after compact gas cores condense out of larger molecular clouds and collapse. How these cores themselves form has been difficult to observe, given the limitations of detecting from the ground faint, diffuse sub-structure in clouds (e.g., clumps and filaments). With its sensitive, spaceborne instrumentation, however, Herschel has now detected these structures in numerous clouds out to several kiloparsecs from their continuum emission. Indeed, the continuum data from PACS and SPIRE are revolutionizing our understanding of the environments from which cores themselves arise. In this review, we will summarize the recent results of several Herschel Key Programmes whose goals include better physical understanding of these environments. The specific programmes with prestellar core targets include the Herschel Gould Belt Survey (GBS; PI: Ph. André), the Herschel OB Young Star survey (HOBYS; PI: F. Motte), Galactic Cold Cores (GCC; PI: M. Juvela), the Earliest Phases of Star Formation (EPoS; PI: O. Krause), and the Herschel Galactic Plane Survey (HiGAL; PI: S. Molinari). We show in general that filaments are found on many scales throughout the Galaxy, and are a key aspect to the pre-collapse phase of star formation not previously appreciated before Herschel. In addition, the continuum data are providing new direct probes of the thermal and density structures of pre-collapse star-forming objects.

Characterizing interstellar filaments with Herschel in nearby molecular clouds

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Herschel observations of molecular clouds reveal the presence of complex filamentary structures which are shown to be the main sites of core and protostar formation (André et al. 2010). Understanding the properties of these filaments is a first step toward establishing a broader scenario of star formation in the Galaxy. Thanks to their unprecedented spatial dynamic range in the submillimeter regime, the Herschel images provide detailed quantitative information on these filaments, making it possible to characterize their properties in a statistical manner (Arzoumanian et al. 2011). I will discuss the properties of filaments seen by Herschel in 5 regions from the Gould Belt survey (IC5146, Aquila, Pipe, Taurus, Polaris), located at distances from 150 pc to 460 pc and having different star formation activities (filaments with column densities from $\sim 10^{20}\mathrm{cm}^{-2}$ in Polaris to $> 10^{23}\mathrm{cm}^{-2}$ in Aquila). The radial density profiles of the filaments show a power-law behavior at large radii of r^{-2} (shallower than the hydrostatic isothermal Ostriker model described by $\rho \sim r^{-4}$) with a flat inner part, which is remarkably uniform (~ 0.1 pc) for all filaments in our sample (~ 150 filaments) regardless of column density. The observed filaments are not strictly isothermal, their dust temperature profiles show a slight (~ 3K) but significant decrease in temperature toward the center. I will complement the analysis based on Herschel with preliminary line-width measurements with the IRAM 30m telescope. We find evidence of an increase in non-thermal velocity dispersion with column density, denser filaments being more turbulent than more diffuse ones (Arzoumanian et al. in prep.).

From diffuse ISM to cores : formation of molecular clouds, filaments and prestellar condensations

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I will review the various processes and subsequent steps that theorists believe to be triggering the evolution of the diffuse interstellar medium into prestellar condensations. More precisely, I will first describe the mechanisms through which molecular clouds form out of the diffuse atomic gas, then the various possible origins of filaments within molecular clouds and finally how self-gravitating prestellar cores form inside molecular clouds and their possible link to filaments.

Coagulation and fragmentation in molecular clouds

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Dense molecular cloud cores exist long enough for dust grains to collide and coagulate. The emerging grain size distribution may deviate substantially from that of the diffuse ISM (e.g., the MRN). This affects the opacity of the dust and the interpretation of data from observatories like HERSCHEL. For example, reliable sub-mm opacities are paramount for the mass determination of molecular clouds as well as for protoplanetary disks. We have numerically modelled the coagulation process and investigated the effects of grain growth on the IR-opacities of the dust, focusing on key indicators such at the near-IR colors and the sub-mm power-law index (Ormel et al. 2009, 2011). First, we numerically compute the dust size distribution as function of time, using a combination of a binary molecular dynamics code and a collisional evolution code. Our calculations take full account of the internal structure of the aggregates – their porosity and composition – and detail how this affects the collisional outcome. We find that ice-mantle formation, which enhances the strength of aggregates, triggers strong growth; alternatively, the distribution may evolve to a steady-state where fragmentation balances growth. From the simulated size and porosity distribution, we compute the mass-weighted opacity using an effective medium theory applicable for aggregates (Min et al., 2008). The synthetic opacities are compared to IR and sub-mm observations of molecular clouds. Our results do not indicate that the evolution of near-IR color excess *vs* silicate depth as observed by Chiar et al. (2007, 2011) and McClure (2009) is governed by coagulation; but we do see a strong dependence of opacity on the material properties (bare silicate grains, ice-coated silicates, mixed material) of the dust. At sub-mm wavelengths, our simulations show a steeper dependence of the sub-mm opacity with wavelength (*i.e.,* a larger β value), in line with recent PLANCK observations of dense cores.

3D numerical calculations and synthetic observations of magnetized massive dense core collapse and fragmentation.

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I will present radiation-magneto-hydrodynamics calculations of low-mass and massive dense core collapse, focusing on the first collapse and the first hydrostatic core (first Larson core) formation. The influence of magnetic field and initial mass on the fragmentation properties will be investigated. In the first part reporting low mass dense core collapse calculations, synthetic observations of spectral energy distributions will be derived, as well as classical observational quantities such as bolometric temperature and luminosity. I will show how the dust continuum can help to target first hydrostatic cores and to state about the nature of VeLLOs. Last, I will present synthetic ALMA observation predictions of first hydrostatic cores which may give an answer, if not definitive, to the fragmentation issue at the early Class 0 stage. In the second part, I will report the results of radiation-magneto-hydrodynamics calculations in the context of high mass star formation, using for the first time a self-consistent model for photon emission (i.e. via thermal emission and in radiative shocks) and with the high resolution necessary to resolve properly magnetic braking effects and radiative shocks on scales < 100 AU (Commercon, Hennebelle & Henning ApJL 2011). In this study, we investigate the *combined* effects of magnetic field, turbulence, and radiative transfer on the early phases of the collapse and the fragmentation of massive dense cores ($M = 100M_{\odot}$). We identify a new mechanism that inhibits initial fragmentation of massive dense cores, where magnetic field and radiative transfer interplay. We show that this interplay becomes stronger as the magnetic field strength increases. We speculate that highly magnetized massive dense cores are good candidates for isolated massive star formation, while moderately magnetized massive dense cores are more appropriate to form OB associations or small star clusters. Finally we will also present synthetic observations of these collapsing massive dense cores.

From the filamentary structure of the ISM to prestellar cores to the stellar IMF: First results from the Herschel Gould Belt Survey

André, Ph.[1]; Men'shchikov, A.[1]; Könyves, V.[1]; Schneider, N.[1]; Arzoumanian, D.[1]; Peretto, N.[1]; Palmeirim, P.[1]; Didelon, P.[1]; Ward-Thompson, D.[2]; Di Francesco, J.[3]; Bontemps, S.[4]; Motte, F.[1]; Molinari, S.[5]; and the Herschel Gould Belt Consortium[6]

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The Herschel Space Observatory provides a unique opportunity to improve our global understanding of the earliest phases of star formation. I will present an overview of the first results from the Gould Belt survey, one of the largest key projects with Herschel. The immediate objective of this imaging survey of nearby clouds is to obtain complete samples of prestellar cores and Class 0 protostars with well characterized luminosities, temperatures, and density profiles, as well as robust core mass functions in a variety of environments. The main scientific goal is to elucidate the physical mechanisms responsible for the formation of prestellar cores out of the diffuse interstellar medium. Our early findings confirm the existence of a close relationship between the prestellar core mass function (CMF) and the stellar initial mass function (IMF). The Herschel images also reveal a rich network of filaments in every interstellar cloud and suggest an intimate connection between the filamentary structure of the ISM and the formation process of prestellar cores. Remarkably, filaments are omnipresent even in unbound, non-star-forming complexes and seem to be characterized by a narrow distribution of widths around ~ 0.1 pc. This characteristic width approximately corresponds to the sonic scale below which interstellar turbulence becomes subsonic in diffuse gas, supporting the view that the filaments may form as a result of the dissipation of large-scale turbulence. In active star-forming regions, most of the prestellar cores identified with Herschel are located within gravitationally unstable filaments above a critical threshold $\sim 15 M_\odot/\mathrm{pc}$ in mass per unit length or $\sim 150 M_\odot/\mathrm{pc}^2$ in gas surface density. Altogether, the Herschel results favor a scenario in which interstellar filaments and prestellar cores represent two fundamental steps in the star formation process: First, large-scale magneto-hydrodynamic turbulence generates a complex web of filaments in the ISM; second, the densest filaments fragment and develop prestellar cores (and ultimately protostars) via gravitational instability.

The initial conditions of high-mass star formation

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Although the identification of candidates for the earliest stages of high-mass star formation has made considerable progress over the last decade by studies of infrared dark clouds (IRDCs), studying their physical properties had been strongly hampered by their non-accessibility at the peak of the spectral energy distributions (SEDs) in the far-infrared. This situation has drastically changed by the advent of Herschel that exactly covers this part of the SED. Within the Herschel key project EPOS (The Earliest Phases of Star Formation) we have observed a large sample of very young high-mass star-forming regions with the goal to characterize the physical conditions prior or at the onset of high-mass star formation. Here, I will focus on the question whether the initial conditions are universally the same, or whether we can identify physical differences between "isolated IRDCs" and those closely linked to very active sites of already ongoing star formation?

Herschel Observations of EXtra-Ordinary Sources (HEXOS): Analysis of the HIFI 1.2 THz Wide Spectral Survey Toward Orion KL

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We present a comprehensive analysis of the most detailed sub-mm spectrum of a massive star forming region. In all, we analyze the complete 1.2 THz wide *Herschel*/HIFI spectral survey toward the Kleinmann-Low nebula within the Orion Molecular Cloud (Orion KL), one of the most chemically rich regions in the galaxy. Given the exceptional frequency coverage of HIFI, we are sensitive to lines with excitation energies over an unprecedented range observed with the same instrument and near uniform efficiency. As a result, we have placed robust constraints on over 20 molecular species using, in some cases, over 10^3 transitions for a single molecule. Our analysis points to a diversity of environments toward this source. Some species show clear evidence for the presence of excitation gradients while others are fit nicely by a single temperature LTE fit. In addition, some molecules exhibit emissions at very high energies ($>$ 1000 K) and temperatures (e.g. CH_3CN and C_2H_5CN), while others only probe warm ($\sim$100 K) regions along the line of sight (e.g. CH_3OCHO). More detailed analysis of the light hydride H_2S, reveals the presence of very dense gas (n$>10^{7-8}$ cm^{-3}) emitting from the Orion hot core. In this presentation, we will explore the full breadth of these results and the implications on the origin of organics in the dense ISM.

Filaments, ridges and a mini-starburst - HOBYS' view of high mass star formation with Herschel

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With its unprecedented spatial resolution and high sensitivity, Herschel is revolutionising our understanding of high mass star formation and the interstellar medium (ISM). In particular, Herschel is unveiling the filamentary structure and molecular cloud constituents of the ISM where star formation takes place. The Herschel Imaging Survey of OB Young Stellar objects (HOBYS; Motte, Zavagno, Bontemps, see http://www.herschel.fr/cea/hobys/en/index.php) key program targets burgeoning young stellar objects with the aim of characterising them and the environments in which they form. HOBYS has already proven fruitful with many clear examples of high-mass star formation in nearby molecular cloud complexes (e.g. Motte et al., 2010). Through multi-wavelength Herschel observations I will introduce select regions of the HOBYS program, including Vela C, M16 and W48 to start. These data are rich with filamentary structures and a wealth of sources which span a large mass range including, low, intermediate and high-mass objects in the pre-collapse or protostellar phase of formation, many of which will proceed to form stars. The natal filaments themselves come in many shapes and sizes, they can form thick ridge-like structures, be dispersed in low column density regions or cluster in higher density regions. In Vela C, high-mass star formation proceeds preferentially in high column density supercritical filaments, called ridges, which may result from the constructive convergence of flows (Hill et al., 2011). I will present other examples of ridges identified in HOBYS regions. In addition, I will present the latest results on the Eagle Nebula (M16). This region was made iconic by Hubble, but only Herschel can trace the cold, dense early prestellar phases of star formation, and their natal interstellar filaments, in this infamous star-forming complex. The cavity ionised by the nearby OB cluster in M16 serves to heat the Pillars of Creation and the surrounding interstellar filaments. We draw hypotheses regarding the long, cold resilient (enduring) filament in the eastern portion of M16, offset from the ionised cavity. In W48, the IRDC G035.39-00.33 is likely undergoing a mini star-burst of star formation (Nuygen-Luong et al., 2011).

Star Formation in Infrared Dark Clouds

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Using a catalogue of $\sim 15,000$ infrared dark clouds (IRDCs) derived from the Spitzer GLIMPSE data, together with the Spitzer MIPSGAL 24μm data, we have carried out a statistical study of the star formation in IRDCs. Performing PSF fitting on more than a 100,000 24μm sources, we have defined criteria to determine which objects are associated with a cloud based on both distance from the cloud and the object's 8μm-24μm spectral index. Overall 27 to 36% of the Spitzer dark clouds show some star formation activity. However, the fraction of star-forming clouds is a function of the size and mass of the clouds, reaching more than 80% for IRDCs with masses larger than $\sim$ 300 $M_\odot$. The Herschel HiGAL data have been used to probe the nature of these stars associated with the IRDCs and in particular identify the best candidate massive young stars. In this presentation we will discuss the results of this analysis of the star formation activity in IRDCs and the nature of the sources being formed.

HOPS + MALT90 + Hi-GAL: Probing star formation on a Galactic scale through mm molecular line and far-IR continuum Galactic plane surveys

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With the HOPS and MALT90 Galactic plane surveys we are mapping a significant fraction of the dense molecular gas in the Galaxy in over 20 dense-gas-tracing transitions (e.g. from H2O, NH3, HC3N, HC5N, N2H+, HCN, HNC, HCO+, CH3CN, SiO, C2H, ...). Combining this with the far-IR continuum emission from Hi-GAL we can derive the physical/chemical/kinematic properties and evolutionary state of much of the molecular gas in the Galaxy destined to form stars. I will present results from three science projects based on this combined dataset, namely: i) looking for variations in the star formation rate across the Galaxy as a function of environment, in particular, comparing the CMZ with the rest of the Galactic disk – we find the rate of star formation per unit mass of dense gas in the CMZ may be an order of magnitude lower than that in the disk; ii) seeing if Galactic dense molecular clouds follow the empirical relations observed in extragalactic systems (e.g. the Kennicutt-Schmidt and Gao & Solomon relations) and what this implies for interpretating the extragalactic relations; iii) searching for molecular cloud progenitors of the most extreme (massive and dense) stellar clusters. I will present one cloud we have studied as part of project iii) which lies close to the Galactic center and which is clearly extreme compared to the rest of the Galactic molecular cloud population. With a mass of 10^5 Msun, a radius of only 3pc and almost no signs of star formation it appears to be the progenitor of an Arches-like stellar cluster. As such, we speculate this molecular cloud may be a local-universe-analogue of the initial conditions of a super star cluster or potentially even a small globular cluster. From our Galactic plane survey data this object appears to be unique in the Galaxy, making it extremely important for testing massive cluster formation models. We have been awarded 6 hours of ALMA Cycle 0 observing time to study this object in detail and I hope to show preliminary results from this data at the meeting.

The CHESS Spectral Survey of Pre-stellar Cores

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We present the results of the HIFI observations of the pre-stellar cores L1544 and 16293E, as part of the CHESS Key Program. Pre-stellar cores, being cold and dense, have a chemistry dominated by the freeze-out of molecular species and enhanced deuteration, both phenomena being linked. L1544 is a well-studied prototypical pre-stellar core and 16293E is one of the very few source where the species para-D_2H^+ and ortho-H_2D^+ were both detected. These ions play a key role in the deuteration process. We report here the detection of HDO and ND in 16293E (together with their hydrogenated counterparts H_2O and NH). This is the first time these species have been observed in pre-stellar cores. Both species represent particularly interesting cases since they have completely different behaviours with respect to freeze-out. In L1544, we report the detection of high critical density transitions of NH_2D, tracing the very inner parts of the core. We discuss the implications of the species' abundances and deuterium fractionation on our understanding of pre-stellar core chemistry.

Galactic Cold Cores:

Juvela, M., on behalf of the Planck and Herschel projects on cold cores
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The Herschel programme Galactic Cold Cores is carrying out a survey of cloud cores within dense interstellar clouds of the Milky Way. The study is based on the all-sky survey made by the Planck satellite. The analysis of the Planck sub-millimetre data has lead to the detection of more than 10000 cold sources, many of them at mid and high Galactic latitudes. A sample of more than 100 fields has been selected for further Herschel studies. This Herschel survey complements other Herschel projects that are investigating the Galactic plane and the main nearby molecular clouds. I will discuss the general goals of the Cold Cores project and present the results from the analysis of some 70 fields for which the Herschel observations have been analysed.

TOPIC 2 – **Protostellar Phase**
Oral Presentations

Protostellar phase: a pre-Herschel review

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Herschel is providing a mine of new data that are changing our view of how solar type stars form. In order to make appreciate even more the Herschel contribution, I will review the status of the observations and models in the pre-Herschel era, especially focussing on the aspects where Herschel is contributing most, from gas chemistry and dynamics, to ices and large scale protostars distribution. The presentation will include the review of the questions raised by the latest space borne missions as ISO, SWAS and SPITZER and whose answers are in the domain of Herschel.

Protostellar Phase: Herschel Overview

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In this talk I will summarize Herschel results on protostars from a range of guaranteed time and open time programs. Where possible I will attempt to cover areas where Herschel is providing unique contributions. This includes the broad band emissions of the dust enshrouding envelope which sets some constraints on the evolutionary state and overall source structure. In addition, I will explore the diverse spectral information that is coming from both high and low mass sources. This information constrains the gas physics (density/temperature/kinematics) via the detection of tens of transitions of carbon monoxide, but also numerous transitions of water vapor. The broad band spectra also also providing new ways look at protostellar chemistry with an expansive view of the oxygen, carbon, and nitrogen chemistries. Data on protostellar sources will represent a key component of the Herschel legacy to the science of the dense ISM. Where possible this will be noted.

The Herschel/HIFI unbiased spectral survey of the solar-mass protostar IRAS16293

Bottinelli, S.[1,2]**; Caux, E.**[1,2]**; Cecarelli, C.**[3]**; Kahane, C.**[3]**; and the CHESS Consortium**
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Unbiased spectral surveys are powerful tools to study the chemistry and the physics of star forming regions, because they can provide a complete census of the molecular content and the observed lines probe the physical structure of the source. While unbiased surveys at the millimeter and sub-millimeter wavelengths observable from ground-based telescopes have previously been performed towards several high-mass protostars, very little data exist on low-mass protostars, with only one such ground-based survey carried out towards this kind of object. However, since low-mass protostars are believed to resemble our own Sun's progenitor, the information provided by spectral surveys is crucial in order to uncover the birth mechanisms of low-mass stars and hence of our Sun. To help fill up this gap in our understanding, we carried out an almost complete spectral survey towards the solar-type protostar IRAS16293-2422 with the HIFI instrument onboard Herschel. The observations covered a range of about 700 GHz, in which a few hundreds lines were detected with more than 3σ confidence interval certainty and identified. All the detected lines which were free from obvious blending effects were fitted with Gaussians to estimate their basic kinematic properties. Contrarily to what is observed in the millimeter range, no lines from complex organic molecules have been observed. In this work, we characterize the different components of IRAS16293-2422 (a known binary at least) by analyzing the numerous emission and absorption lines identified.

Water in Star-forming Regions with Herschel (WISH): recent results and trends

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Water is a key molecule in the physics and chemistry of star- and planet-forming regions. In the 'Water in Star-forming Regions with Herschel' (WISH) Key Program, we have obtained a comprehensive set of water data toward a large sample of well-characterized protostars, covering a wide range of masses and luminosities –from the lowest to the highest mass protostars–, as well as evolutionary stages –from pre-stellar cores to disks. Lines of both ortho- and para-H_2O and their isotopologues, as well as chemically related hydrides, are observed with the HIFI and PACS instruments. The data elucidate the physical processes responsible for the warm gas, probe dynamical processes associated with forming stars and planets (outflow, infall, expansion), test basic chemical processes and reveal the chemical evolution of water and the oxygen-reservoir into planet-forming disks. In this brief talk a few recent WISH highlights will be presented, including determinations of the water abundance in each of the different physical components (inner and outer envelope, outflow) and constraints on the ortho/para ratio. Special attention will be given to trends found across the sample, especially the similarity in profiles from low to high-mass protostars and the evolution of the gas-phase water abundance from prestellar cores to disks. More details can be found at http://www.strw.leidenuniv.nl/WISH, whereas overviews are given in van Dishoeck et al. (2011, PASP 123, 138), Kristensen & van Dishoeck (2011, Astronomische Nachrichten 332, 475) and Bergin & van Dishoeck (2012, Phil. Trans. Royal Soc. A).

Water high resolution spectroscopic observations of massive protostars with Herschel

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I will present the results from the Water In Star-forming regions with Herschel Space Observatory key program (WISH) concerning high-mass protostars. This project is designed to probe with HIFI and PACS instruments the physical and chemical structure of these young stellar objects using water and related molecules, and to follow the water abundance all along their evolution. About 20 sources are targeted covering a wide range of evolutionary stages from cold prestellar cores to Ultra-Compact HII regions. Massive stars are rare but are the main contributors to the matter cycle in the Universe due to their short lifetimes and rapid ejection of enriched material. OB stars dominate the energy budget of star-forming galaxies and are visible at great distances. Their formation, however, is not understood and the classical scheme for low-mass star formation cannot be applied as such to OB stars. The dynamics of such (cluster-forming) regions may either be the monolithic collapse of a turbulent core, or competitive accretion. Water, one of the most abundant molecules in the Universe, might elucidate key episodes in the process of stellar birth and, in particular, may play a major role in the formation of high-mass stars. Our main goals are to use the water molecule as a good tracer of the dynamics of the inner regions, to precise the physical structure of the massive protostars, and to measure the amount of water around it. Using Herschel-HIFI and PACS observations of water lines, and using our modeling of the continuum spectral energy distribution, we analyze the gas dynamics from the line profiles. The spectral modeling tools allow us to estimate outflow and infall velocities, turbulent velocity, and molecular abundances. We present also the water maps of these objects. First results (see Chavarria et al. 2010 and Herpin et al, submitted) indicate that the turbulence is highly supersonic and dominates most water line profiles. In the W43-MM1 HMPO, we measure strong accretion rate, 3.5–4.0 $\times$ 10^{-2} $M_{\odot}/yr$, from the fast infall observed. The estimated accretion luminosity is high enough to overcome the expected radiation pressure. We also find that the turbulent velocity increases with the distance to the center. While not in clear disagreement with the competitive accretion scenario, this behavior is predicted by the turbulent core model.

Theory and modeling of protostars

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Protostars are highly dynamic systems with a wide array of physical components. Surrounding the central star is a molecular envelope of some 10,000 AU in size, whose density and temperature decrease from $> 10^8$ cm^{-3} and a few 100 K at the center to $\sim 10^4$ cm^{-3} and $\sim$10 K at the outer edge. The youngest systems have a rotationally flattened density profile in the inner few 100 AU, which evolves into an embedded circumstellar disk at later times. Meanwhile, the central source powers a bipolar jet that carves out a large outflow cavity. I will review our current theoretical understanding of protostars and I will present an overview of recent modeling efforts. Topics addressed include: the physical structure in the inner few 100 AU; energetic feedback from shocks and UV radiation onto the envelope; episodic accretion; kinematics of infall and outflow; and protostars as factories of complex organic molecules.

Constraining the Physical Structure and Dust Opacities Toward the Class 0 Protostar B335

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The problem of determining exactly how a dense core collapses to form a protostar remains unsolved. Multiple theoretical models currently exist that predict the (magneto)-hydrodynamic evolution of a protostellar envelope. In order to distinguish between the theoretical models, we must constrain the density ($n(\vec{r})$, and in particular variations in the density structure) as well as the velocity ($v(\vec{r})$) structure of the core envelope. Barnard 335 (B335) is an excellent laboratory to study the details of (magneto)-hydrodynamic collapse because it is one of the nearest star forming cores ($D \sim 100 - 150$ pc) and because it is isolated and unconfused and displays blue asymmetric optically thick line profiles in multiple molecular species indicative of infall motions. We present new constraints on the density structure and the variation of dust opacities for B335 from dust continuum models of combined observations from *Herschel* (100, 160, 250, 350, and 500 μm), SMA (870 and 1300 μm), and MUSTANG (3300 μm). Comparison of near-IR extinction to submillimeter emission along lines-of-sight of background stars indicate that the submm dust opacity β may be greater than 2 in the outer envelope ($r > 10000$ AU). Therefore, we explore the properties of a new class of radiative transfer models with an inverse temperature dependence of the submm dust opacity index which may be appropriate at cold temperatures for amorphous silicate grains.

The CHESS survey of the L1157-B1 shock

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Outflows generated by protostars heavily affect the kinematics and chemistry of the hosting molecular cloud due to strong shocks. These shocks heats and compress the ambient dense gas switching on a complex chemistry that leads to an enhancement of the abundance of several species, as reported in "chemically active" outflows, whose archetype is the outflow of the low-mass Class 0 protostar L1157. We present the results of the spectral survey of the shock region L1157-B1 carried out with PACS, SPIRE and HIFI instruments in the framework of the Herschel key program CHESS. The high spectral resolution data from HIFI show that different excitation conditions coexist in the B1 shock while the high PACS spatial resolution data shows a different spatial distribution of the the detected specie. We will discuss the properties of the different gas components and present the physical conditions derived from different species. We will present a first comparison with shock models highlighting the complex structure of this shocked region.

Feedback from low-mass protostars onto their surroundings: some like it hot

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During the earliest embedded stages of low-mass star formation the protostar interacts with its surroundings through high-velocity shocks and UV radiation, providing feedback to the material from which the star forms. At the same time, in-falling gas is heated to several 100 K by the accretion luminosity. Each of these processes has the ability to chemically alter the material from which the proto-planetary disk assembles, thereby changing the initial chemical conditions in the disk. What is the amount of warm gas, the temperature of the gas, the dominant excitation mechanisms, how do the systems evolve, etc. are all questions that need to be addressed before exploring chemical alterations in inflowing material. Herschel-PACS observations reveal surprisingly high-J CO emission (up to $J = 47$–46; $E_{\rm up}/k_{\rm B}\sim$5000 K) around several low-mass protostars, as observed in the context of the "Water in Star-forming regions with Herschel" key programme (van Dishoeck et al. 2011). These data immediately point to a reservoir of warm and hot gas (ranging from several 100 K to > 1000 K) around the protostars. Velocity-resolved spectra of CO $J = 16$–15 and, especially, H_2O obtained with Herschel-HIFI reveal new dynamical components not previously seen in spectra obtained from the ground. The new components are attributed to shocks in the inner parts of the accreting molecular envelope, but little is known about them and their role in the star-formation process, e.g., their origin

and the impact they have on the inner envelope currently accreting onto the disk. Explaining these data requires a combination of state-of-the-art shock and PDR models, where the shocks and PDRs are physically located along the outflow cavity walls. New advances in the 2/3D modeling, interpretation and understanding of the densest, innermost parts of the deeply embedded protostellar system will be highlighted. Both model and observations point to an evolutionary scheme in which shocks dominate the earliest phases of protostellar evolution, but the effects diminish with time, thus providing new insights into the energetic youth of low-mass stars.

Herschel far-infrared photometric monitoring of protostars in the Orion Nebula Cluster

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We have recently obtained time series observations of the Orion Nebula Cluster at 70 μm and 160 μm from the *Herschel*/PACS Photometer. This represents the first sensitive wide-field far-infrared photometric monitoring of a young star forming region. The $35' \times 35'$ maps show complex extended structures, with unprecedented details, that trace the interaction between the molecular gas and the young hot stars. We detect 43 protostars in their earliest phases of evolution, most of which are situated along the Orion A molecular ridge. We build light curves for all these objects using the first six epochs of our observing program spread over a two-month visibility window. We find strong amplitude variations (up to 30%) for a fraction of the detected protostars over periods as short as a few weeks. These observations support recent results from models of the dynamical evolution of circumstellar disk and envelope structure around protostars.

A Multi-Observatory Survey of Protostars in the Orion Molecular Clouds

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The Orion molecular clouds contain the richest sample of protostars within 500 pc. They encompass diverse environments from rich clusters to sparse groups, and provide a remarkable laboratory for studying protostellar evolution and its dependence on environment with a large sample of protostars at a common distance. We are engaged in a multi-observatory study of 280 Orion protostars and the environments in which they form. We have constructed 1.6 - 160 μm spectral energy distributions for these protostars using a combination of Herschel 70 and 160 micron imaging (as part of the Herschel Orion Protostar Survey key project), 3.6-40 μm Spitzer imaging and spectroscopy, and 1.6 μm HST imaging. These data are complemented by ground based observations, including APEX imaging at 350 and 850 μm of both the protostellar envelopes and the surrounding filamentary gas, and molecular line observations with the JCMT, APEX and GBT to measure gas temperatures, turbulence, infall and outflow. This unparalleled coordinated study is now providing new observational constraints on the evolution of protostars. We examine protostellar evolution using bolometric luminosities and temperatures corrected for extinction, inclination and scattering. After binning the protostars by their bolometric temperatures, we find that the average luminosity in each bin is relatively constant: the average luminosity of the protostars does not appear to change with increasing bolometric temperature. The luminosity of a protostar increases with the column density of gas surrounding the source, a clear indicator that protostellar evolution is influenced by environment. In addition, the spacing of the protostars increases with the reciprocal of the gas column density, a result consistent with Jeans fragmentation. We discuss the implications of

these findings for models of fragmentation, infall and accretion.

A new population of protostars discovered by Herschel

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We present a newly discovered Herschel–detected class of very red protostars found in the Herschel Orion Protostar Survey (HOPS). In contrast to the known Orion protostars targeted with HOPS, the new sources are undetected or very faint in the Spitzer 24 μm imaging. A subset of these sources is redder than any of the known Orion Class 0 protostars, and appear similar in their 70 μm to 24 μm colors to the most extreme Class 0 objects known. These new Orion protostars are likely to be in a very early and short lived stage of protostellar evolution. As a sample of extremely red sources at a common distance, they represent an important new population of protostars. The majority of these reddest sources exhibit associated IRAC 4.5, and 5.8 μm extended emission that suggests the presence of an outflow, confirming their protostellar nature. In addition, many of these sources are located within classical filaments as traced by Spitzer absorption features and APEX 870 μm dust emission maps. Fits of the broad–band SEDs to radiative transfer models of protostars suggest that the extremely red 70 μm to 24 μm colors result from a combination of nearly edge–on viewing angles and high envelope infall rates. We analyze the properties of the filaments from which these sources form using sub–mm and IRAM 30 m N_2H^+ measurements. Finally, we present the initial results of a search for outflows using IRAM 30 m CO maps. As a population of cold protostars detected by Herschel but not Spitzer, the PBRS extend the Spitzer–identified sample to earlier stages of envelope evolution, allowing the most complete census yet of the Orion protostellar population.

The star formation and disk evolution history of a sparse region: The Coronet cluster

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The Coronet cluster is a young (1-2 Myr) star-forming region with a few intermediate-mass stars and a moderate low-mass population, concentrated in a cloud about 0.7 pc in radius. Despite its compactness, Herschel/PACS observations, together with ground-based spectroscopy and Spitzer data, reveal that the region contains objects in very different stages of evolution, from embedded protostars in the densest parts of the cloud to protoplanetary disks, together with less dense parts of the cloud without evidence of star formation. Among the protoplanetary disks, we find both primordial disks with strong accretion and objects with evident inside-out evolution. This makes the Coronet cluster an interesting region to study the different phases of star formation and the physical processes leading to protoplanetary disk evolution. In addition, its sparse population presents as well an important contrast to populous clusters that can be used to study the influence of environment on the formation, structure, and fate of protoplanetary disks.

The evolution of Dust, Ice and Gas in Time: The DIGIT Herschel Key project

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The discovery of a large variety of exoplanetary systems in the last decade has triggered many new questions about their formation. Of particular interest is the availability of ingredients for building planets and small icy bodies in

planetary systems. During the formation of stars and planetary systems, the dust, ice, and gas experience a rich array of transformations in physical and chemical state. While the refractory dust provides the building block of planetary cores, ices survive in parts of the disk, providing the volatiles for atmospheres, oceans, and possible life on rocky planets. Gas chemistry is driven by ultraviolet radiation and X-rays from near the young star, and gas is lost to photo-evaporation and winds, changing the nature and amount of the materials for giant planet atmospheres. Tracing this chemical and physical evolution in its diversity requires a combination of observations from infrared (IR) to millimeter (mm) wavelengths, where dust, ice and gas have their principal spectroscopic features. We present an overview of the results sofar of the Herschel Key Project DIGIT (dust, ice, and gas in time), which studies the evolution of the circumstellar environment from young protostars still embedded in cloud cores through the late stages of pre main sequence systems at the time of disks dissipation. We will show an overview of the Herschel data obtained within the DIGIT program, showing a rich dust and gas chemistry, and discuss the constraints these observations place on the formation of planetary systems.

TOPIC 3 – **Planet-Forming Disks**
Oral Presentations

Protoplanetary disks before Herschel

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Only two decades ago, our understanding of planet formation was largely theoretical, and it was unclear whether the planets of our Solar System were a rare occurrence in the Galaxy. Today, thanks to the emergence of efficient planet-detection techniques, we know that planets are common. Further, a revolution in infrared to millimeter astronomy has led to an increasingly detailed understanding of how planetary systems form from protoplanetary disks as a natural consequence of star formation. We have learned that a large fraction of young stars are surrounded by dusty clouds with sizes and masses similar to those of the Solar System. High resolution imaging/spectroscopy has demonstrated that these clouds are disk-shaped, with Keplerian velocity fields and that they generally obey accretion disk theory. Spitzer made mid-infrared spectroscopy easy, and showed that the dust in the inner regions these disks is larger than that in the interstellar medium. Millimeter photometry similarly demonstrated the presence of millimeter-centimeter sized grains in their outer regions. The chemistry of the gaseous component has been mapped, and found to be exceedingly rich, laying the foundation for a great diversity of planetary compositions. Recently, multi-wavelength observations have now shown tantalizing signs of dynamical interactions between disks and young protoplanets in many disks. Altogether, the common term "protoplanetary disk" (indicating that planets are, in fact, forming within these objects) seems increasingly relevant. I will review how our understanding of planet formation, and protoplanetary disks, has evolved over the past decade; what were the major questions? Which of these have already been addressed, and which still remained unanswered leading up to the launch of Herschel in 2009?

Herschel observations of protoplanetary disks

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Herschel's sensitivity and spectroscopic capability has allowed large surveys and detailed studies of the planet forming region of circumstellar disks. I will review early results on the gas and dust content of disks with a focus on two complementary key programmes, Dust, Ice, and Gas in Time (DIGIT) and Gas in Protplanetary Systems (GASPS). [OI]63um is the most commonly detected line and found in disks around both low and intermediate mass stars. Gas masses can be determined to within a factor of about three and show that planet forming reservoirs drop below a Jupiter mass within a few Myr. Few other lines are detected in non-embedded, non-outflow sources with the notable exception of transition disks with warm, exposed inner rims. In these cases, the solid state 69μm forsterite feature has also been detected and contains signatures of dust processing and composition. For older, gas-poor systems, PACS and SPIRE photometry has improved the characterization of grain properties and disk structure. Through both detailed modeling of individual systems and statistics from surveys, Herschel data provide new and important clues to the formation of planets.

Herschel/PACS Survey of protoplanetary disks in Taurus/ Auriga- Investigating the source of [OI] 63 μm line emission

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GASPS is a large *Herschel* Open time Key project studying the evolution of gas in protoplanetary disks. We target about 240 nearby objects in Taurus and young associations covering stellar ages between 0.3 - 30 Myr. We use the PACS instrument to observe continuum and selected gas tracers, like [OI] at 63 and 145 μm, [CII] at 158 μm as well as several molecular lines like OH, H_2O and CO. The strongest line we see is the [OI] at 63 μm. However, although it is clear that [OI] 63 μm traces gas in the disk, it is also strong in jets and outflows. Using the sources observed so far (42 sources detected in both line and continuum of 75 sources observed in spectroscopy and 92 in photometry) in Taurus/Auriga we explore how the [OI] 63 μm line strength correlates with 63 μm continuum, disk mass, accretion rate, stellar luminosity, and strength of the [OI] 6300 Å emission for both outflow and non-outflow sources. We find a clear, tight correlation between the strength of the [OI] 63 μm line emission and 63 μm continuum for non-outflow sources and a weaker correlation for outflow sources. In outflow sources the line can be up to 20 times stronger than in non-outflow sources, indicating that the [OI] 63 μm emission from the outflow will dominate over the disk emission. For the few sources where we also detect the [OI] 145 μm line, we find line ratios of 145 to 63 μm of 0.04 - 0.05, suggesting optically thin lines originating from gas with a temperature of a few 100 K, which suggests that the emission comes from the inner part/surface layers of the disk or from the shock regions in the outflow.

A *Herschel* Search for Cold Dust in Brown Dwarf Disks

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The properties of protoplanetary disks seem to show a dependence on the mass of their host stars. Although young brown dwarfs show evidence for gas accretion and the presence of dust-gas disks, our knowledge of their disk mass distribution and structures is relatively limited. Only very few disks around brown dwarfs could be detected at far-infrared and submillimeter wavelengths. The sensitivity and spatial resolution of the *Herschel* observatory have changed this situation dramatically. We will present the results of a dedicated PACS program to search for far-infrared emission around a statistically significant sample of young brown dwarfs. We detected dust emission both at 70 and even at 160 μm for a relatively large number of objects. We will discuss the relevance of the observational results and highlight measurements of individual sources.

Search for rapid inner disk re-arrangements in a young eruptive star

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Young eruptive stars form a spectacular class of Sun-like pre-main sequence objects. They are characterized by strong optical outbursts due to enhanced accretion from the circumstellar disk onto the star. Recently, some unusual eruptive stars were identified where the brightening was due partly to enhanced accretion and partly to a dust-clearing event which reduced the extinction along the line of sight. In 2010, the outburst of a so-far unknown young star, V2492 Cyg, provided an opportunity to study the dust clearing phenomenon. Here we report on the first results of our coordinated Herschel, Spitzer, and ground-based monitoring of V2492 Cyg. Comparing the amplitude of observed variability at different wavelengths from optical to far-infrared, we investigate the physical cause of the extinction changes towards the star. We consider two scenarios: (1) a transient appearance/disappearance of a large amount of dust in the system either due to dust condensation/evaporation driven by the changing accretion heating, or being released from the disk surface by turbulence; (2) a pre-existing, long-lived dust structure that moves in/out of the line of sight, similarly to the orbiting warp in the inner disk of the low-mass young star LRLL 31. The Herschel/PACS 70 and 160 μm light curves trace the effect of rapid inner disk re-arrangements on the outer cold disk and help to decide between the two scenarios.

Locating dust crystals in protoplanetary disks with Herschel PACS

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Forsterite is one of the crystalline dust species that is often observed in protoplanetary disks and solar system comets. Being absent in the interstellar medium, it must be produced during the disk lifetime, though its connection with disk evolution and planet formation remains unclear. One reason for this is that mid infrared spectroscopy can only give a hint of crystal location and abundance. Additional information – such as the shape of the temperature dependent 69 micron feature of forsterite – is necessary to pin down its exact location. The DIGIT key program targets a sample of 24 Herbig stars with Herschel PACS at sufficient resolution to spectrally resolve the shape of the 69 micron feature. Combined with spatially resolved imaging and radiative transfer calculations, these data allow us to constrain the crystal location with great precision. We report on detailed studies of the spatial distribution and abundance of forsterite in three transitional disks. In HD100546 and HD169142, we find that forsterite is concentrated at the outer edge of the disk gap, with a local abundance that is much higher than the overall crystallinity. This suggests that the origin of forsterite in these objects is closely linked to the disk gap, carved by protoplanets. IRS 48 shows a different pattern: although similar in disk morphology, its forsterite is much colder and located further out in the disk, suggesting a different formation channel. These objects demonstrate the diagnostic power of the 69 micron forsterite feature observed as part of DIGIT, and show that the standard scenario of radial mixing of crystals from the inner disk does not suffice. A different formation mechanism, perhaps tied to the transitional nature of these disks, is necessary to explain the observed location of dust crystals.

PACS OBSERVATIONS OF DUST AND GAS IN TRANSITION DISKS

Ménard, F.[1]; Grady, C.; Howard, C.; Mathews, G.; Sandell, G.; Cabral, N.; Roccatagliata, V.; Meeus, G.; Pinte, C.; Thi, W.-F.; Benisty, M.; Dent, W.R.F.; Pascucci, I.; Kamp, I.; Woitke, P.; Aresu, G.; and the GASPS collaboration

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The GASPS Open Time Key Programme has observed a large sample of about 250 protoplanetary disks with the PACS instrument in both the continuum and atomic and molecular emission lines. The sample spans a range in mass and ages in several star forming regions. It also contains a significant number of so-called transition disks. In this contribution we will discuss the transition disks that show clear signs of inner holes or gaps in dust thermal emission. We will revisit them in view of the new Herschel PACS continuum and line observations. We will re-examine the geometry of the disks and the properties of their central gaps using full radiative transfer models of the continuum emission (SED fitting). When available, (sub-) millimeter interferometry data, as well as constraints from NIR longbaseline interferometry and/or high-resolution imaging of the disks (and their associated gaps) will be used. The gas properties (T_{gas}, abundances, level population) will then be calculated and line fluxes compared with the PACS line data for a few species. Finally, trends will be discussed, e.g., the [OI] 63 micron line fluxes with respect to the nearby continuum. Transition disks around T Tauri stars will be compared to those around Herbig AeBe stars. The transition disks will be compared to other "normal" protoplanetary disks around samples of single T Tauri stars (with or without jets/outflows) or located in binary systems with circumbinary disks (e.g., GG Tau, UY Aur). We will discuss the differences and propose interpretations.

Herschel observations of cold water vapor and ammonia in protoplanetary disks

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We present the results of a Herschel/HIFI study into the presence of cold water vapor in a sample of protoplanetary disks, carried out as part of the Guaranteed Time Key Program 'Water in Star Forming Regions with Herschel' (WISH). While toward most disks only upper limits are obtained, rotational ground-state emission lines of ortho-H_2O and para-H_2O are clearly detected toward the disk of TW Hya. The detection of cold water vapor, extending to at least 115 AU, in this disk indicates the presence of a vast reservoir of water ice totalling $\sim 10^{28}$ g or thousands of Earth Oceans. Photodesorption by stellar ultraviolet radiation likely liberates a small amount of water vapor from icy grains. Significant settling of such icy grains toward the disk midplane is required to match the detected amount of water vapor. The water ortho-to-para ratio of 0.77 is significantly different from that observed in Solar System comets where a range of 1.5–3 is found. If this reflects the temperature regime of the water ice (formation), this finding suggests that long-range mixing of volatiles has occured in the Solar Nebula. The same Herschel/HIFI data also detect the emission of NH_3 in TW Hya's disk, and the implications of this finding are discussed.

Modelling planet-forming circumstellar discs

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With the improved wavelength coverage and instrumental capabilities to observe planet-forming circumstellar discs in the X-ray regime, the UV, and the near, mid and far infrared (XMM, HST, VLT, Spitzer, Herschel, soon ALMA) there is an increasing scientific need to develop equally sophisticated models for the physical, radiative and chemical processes in these discs. The discs are composed of dust and gas spanning 10 orders of magnitude in density, and temperatures differ by a factor of about 100. There is hard irradiation that provokes various non-LTE effects, thermal and position de-coupling of icy dust and gas, and the differential rotation causes instabilities and mixing. In the last few years, new theoretical models have been developed that simulate different aspects of these complicated physical systems. I will focus mainly on models that model the chemical, radiative, and heating & cooling processes in these discs, pointing out some important coupling mechanism and feedbacks between them. In the new major European FP7-SPACE project *DIANA*, we will use these novel disc models to coherently analyse and interpret new

multi-wavelength data sets from X-ray to cm, probing in physics and chemistry in protoplanetary dicsc at different radii and depths. The general aim of the new models is to arrive at a common understanding of dust *and* gas, over the full radial extent of the disc, and to make use of continuum *and* line observations to constrain dust *and* gas properties in the disc. I will discuss where the various near-IR to sub-mm emissions (CO ro-vib, high-J CO lines, sub-mm CO lines, Spitzer water, Herschel/PACS water, Herschel/HIFI water, Herschel/PACS atomic lines) originate from, and how they are influenced by disc shape, irradiation, dust properties, and the chemical and radiative details.

Herschel Constraints on Ice Formation and Destruction in Protoplanetary Disks

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The study of the chemistry in protoplanetary disks is central to exploring the origins of planetary systems. We present the results of a detailed study of the DM Tau disk system where we examine the importance of grain surface chemistry for the formation of formaldehyde and water. Herschel observations of low abundances of H_2O toward DM Tau cannot be explained by standard chemistry models, and it was theorized that the upper layers of water in protoplanetary disks are H_2O-ice poor due to grain settling. Other possible explanations are that grains are kept dry via X-ray desorption and that the H_2O ice is buried under a carbon-rich ice layer. We explore whether these scenarios are consistent with the H_2O observations as well as with spatially resolved H_2CO data from the Submillimeter Array (SMA), assuming H_2CO is produced on grain surfaces and/or via gas phase chemistry.

Warm gas atmospheres of the protoplanetary disks seen by Herschel: Gas rich and carbon poor?

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With the Herschel Space Observatory, lines of simple species ([CII], [OI] and high-J lines of CO) have been detected in the atmosphere of protoplanetary disks. When combined with ground-based data on [CI] all principle forms of carbon can now be studied. This allows to test model predictions for the main carbon bearing species to study the gas-phase carbon budget and the presence of a warm surface layer. We present new thermo-chemical modeling of the well studied disk around the Herbig Be star HD 100546. Using our model, we can reproduce the CO ladder ($J = 3-2$ to $30-29$) together with the atomic fine structure lines of [OI] (63 and 145 μm) and either [CII] (158 μm) or the upper limit of [CI] (370 μm). We find that the high-J lines of CO can only be reproduced by a warm atmosphere with a gas temperature much increased over the dust temperature. The low-J lines of CO, observed from the ground, are dominated by the outer disk with radius of several 100 AU while the high-J CO observable with Herschel-PACS are dominated from regions within some tens of AU. The profiles of high-J lines of CO are predicted to be broader than the low-J lines. We study the effect of several parameters including the size of the disk, the gas mass of the disk, the PAH abundance and distribution and the amount of carbon in the gas phase. The absence of neutral carbon [CI], which is predicted to be strong by thermo-chemical models, is discussed in the context of the gas-phase carbon budget.

From pebbles to planets

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The formation of km-sized planetesimals from smaller cm-dm sized pebbles faces major difficulties in the traditional coagulation scenario. Such particles do not stick well and very quickly drift towards the star to sublimate in the inner nebula. I will present an alternative scenario where overdense regions of particles collapse under their own gravity to form massive 1000-km-scale planetesimals. The overdensities are seeded by hydrodynamical streaming instabilities arising in the coupled motion of gas and particles. New computer simulations that include particle collisions show the perseverance of planetesimal formation by this route. Planetesimal masses are relatively independent of the computational resolution and the simulations reveal a characteristic planetesimal size that increases with distance from the sun. The resulting planetesimal sizes agree well with the observed largest bodies residing in the asteroid and Kuiper belts.

TOPIC 4 – **Debris Disks and Exoplanets**
Oral Presentations

Observations of Debris Disks before Herschel

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Before the launch of Herschel, the physical properties of debris disks were determined by pioneering observations from a series of ground-breaking instruments and missions. I will review these milestones and how they influenced the science of debris disks in the years leading up to Herschel.

Herschel Observations of Debris Disks from WISE

Padgett, D. L.[1]**; Stapelfeldt, K. R.**[1]**; Liu, W.**[2]**, Leisawitz, D. T.**[1]**, Fajardo-Acosta, S.**[2]
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The Wide Field Infrared Survey Explorer (WISE) has just completed a sensitive all-sky survey in photometric bands at 3.4, 4.6, 12, and 22 microns. We report on a study of main sequence Hipparcos and Tycho catalog stars within 120 pc with WISE 22 micron emission in excess of photospheric levels. This warm excess emission traces material in the circumstellar region likely to host terrestrial planets and is preferentially found in young systems with ages < 1 Gyr. Nearly a hundred of the WISE new warm debris disk candidates detected among FGK stars are being observed by Herschel/PACS to characterize circumstellar dust. Preliminary results indicate 70 micron detection rates in excess of 80% for these targets, suggesting that most of these systems have both warm and cool dust in analogy to our asteroid and Kuiper belts. In this contribution, we will discuss the WISE debris disk survey and latest results from Herschel observations of these sources.

The connection between inner and outer debris disks probed by infrared interferometry

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The far-infrared surveys of nearby main sequence stars performed since the launch of IRAS have shown that a significant fraction of main sequence stars are surrounded by cold dust populations. These surveys are now culminating with the the DUNES and DEBRIS key projects of the Herschel Space Observatory, which is more sensitive than ever and is able to detect cold dust populations with densities similar to that of the solar system Kuiper belt. However, little is known about the occurence of warm dust populations, the equivalent of our zodiacal cloud. Since 2005, high-precision infrared interferometers have opened a new way to directly resolve these exozodiacal dust populations. Interferometric observations enable to reach dynamic ranges (larger than 100:1) that are generally not achievable with classical spectro-photometric observations. We are currently carrying out a survey to characterise the hot dust populations around main sequence stars. The first results of this survey, performed on the CHARA array with the FLUOR instrument, will be presented in this talk. The results are based on a magnitude-limited sample of stars surrounded by cold dust and on an equivalent sample of stars showing no cold dust emission. The statistics

for the occurence of bright exozodiacal disks will be presented, and compared with the Spitzer and Herschel results. The possible (dynamical) connections between the two populations will be discussed. We will also review the results obtained by other interferometers and discuss the on-going projects.

Ocean-Like Water in the Jupiter Family Comet 103P/Hartley 2

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Comets are among the most primitive bodies left from the planetesimal building stage of the Solar Nebula. Submillimeter wavelengths are well matched to the cold environments of cometary atmospheres ($T \sim 40-100$ K). Over two dozens of molecules have been detected in comets, primarily by means of (sub)millimeter spectroscopy. Measurements of isotopic ratios, in particular D/H, provide key information about the origin and evolution of cometary ices and possible links with the interstellar medium. The D/H ratio in water in long period, Oort cloud comets, $\sim 3\times10^{-4}$, corresponds to a factor of ~ 12 enrichment over the protosolar value and twice the Earth ocean ratio, VSMOW 1.56×10^{-4}. These measurements imply that comets incorporated material partially reprocessed in the inner Solar Nebula and could have contributed at most $\sim 10\%$ of the Earth ocean water. Using Herschel/HIFI, we have measured for the first time the D/H ratio in a Jupiter family comet, originating from a different, large reservoir of water ice rich material—the Kuiper belt. We derive a D/H ratio in water of $(1.6\pm0.24)\times10^{-4}$ (1σ), a factor of 2 lower than the earlier measurements in Oort cloud comets and the same as VSMOW. This indicates that the high D/H values previously measured in Oort cloud comets are not representative of all comets and that the current understanding of deuteration in different solar system reservoirs, or solar system dynamics, is incomplete and has to be revisited. Furthermore, comets similar to Hartley 2 could have delivered a much higher fraction of the Earth ocean water than previously thought.

Debris Discs and Connection to Exoplanets: Herschel Overview

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Debris discs are an exciting science area that has been opened up by Herschel through deep far-infrared observations. Key Projects cover disc evolution from the early stages when planets form (GASPS) and onwards to discs hosted by stars even older than the Solar System (GT, DUNES, DEBRIS). New categories are being discovered, including very cold cometary belts and unusual types of dust grain, and new connections are being made for systems of low-mass stars and planets. I will review these discoveries in the context of our ideas on how planetesimal belts from and evolve.

Spatially resolved far-infrared imaging of bright debris disks: studying the disk structure and the stirring mechanism

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A significant fraction of main-sequence stars are encircled by dusty debris disks. The short lived dust particles of these disks are believed to be replenished through destructive collisions between unseen planetesimals whose orbits are stirred up by some mechanism. In the literature three candidate mechanisms compete: the most commonly invoked self-stirring, the giant planet induced planetary stirring and close stellar flyby. We use Herschel/PACS and Herschel/SPIRE to study 10 carefully selected debris disks, whose young age and relatively large disk size, estimated from Spitzer observations, hint for stirring mechanism other than self-stirring. With our new observations we could resolve the debris disks at 70 μm (and in some cases at 100/160 μm as well) and detect them with SPIRE, too. With the aim of identifying the stirring mechanism, we characterize the spectral energy distributions, and study the radial and azimuthal distributions of the cold debris.

Cometary dust in the planetary belts of β Pictoris

de Vries, B.L.[1]; Acke, B.[1]; L.B.F.M. Waters[2,3]; Blommaert, J.A.D.L.[1]; Vandenbussche, B.[1]; Dominik, C.[3]; Waelkens, C.[1]; Herschel Stellar Disk Evolution Consortium

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The discovery of more than 600 exo-planets in the past two decades has shown an amazing diversity in the properties of planetary systems. The origin of this diversity and the way the Solar System fits in must be understood by studying young systems in which planet formation is ongoing, and by comparing the properties of these young systems with the historic records of the formation of the Solar System as recorded in e.g. asteroids and comets. Strong evidence that gas-phase condensation produces Mg_2SiO_4, comes from observations of crystalline olivine grains in evolved cool red giants. In another study we have detected the 69 μm crystalline olivine band in several red giants and the wavelength and band shape of the resonance are in agreement with pure Mg_2SiO_4. In contrast, Solar System comets such as Wild 2 and chondritic meteorites show a small but significant fraction of Fe in the crystalline olivine of $\sim$1 per cent. β Pictoris is a young (12 Myr) main-sequence star surrounded by at least one planet at a distance of $\sim$10 AU, and a dusty debris disk created by catastrophic collisions of planetesimals. We have detected the 69 μm band in a HERSCHEL- PACS Range Scan of β Pictoris. Modeling this band gives an Fe/Mg ratio of 0.01 and constrains the location of the crystalline olivine to 8-16 AU. The crystalline olivine grains are probably produced by collisions between planetesimals in the known belts at 6 and 16 AU. The composition of the crystalline olivine is strikingly similar to that of Solar System bodies like comets, IDPs and meteorites. But an Fe/Mg ratio of 0.01 is not compatible with crystalline olivine grains produced through gas phase condensation, meaning that the crystalline olivine in β Pictoris must come from another source, similar to the one in our Solar System.

Fomalhaut's debris disk as seen by Herschel

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The Herschel space telescope has provided stunning images of the debris disk around Fomalhaut. Fomalhaut is one of the bright, nearby debris disks that can be well resolved. The faint scattered light observed by HST in 2005 already gave hints about an offset, possibly caused by a planet. In the thermal infrared, as imaged by Herschel, the ring shows up in all its glory as a textbook example of a debris ring. Together with the spectral energy distribution and scattered light images, this new information allows to constrain the dynamical state of the disk, as well as its geometry. We show that the collisional cascade must in the disk must be very active, so that smaller grains provide an important contribution to the emission of the ring. We also detect and resolve emission inside of the main ring, and constrain an unresolved component of much warmer dust, close to the star. We will discuss the new results and implications of the data.

Debris Discs: Modeling/theory review

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An impressive amount of photometric, spectroscopic and imaging observations of circumstellar debris discs has been accumulated over the past 3 decades, revealing that they come in all shapes and flavours, from young post-planet-formation systems like Beta-Pic to much older ones like Vega. What we see in these systems are small grains, which are probably only the tip of the iceberg of a vast population of larger (undetectable) collisionally-eroding bodies, leftover from the planet-formation process. Understanding the spatial structure, physical properties, origin and evolution of this dust is of crucial importance, as it is our only window into what is going on in these systems. Dust can be used as a tracer of the distribution of their collisional progenitors and of possible hidden massive pertubers, but can also allow to derive valuable information about the disc's total mass, size distribution or chemical composition. I will review the state of the art in numerical models of debris disc, and present some important issues that are explored by current modelling efforts: planet-disc interactions, link between cold (i.e. Herschel-observed) and hot discs, effect of binarity, transient versus continuous processes, etc. I will finally present some possible perspectives for the development of future models.

Study of debris disks in planet-host stars: are planets and debris correlated? Results from the DEBRIS and DUNES Herschel surveys.

Moro-Martín A.[1]; Marshall, J. P.[2] and the DEBRIS and DUNES teams. Presented by Mark Wyatt
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Debris disk studies with Spitzer found no evidence of a correlation between (giant) exoplanets and circumsteallar dust. Since these studies were carried out, a new parameter space of fainter and colder debris disks has been opened up by the Herschel Space Observatory – improving our knowledge of the disk frequency, in particular around cooler stars – and simultaneously higher precision doppler surveys have allowed the detection of lower-mass planets, the frequency of which can now be characterized. Here, we revisit the planet-debris disk correlation using Herschel data from the DEBRIS and DUNES surveys. We assess whether the frequency and properties of disks around stars with high-mass and low-mass planets are any different from a control sample, and if these differences can be used to shed light on planet formation mechanisms and to predict the presence of planets around stars with certain disk characteristics.

The Mystery of Herschel's "Cold Debris Disks"

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An important result of the Herschel Open Times Key Program DUNES is a discovery of a new class of "cold debris disks". These are tenuous disks that show little or no infrared excess at 100μm, but a significant one at 160μm and possibly longer wavelengths. A comparison of the dust temperatures inferred from the SEDs to the disk radii estimated from resolved images suggests that the dust is colder than a black body at the dust location. This requires the grains to be large (compared to far-infrared wavelengths) and to have low absorption in the visible. While the latter can be achieved, for instance if the dust is rich in ices, the absence of small grains is puzzling, since collisional models of debris disks predict the grains of all sizes down to several times the radiation pressure blowout limit to be present. We will discuss several scenarios proposed to explain depletion of small grains: transport-dominated disks, disks with dynamically cold dust-producing planetesimals, and the disks of unstirred primordial millimeter-sized grains. While the first two scenarios encounter problems, the last one looks more promising. Our collisional simulations show that, at least for some collision outcome prescriptions, such disks can indeed survive for gigayears, largely preserving the primordial size distribution. The modeled thermal emission appears to be roughly consistent with the observed one.

TOPIC 1 – **Pre-Collapse Phase**
Posters

Temperature, kinematics and turbulence of infrared dark clouds (IRDCs) at high spatial resolution

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While high-mass stars, such as OB stars, affect their environment significantly with uv-radiation or supernovae, they also influence the interstellar medium and the development within entire galaxies. Although their importance is undoubted, the formation process of massive stars remains poorly understood. Herschel gives us a unique chance to study dust properties of dense cores in details, but the bolometric data lack any kinematical information. Therefore, we have embarked on an eVLA NH_3 study to investigate the temperatures, kinematics and turbulent properties of the dense gas in a sample of Herschel selected infrared dark clouds (IRDCs). We observed the $NH_3(1,1)$ and $(2,2)$ transition lines towards seven IRDCs with the eVLA at high spatial resolution of $\sim 3''$ ($\sim 9000AU$) in 2010 and we will observe a part of this sample with the Effelsberg 100m telescope in January 2012.

On my poster, I will present the results of these observations. Due to the high resolution of $\sim 3''$ we are able to spatially resolve the kinematics and turbulence within the IRDCs. As the temperature of IRDCs is in the range of 10-20K, ammonia can also be used as a thermometer. Therefore we are able to determine temperature maps and we find decreasing temperature gradients from the cloud edges toward the dark cloud centers. These cold dense clumps have no $24\mu m$ counterpart, that means no embedded heating source. Hence they represent the earliest stage of massive star formation.

Another result of our ammonia observations is to probe directly the collisional coupling regime between dust and gas within star-forming regions. Herschel data allows us to derive accurate dust temperature maps and density distributions. Because our ammonia observations reveal gas temperature maps, we can compare both temperatures within different density regimes.

Variation of the FIR/submm optical properties of interstellar dust analogues at low-temperature.

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Observations in the far infrared and submillimeter range trace cold dust and allows us to detect pre-stellar clouds prior to their collapse, and thus to study the first steps of star formation, and to estimate the dust mass in cold interstellar clouds. A good knowledge of the dust physical, chemical and optical properties, and its thermal emission is therefore needed in order to correctly interpret observational data. However, the variations of the dust emissivity observed by the Herschel and the Planck missions and previously by the balloon-borne missions ARCHEOPS and PRONAOS and by the sattelite COBE (β-T anticorrelation, submm excess) are confirming that the dust emission is not as simple as it is usually assumed in astronomical models (modified blackbody emission) and that laboratory data on cosmic dust analogues are needed to interpret the observations and to model the FIR dust emission.

For the last 15 years, only a few laboratory studies were dedicated to the FIR/submm spectral range and to temperature effect. Consequently, the dust optical properties at these long wavelengths are often extrapolated from those measured at shorter wavelengths and this is almost certainly not valid. In addition, there still exists a gap in our understanding of the detailed behaviour of interstellar dust analogues at low temperatures and long wavelengths

and how those properties evolve with the dust structure, composition (mineralogical and chemical) and temperature within the astrophysical context.
The latest experimental results of the spectroscopic characterisation of Mg- and Fe-rich amorphous silicate dust analogues at low-temperature will be presented. They show that the dust properties in this domain are complex and depend on the temperature. The implications for the interpretation of FIR/submm observations will be discussed.

The full map of M33

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The IRAM Large Program to fully map the Local Group Galaxy M 33 is now finished and I will present first results of the completed survey.

The ortho/para chemistry of nitrogen hydrides in dark clouds

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The chemistry of nitrogen hydrides in dark clouds is initiated by the key reaction $N^+ + H_2 \rightarrow NH^+ + H$. This reaction is known to depend critically on the ortho-to-para ratio of H_2 which, in turn, is driven by a competition between the rate of H_2 formation and the rate for ortho/para H_2 conversion. This latter is expected to be dominated by (reactive) collisions with protons and H_3^+. The ortho/para chemistry of nitrogen hydrides has been introduced in a time dependent chemical model using updated rates for, in particular, proton exchange reactions and dissociative recombinations. New results will be discussed in the light of recent Herschel/HIFI observations towards star forming regions.

Depletion and ionization fraction in the L1498 and L1517B prestellar cores

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Prestellar cores represent the earliest stage of the formation of star. Constraining their physical and chemical properties is therefore important to better understand the star formation process as a whole. In this contribution, we present a detailed model of $C^{18}O$ (1-0) and $H^{13}CO$ (1-0) line emission in two prestellar cores, L1498 and L1517B. Both cores are located in the Taurus-Auriega molecular complex, and were choosen because of their simple spherical shape and well constrained density and temperature profiles. Our model couples a detailed gas-phase chemistry model that includes gas-grain interactions (depletion and desorption) with a non-LTE radiative transfer code. This allows for a direct comparison between the model and the observations. We find that the model successfully reproduces the $C^{18}O$ (1-0) maps in both cores, if the chemical model is run for $(2-3)\times10^5$ years. $C^{18}O$ is found to be depleted by about 2 orders of magnitude at the center of L1498 with respect to the core age. In L1517B, which is denser, we found a depletion factor of about 3 orders of magnitude. The $H^{13}CO$ (1-0) is also well reproduced for cosmic-ray ionization rate of $(3-10)\times10^{-17}$ s^{-1}. The ionization fraction found to be of the order of 10^{-8} at the center of the two cores. The corresponding ambipolar diffusion timescale is about 2×10^6 yr, i.e. about an order of magnitude larger that the prestellar core lifetime, as estimated from large scale surveys. This favors a rapid formation scenario rather than a quasi-static formation through ambipolar diffusion.

CH^+ formation the Orion Bar as seen by Herschel HIFI

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CH^+ is among the first molecules that have been detected in the interstellar medium (Douglas & Herzberg, 1941). The observed CH^+ abundances are typically a few orders of magnitude larger than predictions of steady-state chemical models of cool, quiescent molecular clouds. The most probable reaction to form CH^+ is the highly endothermic reaction: $C^+ + H_2 \rightarrow CH^+ + H$ $(E/k = 4640K)$. To overcome the activation barrier, a couple of scenarios have been suggested, including C-shocks (Pineau des Forets et al., 1986), turbulent interfaces between the warm and cold neutral medium (Lesaffre et al., 2007), regions of intermittent turbulent dissipation (Godard et al., 2009) and H_2 vibrational excitation (Sternberg & Dalgarno, 1995 ; Agundez et al., 2010). The $^{12}CH^+$ $(1-0)$ transition (at 835 GHz) cannot be detected from the ground due to its proximity to a strong atmospheric line of water vapor. Herschel HIFI offers the first opportunity to detect it. We investigate the formation of CH^+ in the case of a prototypical photon dominated region, the Orion Bar, using data from the HEXOS (Herschel/HIFI Observations of EXtraOrdinary Sources, PI: E. Bergin) key program for the HIFI instrument onboard the Herschel Space Observatory. We compare the observed CH^+, C^+, C and CO line parameters to clumpy PDR models, using the KOSMA-τ code (Röllig et al., 2006). Based on our preliminary result, using a two-level approach, the most probable mechanism to drive CH^+ formation in the Orion Bar is H_2 vibrational excitation.

High Massive star forming regions from near IR to Herschel

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We present deep and high-resolution broad- and narrow-band near-infrared images of a number of star formation regions selected by the presence of methanol masers and other signposts of massive star formation. The Northern Milky Way regions were observed with the camera NICS attached to the 3.5m Telescopio Nazionale Galileo at La Palma, Islas Canarias, Spain. The southern regions were observed with the Magellan Baade 6.5m telescope with PANIC camera. These images were compared with the corresponding IRAC and MIRAC Spitzer ones. A number of new embedded clusters are found and their physical characteristics (distances, masses, ages) are determined. Herschell images at 70, 160, 250, 350 and 500 μm are available from the Hi-Gal survey for most of our selected sources. A study of their spectral energy distributions including near-IR, Spitzer and Herschel data is presented.

Possible External Triggers of Star Formation in the Orion-A Giant Molecular Cloud

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We present new, wide, and deep images in the 1.1 mm continuum and the ^{12}CO (J = 1–0) emission toward the northern part of the Orion-A Giant Molecular Cloud (Orion-A GMC). The 1.1 mm data were taken with the AzTEC camera mounted on the Atacama Submillimeter Telescope Experiment (ASTE) 10 m telescope in Chile, and the ^{12}CO (J = 1–0) data were with the 25 beam receiver (BEARS) on the Nobeyama Radio Observatory (NRO) 45m telescope in the On-The-Fly (OTF) mode. The present AzTEC observations are the widest (1.7 × 2.3, corresponding to 12 pc × 17 pc) and the highest-sensitivity ($\sim$ 9 mJy beam^{-1}) 1.1-mm dust-continuum imaging of the Orion-A GMC with an effective spatial resolution of 40 arcsec (∼0.07pc). The ^{12}CO (J=1–0) image was taken over the northern 1.2 × 1.2 (corresponding 9 pc × 9 pc) area with a sensitivity of 0.93 K in T_{MB}, a velocity resolution of 1.0 km

s^{-1}, and an effective spatial resolution of 21arcsec (~0.04pc). With these data, together with the MSX 8μm, Spitzer 24μm, and the 2MASS data, we have investigated the detailed structure and kinematics of molecular gas associated with the Orion-A GMC, and have found evidence for interactions between molecular clouds and the external forces that may trigger star formation. Two types of possible triggers were revealed: (1) Collisions of the diffuse gas on the cloud surface, particularly at the eastern side of the OMC-2/3 region, and (2) Irradiation of UV on the pre-existing filaments and dense molecular cloud cores. Our wide-field and high-sensitivity imaging has provided the first comprehensive view of the potential sites of triggered star formation in the Orion-A GMC.

Dense Core Formation by Fragmentation of Velocity-Coherent Filaments in L1517 and B213

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The formation of dense cores in dark clouds is still a poorly understood process, with some models proposing that it is driven by supersonic collisions of gas flows while others defending a more quiescent mode of fragmentation. To shed new light on core formation, we have studied the kinematics of the gas in dense cores and the gas in the surrounding cloud towards two regions in the Taurus-Auriga molecular cloud: L1517 and the 10-parsec long B213 filament. Our observations show that in both regions, the gas surrounding the cores is structured in 0.5 pc-long filaments whose velocity is subsonic and presents at most weak large-scale oscillatory gradients. The cores embedded inside these filaments share the large scale motions of the surrounding gas. This velocity coherence of the core-forming gas rules out core-formation models by supersonic gas collisions, and supports a quiescent mode of fragmentation. In addition, it shows that dissipation of turbulence precedes core formation, and that it gives rise to filamentary structures that later fragment into cores.

The Herschel view of massive star formation in NGC 6334

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I will present first Herschel PACS and SPIRE results for the NGC 6334 complex in the far-infrared regime at wavelnegths of 70, 160, 250, 350 and 500 μm. The Herschel analysis is complemented with sub-millimetric SIMBA/SEST 1.2mm observation. We use the source extraction algorithm 'getsources' to extract compact sources and measure their fluxes. The spectral energy distribution is then fitted to determine the physical parameters of the sources including temperature and masse. I will focus on the sample of massive dense cores (M $\geq$ 180 $M_{\odot}$) which are expected to be the most probable sites for the formation of massive stars, and discuss the statistical properties of the extracted sources and the search for association with signpots of star formation. A short-list of relevant IR-quiet massive dense cores is extracted and will be the targets for an ALMA proposal to explore the fragmentation and the chemistry of these massive dense cores.

The temperature and density structure of nearby star-forming cores

Launhardt, R.[1]; Stutz, A.[1]; Lippok, N.[1]; Henning, Th.[1]; Krause, O.[1]; Balog, A.[1]; Beuther, H.[1]; Kainulainen, J.[1]; Linz, H.[1]; Nielbock, M.[1]; Ragan, S.[1]; Schmiedeke, A.[1]; Steinacker, J.[1,2]

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The evolution of the density structure of a star-forming molecular cloud core is one of the key aspects in protostellar collapse models. We present results from our Herschel KP EPoS observations of 12 nearby, isolated, star-forming globules, each containing one to two embedded cores covering a range of early evolutionary stages, from starless to Class I sources. The Herschel observations in the far-IR regime allow us for the first time to fully sample the cold-dust SEDs in these sources. By combining the Herschel data with ground-based (sub)mm observations and NIR extinction maps, and taking advantage of the isolated location and simple structure of these clouds, we are able to reconstruct their density and temperature structure with unprecedented accuracy. Our method aims at disentangling the effects of temperature and (column) density on the emission maps and deriving the temperature and density profiles directly from the data without being restricted to a particular physical model of the cloud. I will give an overview of our method and present the initial results of our survey. We find that the central dust temperatures of these isolated clouds drop to mean values of 8-10 K when averaged over the central 3000-5000 AU. The energy budget and SED of such cores is completely dominated by external ISRF heating until embedded protostars exceed luminosities of a few tens solar. Linking the physical structure of the cores to both their evolutionary state as well as their local galactic environment brings us one step closer to characterizing the initial conditions of star formation.

The Herschel Dust Temperature Map of B 68

Nielbock, M.[1]; Launhardt, R.[1]; Krause, O.[1]; Stutz, A.[1]; Steinacker, J.[1]; Balog, Z.[1]; Henning, Th.[1]; Kainulainen, J.[1]; Linz, H.[1]; Lippok, N.[1]; Ragan, S.[1]; Schmiedeke, A.[1,2]; Risacher, C.[3]; Hily-Blant, P.[4]

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Isolated starless cores within molecular clouds can be used as a testbed to investigate the conditions prior to the onset of fragmentation and gravitational proto-stellar collapse. In order to deduce the internal structure of the dust temperature and density of such globules, we have initiated a Herschel GT Key Project "*The Early Phases of Star Formation*" to investigate 12 nearby low-mass cores, including Barnard 68, with the Herschel PACS and SPIRE instruments. Ancillary space and ground based data were added to the analysis. By performing spatially resolved SED fitting and subsequently applying a ray tracing algorithm, we have produced empirical dust temperature and density maps of B 68. In this way, we were for the first time able to spatially resolve its dust temperature and density distribution. The peculiar morphology witnessed at the shortest wavelengths indicates a significant anisotropic contribution the interstellar radiation field that heats B 68 from the outside. The side facing the Galactic plane attains a dust temperature of 17.3 K. The shielded dense ($n_\mathrm{H} = 1.3 \times 10^5$ cm^{-3}) centre of the globule cools down to to 9.7 K, where a $C^{18}O$ (1–0) depletion cavity was observed. The resulting total mass of 2.7 $M_\odot$ confirms pervious estimates that were based on NIR extinction measurements. Finally, we find indications for an embedded compact object at the tip of the southeastern extension of B 68. In this talk, I will also discuss how various formation and evolution scenarios that were conceived for B 68 agree with the results of this investigation.

Evidence for the growth of the Taurus B211 filament based on *Herschel* observations

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A growing body of evidence indicates that filaments play a fundamental role in the pre-collapse phase of star formation. In particular, recent results from the *Herschel* Gould Belt Survey (André et al. 2010; Könyves et al. 2010; Arzoumanian et al. 2011) suggest that prestellar cores are primarily located along filamentary structures. Thus, in order to improve our understanding of the formation of prestellar cores, it is essential to study how filaments are generated in the ISM and how they evolve. Here, we present new *Herschel* results towards the B211/L1495 region in the Taurus molecular cloud (Palmeirim et al. 2012), obtained as part of the Gould Belt Survey. The high sensitivity provided by *Herschel* in the submilimeter regime reveals an organized network of low-density striations elongated along the direction of the magnetic field and predominantly perpendicular to the dense, star-forming filament B211. Based on the column density and temperature maps derived from the *Herschel* data, we found that the density profile of the B211 filament approaches a power-law behavior $\rho \propto r^{-2.4\pm0.4}$ and that the temperature profile drops significantly towards the filament center. Fitting theoretical models of idealized cylindrical filaments to the observed density and temperature profiles suggests that the B211 filament is undergoing gravitational contraction with a polytropic (non-isothermal) equation of state: $P \propto \rho^{\gamma}$ and $T \propto \rho^{\gamma-1}$, with $\gamma = 0.97 \pm 0.01 < 1$. The velocities expected from infall of the low-density striations onto the B211 filament are consistent with the kinematical information provided by ^{12}CO observations (Goldsmith et al. 2008). We argue that our results provide evidence that the B211 filament is currently contracting quasi-statically towards its long axis and accreting material from the surrounding environment. According to theory (Kawachi & Hanawa 1998), such a slowly contracting filament, with γ slightly less then 1, is prone to fragmentation into cores, as indeed observed in the case of B211.

The seeds of star formation in infrared-dark clouds

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Infrared-dark clouds (IRDCs) contain a range of objects in the earliest phases of cluster formation, potentially including the elusive precursors to massive stars. IRDCs are cold (T$<$ 20 K) and thus emit most of their radiation in the far-infrared and sub-millimeter regime. As part of the Earliest Phases of Star Formation (EPoS) Herschel guaranteed time key program, we target 45 well-studied IRDCs and ISOSS sources and image them deeply across all PACS and SPIRE wavelengths (70 - 500μm). By fitting the spectral energy distribution (SED) of PACS point sources, we uncover a core population throughout IRDC filaments, nearly half of which are detected with PACS for the first time, lacking a 24μm counterpart. This new point source population represents an early pre- or proto-stellar core phase within IRDCs. We discuss the point source mass, temperature, and luminosity distributions and connect these properties to the immediate core environment and evolutionary sequence. We find that $\sim$30% of the cores have masses greater than 10M$_\odot$, most of which are found in our most massive molecular cloud complexes. We also present results from follow-up sub-millimeter continuum studies with the SABOCA instrument at APEX that further constrain the SED of the cores at 350μm, which can significantly impact their estimated mass. These cores are an important link between the large scale IRDC filaments and the star clusters they will ultimately form. In particular, we are now able to trace how much mass in IRDCs lies in the most massive dense cores, the most promising candidates for the precursors to massive stars and clusters.

The Herschel view of massive star formation in NGC 6334

Russeil, D. [1]**; Tigé J.** [1]**; N. Schneider, N.**[2]**; Zavagno, A.** [1]**, Motte, F.**[2]**; Bontemps, S.**[3]**; Anderson, L.D.** [4]**; Leuleu, G.**[1]**; Men'shchikov, A.**[2]**; Molinari, S.**[5]**, Persi, P.**[6]

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We present first Herschel PACS and SPIRE results for the NGC 6334 complex in the far-infrared regime at wavelnegths of 70, 160, 250, 350 and 500 μm. The Herschel analysis is complemented with sub-millimetric SIMBA/SEST 1.2mm observation. We focus our analysis on the search for infrared-quiet massive dense cores, which are expected to be the most probable sites for the formation of massive stars. We use the source extraction algorithm 'getsources' to extract compact sources and measure their fluxes. The spectral energy distribution is then fitted to determine the physical parameters of those sources previously detected at 1.2mm. In addition, we study physical properties such as temperature and spatial structure of the NGC6334 molecular cloud. We detected 12 massive dense cores (M $\geq$ 180 $M_\odot$) amid which 4 are infrared-quiet (defined as sources with F(70 μm) $<$ 132 Jy). The average physical properties of these infrared-quiet massive dense cores are: $<$T$>$ $\sim$ 13.5 K, $<$FWHM$>$ $\sim$ 0.11 pc and $<$n$>$ $\sim$ 5.2 $\times$ 10^6 cm^{-3}. While the active (F(70 μm) $\geq$ 132 Jy) massive dense cores are located close to HII regions, the IR-quiet ones are more isolated. In agreement with the massive dense cores census, the column density and its PDFs differentiates the NGC 6334 complex into distinct sub-areas, each of them appearing different in terms of morphology, evolutionary status and ability to form massive stars. In particular the central region seems to display a more advanced evolutionary stage.

Detection of HF emission from the Orion Bar

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Using Herschel-HIFI, we have detected HF J=1–0 emission toward the Orion Bar, which is unusual because all lines of sight through the Galactic interstellar medium studied so far show this line in absorption. A model of the collisional excitation and radiative decay of HF indicates that electron collisions dominate the excitation of HF. Collisions with H_2 and He are less important, while infrared pumping and chemical pumping are negligible. The Orion Bar has an unusually high electron density due to the strong ultraviolet irradiation by the Trapezium stars. We conclude that HF emission is a signpost of high electron density, which may also apply to active galactic nuclei where HF appears in emission.

High-angular investigations of IR-quiet massive dense cores discovered by *Herschel*

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At only 6 kpc from us, W43 is one of the most extreme molecular cloud complexes of the Milky Way and it has the potential to form starburst clusters in the near future (Nguyen-Luong et al. 2011). IRAM 30m and *Herschel*

(Hi-GAL or EPOS) images have revealed three massive dense cores (MDCs called W43-MM1, MM2 and MM3) which remain IR-quiet (undetected at 24 μm by Spitzer and with a $L_{\rm submm}/L_{\rm bol}$ ratio of $1-3\%$) and are among the top 1% top most massive subparcsec sources of the Milky Way (Motte et al. 2003, Schuller at al. 2009). We here report the first results of a high-angular resolution study performed at the IRAM Plateau de Bure interfermeter of these 0.25 pc MDCs and their surroundings, which aims at measuring their subfragmentation into single protostars and detect associated SiO outflows. Using *Herschel*/PACS, APEX/SABOCA and IRAM PdBI data, we will estimate the luminosity and mass of the high-mass protostars hosted by these case studies of extreme star-forming sites in terms of density, kinematics, youth, and star formation activity.

The Aquila prestellar and protostellar population revealed by Herschel

Könyves, V.[1]; André, Ph.[1]; Men'shchikov, A.[1]; Schneider, N.[1]; Arzoumanian, D.[1]; Bontemps, S.[2]; Motte, F.[1]; Didelon, P.[1]; Attard, M.[1]; Maury, A.[3]; and the SPIRE SAG3 consortium

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The Herschel Gould Belt survey (André et al. 2010) will soon provide an unprecedented census of starless cores, embedded protostars, and cloud structures, down to the lowest column densities in all nearby molecular clouds. Here, we summarize the results obtained in the $\sim$10 deg^2 field of the Aquila Rift complex (d $\sim$260 pc), which was observed during the Science Demonstration Phase of Herschel. We are currently working on a more detailed study of this field (Könyves et al. 2012, in prep.). I will discuss the core mass function (CMF) for hundreds of starless cores derived from SPIRE and PACS (500–70 μm) data. Most of these cores appear to be gravitationally bound, and thus prestellar in nature. Our Herschel results confirm that the shape of the prestellar CMF resembles the stellar initial mass function (IMF), with much better statistics (Könyves et al. 2010) than earlier submillimeter continuum ground-based surveys. In the entire region, we also find $\sim$ 100 young stellar objects, most of which is newly discovered by Herschel. Their basic properties ($M_{\rm env}$, $L_{\rm bol}$) and distribution suggest that they are probably younger than the Spitzer protostars in the most active subregion of Aquila (Bontemps et al. 2010). The spatial distribution of prestellar cores and protostars is in good correspondence with the regions of gravitationally unstable filaments which shows that these filaments are actively forming stars, and filaments play a key role in star formation processes (André et al. 2010, Arzoumanian et al. 2011).

Observing molecules in the interstellar media: Theoretical and experimental studies of energy transfer.

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In order to retrieve actual molecular abundances from molecular spectral lines observations, knowledge of the molecular rotational levels excitation schemes is essential. Our laboratories have recently calculated a set of collision coefficients characterizing the efficiency of energy transfer between helium and/or hydrogen molecules and a large variety of interstellar molecules. We have been dealing with molecules ranging from light hydrides, observed by the Herschel Space Telescope, to heavy complex organic molecules, observed to the cm range. We shall present a review of recent theoretical results obtained in our laboratories, for various kind of commonly observed molecules. We shall concentrate on particularly important cases, CN bearing molecules, water and its isotopomers, open shell molecules, carbon chains, and SO_2. In order to validate the theoretical computations, comparison with experimental measures is essential. Such comparisons have been performed mainly for water, on total and differential cross section (experiments performed in Nijmegen), and also on broadening cross section (experiments performed at the Jet Propulsion Laboratory).

The HIGAL/HERSCHEL view on SPITZER starless clumps

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The formation of massive stars is a major but still unsolved issue. To put constraints on the formation process itself, the initial conditions prior to massive star formation are crucial to know.
In order to identify potential precursors of massive starformation, we searched 20deg^2 of the 870 μm Galactic plane survey AGLASGAL (Schuller et al., 2009) for clumps with peak column densities larger than 1×10^{23} cm^{-2}. Using both the GLIMPSE point source catalog and the 24 μm MIPSGAL images, we examined the dust continuum clumps for mid-IR tracers of star formation (Tackenberg et al., submitted). In total, out of 901 studied clumps we find 210 clumps, or 23%, to be infrared dark down to 24 μm. On that broad statistics we derive the lifetime of high-mass starless clumps to be $(6 \pm 5) \times 10^4$ yr.
Nevertheless, as shown in Henning et al. (2010) and Ragan et al. (in prep), there exists a (yet unknown) fraction of clumps which are still dark at 24 μm, but have a heating source which is already detectable at 70 μm. Therefore, we investigated the 24 μm starless clumps for 70 μm emission using the HERSCHEL HiGal survey (Molinari et al., 2010).
We will present our results from the ATLASGAL and SPITZER survey and the analysis of starless clumps with the 70 μm HiGal data. With the help of these HERSCHEL data, we are now able to characterize the physical properties of high-mass starless gas clumps in great depth.

Large-Scale Infrared Dark Filaments

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The galactic plane contains long strings of IRDCs with very high aspect ratios, for example the 'Nessie' nebula (Jackson et al. 2010) is 80pc long with an aspect ratio of 150:1. The formation of such filaments is poorly understood; their size implies that it is unlikely that such filaments are formed by turbulence alone, but that cloud-cloud collisions or the interaction of shocks with molecular clouds play an important role. In order to investigate the possible processes behind the formation of such large-scale filaments and the role they play in star formation, a systematic search of the galactic plane has been undertaken. Using the Spitzer IRDC catalogue and minimum spanning trees, 102 candidate filamentary structures have been identified and further investigated using the Herschel HIGAL data to look at their thermal dust emission. This not only provides additional support that the structures detected are indeed coherent, spatially connected filaments, but also allows us to look in greater detail at the fragmentation of the filaments, allowing us to further understand the processes that initiate star formation. The morphologies of infrared dark filaments are varied, ranging from hub-filaments to bubble-like features, but the majority of the structures are long and narrow, similar to Nessie. One of the most intriguing characteristics of the filaments is that the do not appear to be randomly aligned with respect to the galactic plane; they are instead aligned so that they lie parallel to the disc. This could provide evidence that the passage of the spiral arms through the ISM compresses the gas, causing infrared dark filaments to condense and fragment, triggering star formation along the leading edge of the spiral arms.

Chemistry and dynamics of the ultracompact HII region Monoceros R2

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Ultracompact (UC) HII regions constitute one of the earliest phases in the formation of a massive star and are characterized by extreme physical and chemical conditions ($G_0 > 10^5$ in units of Habing field and $n > 10^6$ cm^{-3}). Their understanding is important for distinguishing the different processes in massive star formation (UV radiation vs shocks) and because they can be used as a template for other extreme photon-dominated regions (PDRs) such as the surface of circumstellar disks. Mon R2 is the closest UCHII region to the Sun (d=830 pc) and the only one that can be spatially resolved with Herschel. It has been extensively studied at millimeter and submillimeter wavelengths and all evidences support a chemistry driven by the strong UV field while shocks play only a minor role. It has been observed with Herschel within the Guaranteed Time Key Program WADI (PI: V. Ossenkopf) and the Guaranteed Time Normal Project SPECHIS (PI: Ed Polehampton). HIFI observations revealed that the emission of the o-H_2O $1_{1,0}\rightarrow 1_{0,1}$ line is extended over all the region. The o-$H_2{}^{18}O$ $1_{1,0}\rightarrow 1_{0,1}$ line has been detected towards the ionization front. Combining the o-H_2O $1_{1,0}\rightarrow 1_{0,1}$, o-$H_2{}^{18}O$ $1_{1,0}\rightarrow 1_{0,1}$ with the high-J CO and ^{13}CO lines observed with HIFI, we derived the water abundance profile across this expanding envelope. The o-H_2O abundance varies in the range a few 10^{-7}–10^{-8} with the highest values for the gas closest to the ionized region. HIFI observations of the o-NH_3 $1_0\rightarrow 0_1$ have also been performed toward this PDR. Contrary to o-H_2O, the o-NH_3 abundance is minimum for the gas adjacent to the HII region. We interpret this result in the context of the relative importance of the gas phase and grain surface chemistry in the formation of H_2O and NH_3 in warm star forming regions. UCHII regions are expected to expand at velocities of the order of the sound speed (10 km s^{-1}) until reaching equilibrium at dimensions of a few pc. In regions with density of $n\sim 10^5$ cm^{-3}, HII regions should remain ultracompact for 3000 years and only a few dozen should exist in the Galaxy. However, observations suggest that many more UCHIIs exist in our Galaxy, and that their lifetimes should be one to two orders of magnitude larger. Herschel observations (HIFI, PACS and SPIRE) provide the unprecedented opportunity to determine the kinematics and physical conditions of the molecular gas closest to the HII region and solve the lifetime paradox. Our modelling of the CO and its isotopes HIFI lines proves that the HII region is expanding at a velocity of ~ 0.75 km s^{-1}. This expansion velocity is in agreement with the lifetime derived on basis of statistical studies.

Topic 2 – **Protostellar Phase**
Posters

Water Observations with Herschel/HIFI toward Massive Star-forming Regions

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Massive stars play a major role in the interstellar energy budget and the shaping of the galactic environment. However, the formation of high-mass stars is not well understood for several reasons: they are rare, they have a short evolution time scale, they are born deeply embedded, and they are far from us. The water molecule is thought to be a sensitive tracer of physical conditions and dynamics in star-forming regions because of its large abundance variations between hot and cold regions. Therefore, measurement of the water abundance is a step towards understanding the star formation process. We present Herschel/HIFI observations of water lines toward high mass protostellar objects to learn about physical processes in these regions and to identify links in the water abundance between the various evolutionary stages of high-mass star formation. This work is part of the guaranteed time key program Water In Star-forming regions with Herschel (WISH).

Herschel/PACS survey of deeply-embedded low-mass young stellar objects

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The proper understanding of the physical phenomena involved in the earlierst stages of protostellar evolution requires a knowledge of the heating and cooling processes that occur in the surroundings of a young stellar object (YSO). Spatially resolved information about how a YSO cools itself through emission from its constituent atoms, molecules and dust grains provides the neccessary constrains to distinguish between competing models.

The far-infrared spectra (55-210 μm) of 18 low-mass protostars of various luminosities and ages have been studied as a part of "Water In Star forming regions with Herschel" (WISH) key program (van Dishoeck et al. 2011). The Photodetector Array Camera and Spectrometer (PACS) targeted several lines of CO, H_2O, OH, [OI] and [CII]. Most of our objects show strong far-infrared emission both in molecular and atomic lines. Water is detected in 16 out of 18 observed objects, including all but two Class I sources. This is a first detection of water in Class I sources in this wavelength range. CO transitions from J=14-13 up to J=49-48 are detected and show two distinct components on Boltzmann diagrams, which supports the model that the hot component originates in non-dissociative C-shocks (Visser et al. subm.). The high-temperature, high-density regime is needed to explain the observed emission with 1D slab models.

Molecular line emission is significantly extended for most of our objects, along the outflow directions. A strong correlation is found between high-J CO and H_2O as well as high-J CO and OH suggesting that all those lines originate from the same emitting region. Cooling budget calculations over the entire PACS array show that H_2O and CO are dominant coolants in Class 0/I sources, OH contributes a few percent to the total cooling, while the atomic [OI] contribution increases from a fraction of a percent for the youngest objects up to 40% for the most evolved sources in our sample. The total cooling in infrared lines correlates well with both envelope mass and outflow force, wheareas a weaker correlation is found with bolometric luminosity.

CHESS observations of high-mass protostellar object AFGL 2591

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CHESS - Chemical HErschel Surveys of Star forming regions is one of the Herschel Key Programmes which is focused on chemical compsition of dense regions of the interstellar medium. AFGL 2591 is one of the targets. It is particularly interesting since it is relatively nearby and isolated massive star-forming region. The distance to AFGL 2591 is between 0.5 and 2.0 kpc (van der Tak et al. 1999), recent measurements give 3.3 kpc (Rygl et al. 2011); luminosity at 1 kpc L=20,000 Lo. Because of that AFGL 2591 has been a subject of many studies, infrared/submm/radio observations and models. Here we present its unbiased spectral survey made with HIFI instrument and show many detected lines from 480 to 1900 GHz. Based on high quality spectra from all seven HIFI bands estimation of abundances was made with LTE, non-LTE and Monte Carlo models.

NGC1333: A Glimpse At Low-Mass Protostars Through Sub-mm Spectroscopy

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NGC1333 is one of the most nearby (D=250pc) and young (<1My) star forming regions. It is actually a part of the Perseus OB2 molecular cloud complex and it contains a large number of young stellar objects (YSOs). It hosts 4 out of $\sim$ 50 of the earliest low-mass protostars known, (class 0 YSOs), along with 36 Herbig-Haro objects. Newly born stars are often only visible at infrared wavelengths, being heavily obscured by dust. In order to study the molecular inventory and the physical structure of NGC1333, we take advantage of the unique spectral imaging capabilities of HARP-B/ACSIS, JCMT, Hawaii, by using the complete spectral scans from 325GHz to 375GHz. In addition we use spectra from Herschel-HIFI, with a covered frequency range of 650-800 GHz (Band 2). In this study we focus on the 2 of the brightest deeply embedded Class 0 protostars called A and B in the NGC1333-IRAS 4 region, and we present the 2'$\times$2' maps (R=15") of HCN 4-3, H_2D^+, N_2H^+ and $H^{13}CO^+$.

Outflow and inward motions in a VeLLO, L328-IRS

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The Very Low Luminosity Object (VeLLO) is an object embedded in a dense core which is fainter than 10% of solar luminosity. Its faintness is far below than the luminosity predicted in the standard star formation theory assuming constant accretion rate ($\sim 2 \times 10^{-6} M_{sun}$) which confirms the "Luminosity Problem" seen in low luminosity protostars. One suggested idea is that the VeLLO is faint because it may be now in quiescent stage among episodic accretion. One way to check whether this postulation is feasible may be to observe some evidence of bursting events in the outflow which should be directly related to the possible episodic accretion. In this presentation we report preliminary results of CO, HCN, and N2H+ observations toward L328-IRS with SRAO 6m, ASTE 10m, and KVN 21m telescopes to study on its outflow activity and to find any clue of its faintness ($\sim 0.05Ł_{sun}$). L328-IRS is a VeLLO recently discovered in *starless* core L328 from Spitzer observation. This source has a very small envelope of at most of order $\sim 0.1\ M_{sun}$ and is thought to be a proto-brown dwarf candidate rather than to be a small version of normal protostar. Our CO observations find the outflow in a large scale of at least about $0.2 \sim 0.3$ pc. Outflow seems well divided into blue and red part with wide opening angle (close to ~ 150 degree). Red part of the outflow seems mixed with the envelope tail of L328 dense core extending to SW direction while main part of the blue outflow is well coincident with cavity structure in the NE direction seen in its IR image. Our CO 3-2 maps show some indication of a marginal burst structure in blue components, a hint of possible episodic accretion event, but this needs to be cautiously confirmed with further reduction. We also find an extended infall asymmetric feature in region very near to L328-IRS with such outflow activity. The complicated feature near L328-IRS will be discussed with complimentary observations with N2H+ and HCN 1-0 lines.

Herschel/PACS observations of a low-mass star forming region, L1448-MM

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We present the FIR continuum and line maps of L1448-MM at 55 to 210 μm observed with the range scan mode of PACS on the Herschel Space Observatory, as part of the DIGIT key program. L1448-MM was previously known as an embedded Class O and prominent outflow source although the existence of two young stellar objects has been claimed in L1448-MM based on the Spitzer images and the recent submm interferometric observations. We analyze the energetics over the whole region of L1448-MM by calculating the excitation condition and the cooling rate of each species of CO, OH, H_2O, and OI. The primary heating mechanism is likely shocks and/or UV photons along the outflow cavities. The dominant cooling gas components are H_2O ($\sim$46 %) and CO ($\sim$37 %) although the cooling by OH ($\sim$12 %) and OI ($\sim$6 %) cannot be ignored.

Molecular radiative transfer with "exact methods"

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Cold clouds, proto-stars and proto-planetary nebulae radiate in numerous molecular lines which are well-suited for spectroscopic studies performed in the submillimetric and radio spectral ranges. Indeed these objects belong to the so-called "cold universe" characterized by typical kinetic temperatures in a 10 to 100 K range, and whose most intense spectral signatures are molecular rotational and vibrational lines. Radiative modelling is indispensable for a proper understanding of observations made, for instance, with Herschel spectrometers and in particular HIFI, or soon with the ALMA ground based radio-telescope. An instrument like HIFI has been delivering submillimetric observations with unprecedented sensitivity and spectral resolution, whose careful interpretation requires as accurate and realistic (and possibly, as fast) as possible radiative modelling tools. Hereafter, we discuss comparisons we have made for several representative tests cases, between results obtained with a MALI-based code (Rybicki & Hummer 1991) developed by us and those given by very standard radiative tools such as RATRAN (Hogerheijde & van der Tak 2000) and RADEX (van der Tak et al. 2007). We show in particular that our code is significantly

faster than the later, without any loss of accuracy. Indeed computational time grows with optical depth faster for a Monte-Carle-based code as RATRAN than it is with our MALI-based code. For instance, using a single processor, for a simple isothermal, static, spherical HCO^+ cloud, without dust opacity, with a HCO^+ abundance of $X = 10^{-9}$, and a HCO^+ column density equal to $N_c = 10^{13}\,\mathrm{cm}^{-2}$ (i.e., a maximum optical depth at line center equal to 6.5), the computational time is 35 s for MALI and 120 s for RATRAN. For a column density as large as $N_c = 10^{19}\,\mathrm{cm}^{-2}$ (now 10^5 in optical depth), the computational time grows up to 390 s for MALI and 15000 s for RATRAN. For these two examples we used the same spatial grid and equivalent convergence criteria. This particular example is representative of the overall trend we have been observing.

Direct Probe of the Water Gas-Ice Chemistry in Embedded Protostars

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Water has long been speculated to be a key molecule in the chemistry and physics of starforming regions, but its actual role is only now starting to emerge thanks to *Herschel*. To fully understand the water and oxygen chemistry one has to know the amount of water in the gas phase and on the grains. In the centre of protostellar cores, water molecules are released from the icy mantles surrounding silicate grain cores due to thermal evaporation by heating from the central protostar. In the cold envelope, where thermal evaporation does not play a significant role, other mechanisms (e.g., UV and cosmic ray induced photodesorption) take over. However, the balance between gas-phase chemistry, freeze-out, ice formation and desorption is poorly understood and leaves a lot of space for interpretation. In this study we aim to determine the amount of cold water vapour in the protostellar envelopes of the three embedded low-mass sources Serpens SMM 4, IRAS 15398-3302, and Elias 29, for which direct observations of water ice are available from IR spectroscopy. Observations with *Herschel* show the presence of such water vapour through well resolved absorption features in the lowest rotational transitions of both ortho- and para-water. Deriving its column densities allows us to directly determine the gas/ice column and thus test the gas-grain chemistry.

Mapping dust in Orion Protostars: from Herschel to APEX

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We present submillimeter dust continuum maps of a sample of protostars which are part of our ongoing Herschel Orion Protostar Survey HOPS, taken with the Laboca (870μm) and Saboca (350μm) cameras on APEX. While the Herschel (and Spitzer) infrared data allow us to derive basic properties of the protostars and their inner envelopes, the submillimeter measurements trace the cold, outer envelopes and are therefore crucial for determining the circumstellar mass still available for accretion. Saboca 350μm maps, targeted on individual, Herschel bright protostars, have sufficient spatial resolution to resolve the envelopes and provide valuable constraints on the envelope mass, size, and geometry. The Laboca maps cover a wider field (ultimately the entire area mapped with Herschel), including also the Herschel faint protostars and a newly discovered, rare population of protostars which are detected only at Herschel wavelengths. The Laboca data also provide extended mapping of the (generally filamentary) structures from which the protostars form; with a mass estimate from the dust continuum we will be able to, e.g., check if filaments associated with protostars exceed some critical filament density threshold.

Resolved Protostellar Envelope Structure in the Far-IR/Submm: BHR71 and L483

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We present resolved Herschel PACS and SPIRE photometer imaging of the envelopes surrounding the Class 0 protostars BHR71 and L483 between 70 and 500μm. The envelopes and larger-scale core structure are well-resolved and detected with high signal-to-noise longward of 160μm. The point-like inner envelope emission tends to dominate shortward of 160μm, but there is spatially resolved emission along the outflow cavities. BHR71 is a compact protobinary ($\sim$3400 AU) and we are able to resolve the two components out to 160μm. The resolution of Herschel enables us to determine that the SED of BHR71 IRS1 peaks at $\sim$100μm and IRS2 at $\sim$160μm, implying that IRS2 may be less evolved. The line-of-sight temperature and density structure of envelopes is calculated by fitting a graybody to the resolved multi-wavelength flux across the envelope. The column density sensitivity of the SPIRE and PACS maps ranges from $A_V \sim 1$ to $\sim$100, having substantially more dynamic range than the *Spitzer* 8μm extinction maps. The temperature structure is analyzed with respect to the observed morphology to determine what effect envelope complexity might have on the dust temperature. Deviations from the expected radial temperature distribution may give hints to the 3D structure of the envelope. Specifically, we use the analytic prescriptions for hydrostatic sheets and filaments to determine which is most consistent with the data. The spatially resolved emission along the outflow cavities in both sources is indicative of increased cavity wall temperature. These limb brightened cavities can enable constraints on outflow cavity structure by determining if there is a pile-up of material in the cavity walls, how empty are the cavities are, and how much warmer they are relative to the envelope.

Water emission from the chemically rich outflow L1157

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In the framework of the Herschel-WISH key program, several ortho–H_2O and para–H_2O emission lines, in the frequency range from 500 to 1700 GHz, were observed with the HIFI instrument in two bow-shock regions (B2 and R) of the L1157 cloud. The primary aim is to analyse water emission lines as a diagnostic of the physical conditions in the blue (B2) and red-shifted (R) lobes to compare the excitation conditions. A total of 5 ortho- and para-$H_2{}^{16}O$ plus one o$-H_2{}^{18}O$ transitions were observed in B2 and R with a wide range of excitation energies (27 K$\leq E_u \leq$215 K). The H_2O spectra, observed in the two shocked regions, show that the H_2O profiles are markedly different in the two regions. In particular, at the bow-shock R, we observed broad ($\sim$30 km s^{-1} with respect to the ambient velocity) red-shifted wings where lines at different excitation peak at different red-shifted velocities. The B2 spectra are associated with a narrower velocity range ($\sim$6 km s^{-1}), peaking at the systemic velocity. The excitation analysis suggests, for B2, low values of column density $N_{H_2O} \leq 5\times10^{13}$ cm^{-2}, a density range of $10^5 \leq n_{H_2} \leq 10^7$ cm^{-3}, and warm temperatures ($\geq$300 K). The presence of the broad red-shifted wings and multiple peaks in the spectra of the R region, prompted the modelling of two components. High velocities are associated with relatively low temperatures ($\sim$ 100 K), $N_{H_2O} \simeq 5\times10^{12}$–$5\times10^{13}$ cm^{-2} and densities $n_{H_2} \simeq 10^6$–10^8 cm^{-3}. Lower velocities are

associated with higher excitation conditions with $T_{kin} \geq 300$ K, very dense gas ($n_{H_2} \sim 10^8$ cm^{-3}) and low column density ($N_{H_2O} < 5\times10^{13}$ cm^{-2}). The overall analysis suggests that the emission in B2 comes from an extended ($\geq 15''$) region, whilst we cannot rule out the possibility that the emission in R arises from a smaller ($>3''$) region. In this context, H_2O seems to be important in tracing different gas components with respect to other molecules, e.g. such as a classical jet tracer like SiO. We have compared a grid of C- and J-type shocks spanning different velocities (10 to 40 km s^{-1}) and two pre-shock densities (2×10^4 and 2×10^5 cm^{-3}), with the observed intensities. Although none of these models seem to be able to reproduce the absolute intensities of the water emissions observed, it appears that the occurrence of J-shocks, which can compress the gas to very high densities, cannot be ruled out in these environments.

Studying the OH emission from low- and intermediate-mass protostars

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Water is one of the most abundant species in star-forming regions and therefore plays important roles in the chemical and physical processes of young stellar objects (YSOs) as one of the main oxygen bearing species and efficient coolant. The instruments on board the Herschel Space Observatory offer a unique possibility to study H_2O and chemically related species, which cannot be observed from ground-based facilities. The species that is most tightly linked to the formation and destruction of H_2O is the hydroxyl radical (OH).

Spatially resolved PACS spectroscopy of several OH transitions in a set of 18 low- and intermediate-mass protostars has been obtained in the framework of the “Water In Star-forming Regions with Herschel (WISH)” key program (van Dishoeck et al. 2011). At least one OH line is detected in all sources. Intermediate mass sources show much stronger OH lines than low-mass YSOs. However, towards high envelope masses, transitions connected to the ground state are also observed in absorption. Among the low-mass sources, the OH luminosity of the class 0 sources is higher than the class I YSOs by around a factor of two. The rotational temperatures derived from two class 0 targets with many detected OH lines are around 100 K, with line flux ratios that are relatively constant among the source sample. Although the sources cover wide ranges in luminosity, mass, and evolutionary stages, we find that the OH emission is strongly correlated with the bolometric luminosity for all YSOs. Sources with strong OH emission also show a rich H_2O spectrum and strong [OI] lines. The emission of these species is often spatially extended along the same direction, which usually coincides with the outflow.

From excitation modeling of OH we find that various combinations of OH and dust column densities, kinetic temperature, and density are able to reproduce the observed line ratios, whereby the radiatively dominated regime is slightly favored over collisional excitation. We will discuss different physical scenarios for the origin of the OH emission that are consistent with the new Herschel results and their implications for the water chemistry.

High-*J* CO survey of low-mass protostars observed with *Herschel*-HIFI and `LOMASS` database

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Observations of a broad range of molecular emission lines allow us to fully explore the nature of star-forming regions due to the range of physical and chemical conditions they probe. This is particularly true of the youngest and most deeply embedded protostars, which are surrounded by dense molecular envelopes. For this purpose, a sample of 26 low-mass YSOs have been observed in water and other key species with the Heterodyne Instrument for the Far-Infrared (HIFI) onboard *Herschel* as part of the guaranteed time key program "Water In Star-forming regions with *Herschel*" (WISH, van Dishoeck et al., 2011). CO observations are highly complementary to those of water, as the chemistry is simpler and better understood, allowing for an independent determination of the physical structure. In addition, CO, unlike H_2O, is chemically stable, and therefore provides a reference frame for more complex molecules. In order to get a complete temperature coverage, observations of CO J=3–2 (T$\sim$30 K) to J=10–9 ($\sim$300 K) were obtained from various submm telescopes or as part of WISH. Those complementary ground-based data, along with data from other key species, have been compiled and put into newly developed, soon-to-be publicly available `LOMASS` database. This allows us to derive physical and kinematical properties of the envelopes and their surroundings by comparing both low- and high-J CO lines in a coherent manner. As an example, the CO J = 10–9/3–2 ratio provides an effective measure for the rotational temperature and due to its low critical density, a measure of the temperature of the swept-up gas in the molecular outflow. From the emission it is possible to directly measure the total mass of the swept-up gas. H_2O emission, on the other hand, primarily traces the wind-envelope interface and therefore the gas currently being shocked by the protostellar wind. Thus, by comparing the masses in the two distinct components the entrainment efficiency can be determined, which in turn limits the time scale for clearing out of the envelope. E-mail: yildiz@strw.leidenuniv.nl

H_2O in MHD disk winds from young stars

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The origin of protostellar jets, and their role in extracting angular momentum from the accreting system, remain as major open questions in star formation research. The presence of abundant molecules such as CO, H_2, H_2O, SO and SiO, in the youngest class 0 jets (see eg. Taffala et al. 2010) and recent H_2O lines observations from Herschel provides an important new challenge for proposed ejection models. Here we explore the possibility that the jet may trace a dusty magneto-hydrodynamic (MHD) centrifugal disk wind launched beyond the dust sublimation radius of 0.1-0.2 AU. The coupled ionization, chemical, and thermal evolution along dusty flow streamlines is computed for a prescribed MHD disk wind solution (Casse & Ferreira 2000), using a method developed for magnetized shocks in the interstellar medium (Flower and Pineau des Forłts 2003). We consider 134 species, including gas-phase atoms and molecules as well as species on grain icy mantles and inside grain cores. The time dependant chemistry consists in a network of 1143 reactions including neutral-neutral and ion-neutral reactions, photo-ionization and photodissociation, recombination with electrons, charge exchange, cosmic ray induced desorption from grains, and sputtering of grain mantles and cores by neutral impact. Heating by ambipolar diffusion, irradiation by coronal X-rays and far-ultraviolet photons from accretion shocks have been included (see Panoglou et al. 2011). The self-shielding of H_2 and CO has been improved and non-LTE rotational line transfert treatment of CO and H_2O has been included (Yvart et al. 2012). We present line profiles predictions for CO and H_2O. We explore impact of parameters such as jet inclination, accretion rate and extension of the launching area in the disk. These predictions are compared with the "broad component" of H_2O and CO profiles recently discovered by Herschel/HIFI towards protostars, whose origin is still unclear.

Herschel-PACS full spectral range spectrum of the B1 shock in the L1157 outflow

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We present the Herschel-PACS 55-210 μm spectrum of the B1 shock in the L1157 chemically active outflow obtained within the CHESS (Chemical Herschel Survey of Star forming regions) Key Program, aimed at obtaining an unbiased census of the molecular content in star forming regions. The spatial resolution of the PACS spectrometer (spatial sampling of 9.4$''$/spaxel) allows to map the warm shocked gas traced by far infrared molecular lines with an unprecedented detail. The PACS spectra of the B1 bow shock show emission lines from CO, H_2O, OH and [OI]. We discuss the excitation conditions and relative spatial distribution of the observed lines in comparison with other shock tracers observed by Spitzer and PdBI. We find evidence for a compact spot of high-excitation gas, whose physical conditions are derived from LVG modelling of molecular line emission. The analysis of the molecular and atomic line emission shows, for the first time, direct evidence for a dissociative J-type shock connected with the hot gas.

Where is Chlorine? The missing HCl emission in the protostellar shock L1157-B1

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We present the first detection of hydrogen chlorine in a protostellar shock (L1157-B1), by observing the fundamental transition at 626 GHz with the Herschel HIFI spectrometer. We detected two of the three hyperfine lines, from which we derived a line opacity ≤ 1. Using a non-LTE LVG code, we constrained the HCl column density, temperature and density of the emitting gas. The hypothesis that the emission originates in the molecular cloud is ruled out, as it would imply a too dense gas. Conversely, assuming that the emission originates in the 10$''$–15$''$ size shocked gas previously observed at the IRAM PdB interferometer, we obtain: N(HCl)=0.7–2$\times10^{13}$ cm^{-2}, temperature > 15 K and density $> 3 \times10^5$ cm^{-3}. Combining with the Herschel HIFI CO(5–4) observations allows to further constrain the gas density and temperature, 10^5–10^6 cm^{-3} and 120–250 K, as well as the HCl column density, 2$\times10^{13}$ cm^{-2}, and, finally, abundance: $\sim$ 3–6 $\times10^{-9}$. The estimated HCl abundance is consistent with that previously observed in low- and high- mass protostars. This puzzling result in the L1157-B1 shock, where species from volatile and refractory grains components are enhanced, suggests either that HCl is not the main reservoir of chlorine in the gas phase, against previous chemical models predictions, or that the elemental chlorine abundance is low in L1157-B1. Astrochemical modelling suggests that HCl is in fact formed in the gas phase, at low temperatures, prior to the occurance of the shock, and that the latter does not enhance its abundance.

Study of deuterated water in the low-mass protostar IRAS16293-2422

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Observations of deuterated water are an important complement for studies of H_2O, since they give strong constraints on the formation processes (grain surfaces versus gas-phase chemistry) and because of its link with the comets and the Earth's oceans. The CHESS (Chemical HErschel Surveys of Star forming regions) Key Program has allowed to detect a lot of transitions of HDO and H_2O as well as its isotopes $H_2^{18}O$ and $H_2^{17}O$ towards the low-mass protostar IRAS16293-2422 thanks to the unbiaised spectral survey carried out with the HIFI instrument on board the Herschel Space Observatory. Complementary data of HDO from the ground-based telescopes IRAM and JCMT are also available. In total, 13 HDO lines have been detected towards IRAS16293-2422. It is the first time that so many HDO lines are detected towards a same source, allowing a precise determination of the abundance of deuterated water through the protostar envelope. In order to reproduce the observed line profiles, we have performed a modeling of HDO from the hot corino to the surrounding envelope using the physical structure of the protostar (Crimier et al. 2010) and the spherical non-LTE Monte-Carlo radiative transfer code RATRAN, which takes also into account radiative pumping by continuum emission from dust. We have used new HDO collision rates with H_2, recently computed by Faure et al. (2011, MNRAS) and will discuss the difference with the He rates. The same method has been applied to model the water isotopes $H_2^{18}O$ and $H_2^{17}O$. We will present the results of this analysis and discuss the determined abundances.

Protostars in extreme environments: A Herschel study of the Carina Nebula

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The Carina Nebula plays host to some of the most massive and luminous stars in our galaxy and represents an ideal arena in which to study in detail the physics of violent massive star formation and the resulting feedback effects of cloud dispersal and triggering of star formation. We have used Herschel to obtain the first spatially complete far-infrared maps of the entire Carina Nebula that are sensitive enough to detect the youngest and most deeply embedded protostars (that are yet invisible in the mid-infrared). Our analysis of the Herschel maps reveals 634 point-like sources, clearly demonstrating a high level of star formation activity. We combine the Herschel fluxes with Spitzer- and near-infrared photometry to construct the spectral energy distributions of 202 protostars. Radiative transfer modeling provides crucial information about the protostellar luminosities, masses, and the amount of circumstellar material. Our analysis shows that the currently forming generation of stars is restricted to low- and intermediate mass stars, i.e. considerably lower masses than present in the older generation of stars, suggesting that the current process of triggered star formation is a qualitatively different star formation mode. We interpret this difference as a consequence of the triggered star formation process in the irradiated clouds. We will discuss the disk masses of the low-and intermediate-mass protostars.

Current challenges on interstellar nitrogen chemistry

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The nitrogen element being amongst the five most abundant element in the Universe is of considerable importance in our understanding of the chemical history of the gas, from the diffuse interstellar medium (ISM) to the atmosphere of planets. Unfortunately, the main reservoirs of nitrogen are presumably atomic or molecular nitrogen, both forms of which are not directly observable in the cold ISM. Chemical models are then unavoidable. Yet, the chemistry of nitrogen in the molecular ISM, from diffuse to dark gas, has been challenged by an increasing amount of observational data in the last years. Based on the CHESS key-program, our team reported the first detection of the ND molecule, together with the first spectra of the full hyperfine structures of the NH and NH2 hydrides, towards the Class 0 IRAS16293-2422 (Bacmann et al 2010, Hily-Blant et al 2010). The large inferred ND/NH ratio implies that strong chemical fractionation mechanisms are at work. In addition, the abundance ratios of NH, NH2, and NH3 contrast with chemical model predictions. In the PRISMAS key-program, the same hydrides were detected in more diffuse gas, challenging as well chemical models. In an effort to revisit the nitrogen chemistry, an Herschel program was designed, dedicated to the observation of several key N-bearing molecules. In parallel, our group has started a modelling effort with particular emphasis on the chemical network of gas-phase reactions (Dislaire et al 2011). In this talk we will pay special attention to the chemistry of nitrogen in typical dark cloud conditions. We will present the first observational results from our open-time Herschel program. These observations will be put in perspective with the recent advances made on the modelling of nitrogen chemistry.

The HIFI spectral survey of the protostar OMC-2 FIR 4

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We will present an overview of the Herschel-HIFI spectral survey of the protostar OMC-2 FIR 4 in Orion, covering frequencies from 479 to 1901 GHz, and will introduce the first results from an analysis of the more than 600 spectral lines and two dozen molecules detected. Our results demonstrate the power of unbiased spectral surveys to reveal unanticipated aspects of the source, including new physical components and aspects of the chemical composition. Among others, we will discuss the chlorine-bearing molecules, transitions from high-lying rotational levels, deuteration and the nature of several new physical components discovered in the source.

Peering into the protostellar shock L1157-B1

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Shocks driven by protostellar outflows play an important role in the chemical evolution of the parental cloud. Molecular abundance enhancements up to several orders of magnitude have been reported for various molecular species in "chemically active" outflows, whose archetype is the outflow of the low mass Class 0 protostar L1157. We present the results of the spectral survey of the shock region L1157-B1 from 672μm up to 55μm, carried out with PACS, SPIRE and HIFI onboard Herschel, as part of the CHESS key project. The unprecedented sensitivity and angular resolution of these instruments brings new insight both on the molecular content and the physical conditions of this long studied region, thanks to the detection of hydrides (H_2O, HCl,) and of the high-excitation lines of heavy molecules (CO, CS, HCO^+, HCN,..). We will discuss the molecular content and the properties of the warm chemically enriched gas (abundance, excitation conditions). We will show how multi-transition analysis of the line profiles reveals the presence of multiple emission components of differing excitation conditions and constrains the formation/destruction scenarios of various molecular species, including water, in relation with shock models.

Detection of OH^+, H_2O^+ and HF towards the intermediate-mass protostar OMC-2 FIR 4

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We report the detection with *Herschel*/HIFI of absorption by OH^+, H_2O^+ and HF, towards the intermediate-mass protostar OMC-2 FIR 4 in Orion, indicating the presence of a slab of gas in the foreground of the protostar. Interestingly, the absorption lines are seen at a velocity of ~ 9 km s^{-1}, which distinctly differs from the systemic velocity of OMC 2-FIR 4 (11.5 km s^{-1}). In order to study the nature of this foreground cloud, we have run a homogeneous grid of ~150 models of the Meudon PDR code. Our observations are best reproduced by a diffuse, low-density gas slab ($A_V \sim 1$, $n_H \sim 100$ cm^{-2}) which is irradiated by a strong far-UV field of ~ 100 G_0. We will discuss the possible interpretations of these findings, including the physical connection of the foreground cloud with OMC-2 FIR 4 and the rest of the Northern Orion A complex.

The protostellar phase: Ideal versus Non-Ideal MHD effects in the first and second Larson's cores

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Ambipolar diffusion is now acknowledged to be one of the key processes of star formation in both subcritical and supercritical molecular clouds. Its effects are yet to be understood precisely, and numerical experiments are an efficient if not necessary means to fulfill this goal. At late stages in the star formation history, after the first core formation, ohmic diffusion is expected to play a major role. Since the implementation of these two effects has been completed in the AMR MHD code RAMSES, these issues can be tackled efficiently. Several parameters are of interest, such as the rotational support, the magnitude of the magnetic field, the magnitude of the various resistivities, or the angle between the magnetic field and the axis of rotation. For the moment, a barotropic equation of state is used, but work is in progress to use an accurate equation of state along with the energy equation (accounting for radiative cooling, and non-ideal MHD heating). Results concerning the effects of ambipolar diffusion on the formation of the first core, the repartition of the magnetic energy, and its consequences on fragmentation and disk formation will be presented for several values of the parameters described above. Ohmic dissipation will be studied through an accelerated (with a polytropic index $\gamma = 7/5$) first collapse leading to a second Larson's core. Jets and outflows, and the effects of Ohmic dissipation on their strength and formation will be studied. Some simulations taking into account both Ambipolar diffusion and Ohmic dissipation will also be presented.

Modelling the infall of low-mass protostellar envelopes in Herschel water observations

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Water is one of the key probes of the physical, chemical and dynamical conditions of embedded YSOs. Its role as a catalyst and/or main reactant in the temperature- and density-sensitive gas-grain chemistry which takes place in star formation regions makes it **the** ideal probe of the physics and kinematics of the envelope within which protostars form. In order to use water to probe the physics of star-forming regions, high spectral and spatial resolution space-based observations are crucial in order to provide spectrally resolved data of individual protostars in transitions which are predominantly unobservable from ground-based facilities. Observations with Herschel are therefore revolutionising our access to and understanding of water and star formation. In particular, recent results from the "Water in Star-forming regions with Herschel" (WISH; van Dishoeck et al., 2011) HIFI Guaranteed Time Key Programme have revealed that embedded YSOs have diverse, rich and complex water line profiles, often containing multiple components tracing different physical processes within a single beam. We have discovered that inverse P-Cygni profiles in deeply embedded low-mass protostars are much more common in water than the other chemical species previously studied. Compared to the one previously known source, we have found that 6 out of 15 Class 0 YSOs in the WISH sample exhibit this classical infall signature in water transitions, while a further 3 out of 15 Class I YSOs exhibit regular P-Cygni profiles, indicative of envelope expansion. We present new 1-D multi-transition radiative transfer modelling of WISH HIFI water observations towards these Class 0 (I) protostars, which are used to quantify the infall (expansion) velocities and envelope physical properties in a self-consistent manner. These results are then placed in the wider context of previously determined phase lifetime, mass accretion and outflow properties in order to test the dynamical credentials of the current low-mass star formation paradigm.

Infrared spectroscopy of protostars in Orion: probing protostellar evolution and its impact on the surrounding gas

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Infrared spectroscopy is a powerful tool to probe the excitation conditions and the chemical composition of the warm (~ 300 K) and hot (~ 1000 K) gas in the immediate vicinity of protostars. We have obtained $5-200$ μm spectra of 32 protostars in the Orion molecular clouds as part of the Herschel key program, the Herschel Orion Protostar Survey (HOPS) and several Spitzer GO and GTO programs. Our sample of protostars span a large range in luminosities ($1-300$ $L_\odot$) and evolutionary stages (Class 0 & I and Flat spectrum) and are located in vastly different environments; it is the largest sample of mid- and far-infrared spectra of protostars from a single star forming region to date. We have modeled and analyzed the fine structure and molecular emission lines seen in the infrared spectra of these protostars to constrain the density, temperature and column density of the various components of gas responsible for the line emission. We searched for correlations between the physical properties of the emitting gas and the protostellar properties such as the bolometric luminosity and temperature and the accretion indicators to identify the processes responsible for the heating of the warm and hot gas associated with protostars. We will present the results of this statistical study and discuss their implications for our understanding of the earliest phase of star for-

mation and the ways in which protostars affect and shape the physical and chemical evolution of the surrounding gas.

The *Herschel*-WISH spectral line survey of shock regions in proto-stellar outflows: the L1448 case

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As part of the WISH (Water In Star-forming regions with *Herschel*) key project, different shock regions within Class 0 outflows have been observed with the PACS and HIFI instruments in a set of H_2O lines, together with several transitions of CO, OH and [OI]. The aim of this line survey is to settle the conditions for water formation and understand its role in the gas cooling and in probing specific excitation regimes with respect to other shock tracers. I will present in particular the results obtained on the L1448 outflow, which is one of the brightest water emitting sources so far observed. The HIFI observations reveal peculiar water line profiles which show strong variations in the excitation as a function of velocity. I will discuss the constraints imposed by these observations on the water excitation conditions, showing that water traces a gas very different from that probed by standard jet tracers, such as SiO and low-J CO. Finally, I will show the PACS spectral images of the H_2O, high-J CO and [OI] lines, discussing how the unprecedented PACS spectral resolution can be used to study the different spatial distribution of the various tracers and provide additional constraints on the excitation of the warmer gas component.

Herschel CHESS search of ozone and molecular oxygen in the solar type protostar IRAS16293-2422

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Altough ozone is one of the main chemical components of the upper Earth atmosphere, its presence in the interstellar medium remains poorly known. Detection either in the gas phase or on interstellar grains are almost impossible because of the absorption due to the atmosphere and the overlap of strong absorption bands of methanol and silicates near the 9.6 μm (O-O) vibrational band. However, state-of-the-art astrochemical models have shown that ozone can be formed on grains along with water ice in cold molecular clouds. After its formation, ozone is then desorbed in the gas phase of the envelopes of low-mass protostars, namely the hot corinos, and can react with atomic hydrogen to form molecular oxygen O_2. The Herschel telescope gives us the unique opportunity to observe these two molecules. We present a tentative detection of ozone and molecular oxygen toward the hot corino of IRAS 16293 carried out within the Herschel key program CHESS. The non detection of several lines lying in the HIFI bands have allowed

us to deduce upper limits for the abundances of these molecules in this warm hot corino, and in the colder envelope. The observations are then compared with the gas-grain astrochemical model GRAINOBLE predictions (Taquet et al. 2011) and with other CHESS observations of water. Comparisons between these observations and a grid of results predicted by GRAINOBLE allow us to propose a scenario on the evolution of the oxygen chemistry during the formation of low-mass protostars.

The Herschel-CHESS unbiased search for N-bearing species in the chemically rich outflow L1157

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We present the results of a highly sensitive unbiased spectral survey of the N-bearing species, from the most simple molecules (NH, NH_2, NH_3) to complex organic molecules (CH_3CN, HNCO,etc...) in the shock region L1157-B1. The survey was carried out with the HIFI instrument onboard Herschel and with the IRAM 30m telescope as part of the CHESS key project. The results of the excitation conditions of the ortho and para-NH_3 ratio, obtained with the LVG analysis, in addition with an estimate of the NH:NH_2:NH_3 ratio are displayed. Using a code coupling a gas-grain chemical and radiative transfer model with a parametric shock model we show model predictions of all the N-bearing species detected in the CHESS and IRAM survey. A detailed comparison between the nitrogen species profiles is also provided.

Deuterated water in high-mass star-forming regions

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Water is a primordial species in the emergence of life and comets may have brought a large fraction of the Earth's oceans (Hartogh et al. 2011). To understand the evolution of water from the first stages of star formation to the formation of planets and comets, the determination of the HDO/H_2O ratio is a powerful diagnostic. Observations of the HDO molecules are an important complement for studies of water, since they give strong constraints on the formation processes: grain surfaces versus gas-phase chemistry through energetic process as shocks. In the framework of the PRISMAS Herschel Key Program, a large sample of high-mass star-forming regions (SGR A*, W28A, W31C, W33A, G34.3, W49N, W51, DR21(OH)) have been observed resulting in the detection of many hydrides in the foreground line-of-sight clouds. The HDO ($1_{1,1}$–$0_{0,0}$) fundamental transition has been detected in absorption at the velocity of the hot core towards most of the sources, probably tracing the colder envelopes in their surroundings. Higher energy level transitions has also been observed with our Herschel Open Time program. We will present a full source modeling from the hot core through the envelope combining the Herschel/HIFI data as well as ground-based observations with IRAM, CSO and JCMT using a non-LTE radiative transfer code (as performed by Coutens et al. submitted, for the low-mass protostar IRAS 16293-2422) with the recent collisional rates of HDO with both para and ortho H_2 (Faure et al. 2011, Wiesenfeld et al. 2011). Also, $H_2{}^{18}O$ observations with Herschel/HIFI in the same sources will be used in order to determine the [HDO]/[H_2O] ratio throughout the envelope.

SOFIA -followup opportunities for Herschel

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I give a short review of SOFIA, the Stratospheric Observatory for Infrared Astronomy, and what we can offer to astronomy community. SOFIA is the only far infrared mission after Herschel for quite a few years. Several of the SOFIA first generation instruments are very complimentary to Herschel. SOFIA is a joint project of NASA and DLR. It is a modified Boeing 747-SP airplane with a 2.5 m telescope, designed to operate at altitudes from 12 to 14 km and wavelengths from 0.3 micron to 1.6 mm over a 20 year lifetime. The telescope is diffraction limited at wavelengths beyond 15 micron. At 100 micron the resolution is 10”, which is comparable to the angular resolution of large ground based telescopes in the mm/sub-mm such as IRAM, JCMT, and CSO. SOFIA has seven science instruments and is expected to add or upgrade instruments every few years. The second generation US instrument(s) will already have been chosen by the time of this conference. SOFIA has already completed it’s early science cycle, which was open to the astronomy community, but with rather limited observing time and only two science instruments. The two science instruments were FORCAST and GREAT. FORCAST is a facility instrument, a dual channel infrared camera covering 5 - 25 and 25 - 40 micron with a set of wide and narrow-band filters. GREAT (German PI instrument) is a heterodyne receiver, which in its early science configuration covered 1.25 - 1.5 and 1.82 - 1.92 THz. I will present highlights from the SOFIA early science for both FORCAST and GREAT. SOFIA will be down for upgrades this winter and we are in the process of commissioning the remaining instruments. The call for cycle I is to be issued in mid-November with proposals due by mid-January. In cycle I (July 2012 - July 2013) we also offer prisms for FORCAST, GREAT, HIPO, a high speed optical photometer, and FLITECAM, a near-IR facility camera, also with grisms. SOFIA will be fully operational in 2014.

The Evolution of CO Excitation During Disk Formation: Passive Heating

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During the embedded phase of star formation, a significant fraction of stellar mass is transported through a circumstellar disk. However, little is known of the disk structure and evolution during the embedded phase. This is particularly important because the physical and chemical structure of the disk is set during the early stages of disk formation. On the other hand, the late stages of circumstellar disk evolution, when an envelope is no longer present, have been observed and modeled in detail. With Herschel, the VLT and ALMA, we are beginning to observationally probe the early stages of disk formation. Herschel provides the peak of the SED, which is crucial for SED modeling to obtain the two-dimensional physical structure of the embedded disk. VLT-CRIRES probes the excitation conditions of the gas in the inner few AU. Finally, ALMA can image the structure of the gas and dust within the inner 100 AU. Sophisticated evolutionary models are required to interpret these high-quality data. We present a two-dimensional, semi-analytical model of disk formation as also used in Visser et al. (2009) and Visser and Dullemond (2010). The dust temperature is determined using a three-dimensional dust continuum radiative transfer code (RADMC-3D). Molecular abundances are calculated by following freeze-out and evaporation from dust grains starting from the pre-stellar core phase up to the formation of the circumstellar disk. Synthetic spectra appropriate for various ground-based sub-mm telescopes, Herschel and VLT-CRIRES are then produced at a series of time steps, tracing the different stages of disk formation. We show how the excitation of CO in the embedded disk and in the envelope changes over time, and how this affects the emergent line fluxes. We apply these model results to various ground-based telescopes, Herschel and VLT-CRIRES data to see what information we can extract about embedded disks.

Herschel's view of Chamaeleon II

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The Gould Belt Herschel guaranteed time program (HGB) is devoted to an extensive survey of the densest portions of the Gould Belt with the two Herschel imaging instruments, SPIRE and PACS (100-500μm), thus mapping the same area observed by the Spitzer Gould Belt (SGB) and Core to Disk (c2d) surveys (3.6-160μm). Together with the detection of thousands Class 0 protostars and pre-stellar condensations, which should allow to derive an accurate pre-stellar core mass function down to 0.01-0.1 $M_\odot$ in the nearby (d<0.5 kpc) molecular cloud complexes, Herschel allows the detection of the far-IR and sub-mm emission from more evolved Class I and Class II stars. These data are crucial to estimate their circumstellar disk properties and study the transition from the young optically thick disks to the evolved debris-type disks. In this contribution we present our first results from PACS and SPIRE observations of the Chamaeleon II star forming region in combination with optical, near-IR and Spitzer observations already available in the literature.

The Herschel view on Cygnus X and the massive DR21 filament: Dynamical formation of high-mass stars and evolution of massive protostellar objects

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HOBYS, the Herschel imaging survey of OB Young Stellar objects, has observed the closest galactic massive star-forming regions to study the origin of high-mass stars and Cygnus X is among the most massive and active regions associated with several OB associations and well-known massive young stellar objects. Previous mm-mapping detected 40 massive dense cores which are excellent candidates for high-mass star precursors. Herschel now provides a complete, unbiased view on the population of cold and dense cores in the region and constrains their luminosities, dust temperatures, and envelope masses. For core masses of about 20 to several 100 M_{Sun}, we find typical dust temperatures of around 18^{+3}_{-3}K and a tentative increase of dust temperature with luminosity. These key parameters are used to construct an evolutionary diagram of massive protostellar objects, and we use a set of simple evolutionary tracks to discuss the classification of the sources. Herschel also accesses the detailed column density structure of the region and reveals a filamentary network around the DR21 filament which is the most massive cloud structure in Cygnus X and hosts DR21 and DR21(OH). In particular, several perpendicular "subfilaments" connected to the main DR21 filament are resolved with Herschel. Based on previous velocity studies, they are probably accreting

onto the DR21(OH) clump. The analysis of the sub- and main filament column density structure in conjunction with the velocity information supports the picture that the itself collapsing DR21(OH) clump is forming high-mass stars while continuing to accrete. The subfilaments appear to be gravitationally unstable and protostellar cores are detected towards them which have probably formed from the filaments. Such objects might become part of the OB star cluster that will eventually result from the DR21 filament. The Herschel observations towards the DR21 filament are consistent with a very dynamical picture of high-mass star and cluster formation. We will discuss whether this scenario could be throughout essential or a more quiescent formation process is indicated for other massive protostellar objects in Cygnus X, and also address the link to the filaments in low-mass star-forming regions.

PIONIER: a four-telescope instrument for the VLTI

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The Precision Integrated-Optics Near-infrared Imaging ExpeRiment (PIONIER) combines four 1.8 m Auxilliary Telescopes or four 8 m Unit Telescopes of the Very Large Telescope Interferometer (ESO, Paranal). Since November 2010, this instrument designed, built and operated by IPAG provides very high angular resolution imaging studies at an unprecedented level of sensitivity. In this paper, we shortly present the PIONIER project, the instrumental concept and the typical on-sky performance. We then present the preliminary results of our on-going programmes, putting a special emphasis on the circumstellar disks around young stars, the hot debris disks and the searches for faint companions and planets.

TOPIC 3 – **Planet-Forming Disks**
Posters

Spitzer analysis of gas and solid-state features in FU Orionis objects

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FU Orionis objects (FUors) play a central role in the study of the evolution of young stars. They undergo accretion outbursts that can bring up to about 0.01 solar masses per outburst, therefore providing a significant amount of mass in the pre-main sequence life of a star. We have observed nine FUors with Spitzer IRS to detect and model the silicate and ice (e.g., carbon dioxide, water, etc) features and the gas emission lines (e.g., Ne II, H2, Fe II). Previous Spitzer IRS observations of FUors have shown either silicate features in absorption and ice bands or silicates in emission with no ice bands. This led some authors to propose an evolutionary paradigm in which the former FUors are younger than the latter FUors. This paradigm suggests that the FUor phase may be the link between Class I and Class II sources and that might be a common but rarely observed phase of most young low-mass stars. Our sample of targets show similar features: some targets with deep silicate and ice features in absorption and others with silicates in emission and no ices. In addition gas emission lines are detected in some targets. We present an analysis of the ice components in the Spitzer IRS spectra together with the silicate feature. We plan to compare our FUor targets with other known FUors and to place them into the evolutionary sequence from Class I to Class II stars.

The origin of jets from young stars: SINFONI/VLT observations of the DG Tauri microjet

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Supersonic jets are one of the most spectacular manifestation of the formation of a young star. The exact origin of these jets and the role they play in solving the angular momentum problem in young stars are still major open issues in star formation. The action of large scale magnetic fields is required to explain the efficient jet collimation and acceleration. However, where exactly the jet originates from (stellar surface, star-disc interaction or extended range of radii in the disc) remains unsolved. Distinguishing between these different scenarii is important also for planetary formation and disc evolution models, since they have distinct implications on the degree of magnetization of the inner astronomical unit in the young star-disc system. Strong observational constraints on protostellar jet driving mechanism come from studies of line emission in microjets from the low mass T Tauri stars (Cabrit 2007; Ray, Dougados et al. 2007). We discuss in this contribution spectro-imaging observations with SINFONI/VLT of the DG Tauri microjet, mapped in the near-infrared lines of [Fe II]1.64μm and $H_2 2.212\mu$ at $0.15''$ (20 AU) angular resolution, from which emerges a new picture of protostellar mass-loss. New knots and bubble structures are identified in the atomic plasma, leading to revised ejection variability timescale estimate. The Fe+ observations show gas phase depletion at speeds below 100 km s^{-1}, indicative of the presence of dust in the atomic flow (Agra-Amboage et al. 2011). A small scale wide and slow molecular cavity/flow is detected around the atomic jet (Agra-Amboage et al. in prep.). These observations are compared to predictions for magnetic and photo-evaporating wind models. A scenario combining different wind components will be discussed.

Investigating the X-ray impact on protoplanetary disks: a grid of models

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Young TTauri stars are solar-like stars in the pre-main sequence phase, often hosting a circumstellar disk. Disk observations of both gas (via several species emission lines) and dust (imaging and SED) offer the possibility to understand the relevant physical processes that govern the disk evolution from its formation to its final stages, where the disk possibly turns into a planetary system. The radiation emitted from the central star sets the thermal, chemical and hydrostatic structure of the disk in its earlier stages. Given the complexity of these objects, numerical codes are needed as a key tool for understanding the observed properties. The gas reaches temperatures of the order of 5000 K in the upper layers of the disk, as it is directly illuminated by X-ray and UV irradiation from the central star. The bulk of the gas in this extreme environment is ionized, and the high temperatures lead to infrared fine-structure line emission of species like Ne^+ or Ar^+. We recently set up a grid of 240 disk models where we investigate the effect of X-ray and UV luminosity on the disk, making predictions for the emission and line profiles of Ne^+, Ne^{++} and Ar^+ and other important species like O and C^+. The models will be tested in the context of the GASPS (Gas in protoplanetary disks) key program with Herschel.

H_2 near-IR lines as a tool to understand the circumstellar environment of sources with [Ne II] 12.8 μm emission.

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Spitzer revealed emission from [Ne II] at 12.8 μm in young stars. There is a debate about the origin of the line: is it caused by an X-ray/UV excited disk atmosphere?, a photoevaporative disk wind?, or shocks by outflows/jets?. Near-IR H_2 emission is a powerful tracer of disks, winds and jets. We present a ESO-VLT CRIRES search for H_2 1-0 S(1), 1-0 S(0) and 2-1 S(1) ro-vibrational emission at 2.12, 2.22 and 2.25 μm, at resolution 90000, employing Adaptive Optics, in a sample of T Tauri stars in which Spitzer has detected [Ne II] emission. We report the detection of the H_2 1-0 S(1) line in 4 out of the 7 sources observed. We study the H_2 1-0 S(1) line profiles, their spatial extension, and derive constraints on the origin of the emission. We use the 1-0 S(0)/1-0 S(1) and 2-1 S(1)/1-0 S(1) line ratios upper limits to constrain the temperature of the emitting H_2 gas and its excitation mechanism. Finally, for the sources with ground-based high-spectral resolution observations of [Ne II] emission, we compare the origin, emitting region, and excitation mechanism of the [Ne II] and H_2 lines.

FT Tauri: a passive disk?

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Protoplanetary disks are the birthplace of planets and represent the starting point to fully comprehend planet formation. In this poster we present our results from the study of the physical properties of one protoplanetary disk associated to the Young Stellar Object FT Tauri. This source was included in a number of photometric and spectroscopic surveys at different wavelengths but the properties of the associated disk had never been investigated. This specific study is aimed to address the evolutionary status of the disk around FT Tau, e.g. mass accretion rate, gas mass, etc. What is the disk geometry (e.g. flaring/flat) and its physical and chemical structure? How typical is it in the context of the Taurus star forming region? We analysed multi-wavelength spectroscopic and photometric observations (from optical to far-infrared) taken in the framework of the Herschel Open Time Key Program GASPS (PI: B.Dent) and compared them with predictions from the thermo-chemical disk modeling code ProDiMo (PROtoplanetary DIsk MOdel). The spectroscopic data analysed are from the Telescopio Nazionale Galileo (optical spectra: TNG/DOLoRes), the Nordic Optical Telescope (near-IR spectra: NOT/NOTCam), the Keck Telescope (near-IR spectra: Keck/NIRSpec), the Spitzer Telescope (mid-IR spectra: Spitzer/IRS), and the Herschel Space Telescope (far-IR spectra: Herschel/PACS). We find that FT Tau is an M3 spectral type pre-main-sequence star with a luminosity of 0.35 solar luminosities and an extinction of A(V)=1.8. From optical and near-IR emission lines, we find a consistent estimate of the accretion rate of about 10^{-7} solar masses/year. The ro-vibrational CO lines from Keck spectra are best fitted by an inclination of 45° and an inner disk radius of 0.1 AU. The modeling is still underway, but the currently best fitting model (SED, CO ro-vibrational lines and [O I] 63 micron emission line) suggests a disk mass of 7 10^{-2} solar masses and an outer radius of 100 AU, putting it well into the range of properties observed for low mass stars in Taurus.

TW Hya: A dry desert or a steam bath?

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One of the goals of the GASPS Open Time Key Program is the detection of water in young protoplanetary disk systems. Water - especially in its ice form - plays a key role in the assembly of planetary atmospheres, coagulation of planetesimals and the emergence of life. We targeted several spectral regions that contain strong cooling lines of these young systems, among them also a set of nine water lines with low to high excitation temperatures ($E_{\rm up} \sim 110 - 1100$ K). The spectra of the disk around TW Hya show the p-H_2O 89.988 μm line and the CO J=18-17 line at high confidence and a number of further tentative detections. We discuss here results from detailed modeling of the water chemistry - using the Thi et al. (2010) disk model - considering also the recently published HIFI fluxes of two ground state water lines (Hogerheijde et al. 2011) and Spitzer archival data. The detailed modeling shows that the PACS water lines span the entire range of water reservoirs from the high abundance water vapour reservoir inside the snow line to the outer reservoir that is mainly attributed to photodesorption of water ice from grain surfaces. Some lines such as the 89.988 μm line in TW Hya seem to span across both reservoirs, suggesting that this could explain the high fluxes compared to other lines probing only one of the reservoirs.

Observations and images of Young Stellar Objects at the milli-arcsecond scale: the case of MWC158.

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The young stellar objects are interseting to study since their disk is the place of the planet formation. In the course of our interferometry imaging program performed with VLTI/PIONIER, we focused on MWC158 which is supposed to be a possibly-Herbig B[e] star. The B[e] phenomenon is found in a large spectra of stars and is not well-constrained yet. Our work try to point out the interactions between the star and the disk using the large angular capabilities of the VLTI in the near-infrared (H band). We found a new and strong effect in the data that we have explained by the effect of localization of the spectral channels between the star and the disk predominance in flux. As a consequence, we have developped a method to remove the star flux from visibilities in order to study the disk. We have analized the data by reconstructing images applying different methods. Then, we develop a complex parametric model in order to fit the data. We will present the conclusions of these different ways to extract astrophysical informations from a young stellar object.

Rapid growth of gas-giant cores by pebble accretion

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The core accretion scenario is the most successful theoretical model for gas-giant formation. However, the initial growth of the core depends on arbitrary assumptions on planetesimal sizes. Growing the solid core before gas dissipation is problematic due to the long time-scale for run-away accretion, especially in the outer distant regions of a protoplanetary disc. We have studied the dynamics of gas-coupled cm-sized pebbles, gravitationally interacting with larger than km-sized cores. The Pencil Code is used to correctly model the gas drag hydrodynamics. Probing the accretion efficiency throughout mass growth of the core allows us to construct the formation history, from seed to the critical core mass that is capable of attracting a gaseous envelope. Provided that a significant fraction of the solid density is represented by cm-sized pebbles, accretion on an initial Ceres-like seed mass is rapid. At 5 AU, the core accretion timescale can be reduced by two orders of magnitude, compared to classical gas-free planetesimal accretion.

The influence of X-rays on protoplanetary disks

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We present first results of our ongoing work on the X-DIGIT project. This project is aimed at testing the influence of X-rays on the circumstellar disks of young stellar objects. We combine archival and new data from XMM-Newton and Chandra, using uniform reduction procedures, to get a detailed and comprehensive statistics. We then combine this dataset with results Herschel PACS obtained as part of the OTKP DIGIT. Our sample consists of 94 stars, combining a broad range in mass, X-ray luminosity, as well as bolometric luminosity and also various evolutionary stages from embedded objects to transitional disks. The large sample allows us to study, for the first time, statistical relations resulting from the interaction of high energy radiation with protoplanetary disk material. Initial results show interesting correlations, such as an anti-correlation between the [OI] continuum flux and the X-ray luminosity.

We also discuss the interpretation of the results in the framework of thermo-chemical disk modelling.

Forsterite in the wall of the Herbig star HD169142.

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Previous studies of HD169142 suggested that the rise in the SED at 25um reflects emission from the inner wall of the outer disk. Our model study agrees with this conclusion. In addition, our Subaru/COMICS images at 18.8 and 24.5 um trace dust that emits at the onset of this strong rise and are therefore well suited to determine the location and characteristics of the wall and its dust. Extensive model studies show that the wall has to be located at 23+3-5 AU. However, these models also demonstrate that additional optically thin warm dust – in the inner region – has to be present as well. This dust can be present in a geometrically thin, optically thick disk or in a geometrically thick, optically thin halo. For the mineralogy of HD169142 we find weak forsterite features in the Spitzer/IRS spectrum but lacking in the Herschel PACS spectrum. The non-detection of the forsterite 69 micron feature gives an upper limit to the amount of cold forsterite we observe from the disk. Comparing this result to various radiative transfer models we find that this can only be explained if the forsterite is located in the wall at 23 AU where the dust is 150-200 K. Therefore we conclude that the presence of the gap in HD169142 can be related to the forsterite formation.

Disk models with realistic dust settling: Predictions for Herschel

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Radiative transfer models stand at the core of interpreting Spectral Energy Distributions (SEDs) of protoplanetary disks, of which Herschel will provide many. With the legacy of Spitzer, it has become increasingly clear that dust settling is an essential part in constructing hydrostatic disk models. We present a grid of disk models with realistic dust settling, taking into account the dust-gas coupling of sub-micron to millimeter sized grains. These models are fitted to the SEDs of Herbig stars, T Tauri stars and brown dwarfs, and directly constrain the turbulent mixing strength in the mid infrared emitting region. We find no evidence for significant variations in the degree of settling across the stellar mass range, contrary to previous results. The far infrared emitting regions probed with Herschel are even more sensitive to dust settling, allowing us to also probe radial variations in the turbulent mixing strength, and provide tighter constraints on its value.

Ice condensation as a planet formation mechanism

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In models of dust growth in protoplanetary discs focus is typically on coagulation, a mechanism which unfortunately seems incapable of forming particles larger than centimeters. The concept of icelines is often overlooked, but is of great importance as particles can grow also by condensation. As a volatile species drift in towards the central star,

it sublimates as it passes its specific iceline. The vapour diffuses and condenses onto existing dust grains, leading to significant growth. We model the dynamical behaviour of ice particles close to the water iceline, around 3 AU from the central star. Ice particles and water vapour move in a damped random walk, due to turbulence, gravity towards the midplane and radial drift. Main focus is on diffusion over the atmospheric iceline, but we also look at the effect of including the radial iceline. Condensation and sublimation are modelled with a Monte Carlo approach. The effect of varying the turbulent alpha value, as well as the distance from the atmospheric iceline to the midplane, is investigated. Our results indicate that, with a turbulent alpha-value of 0.01, growth from millimeter-sized to at least decimeter-sized particles is likely in the vicinity of the iceline, on a timescale of 10 000 years. This particle layer may be dense enough to be sensitive to dynamical instabilities, such as the streaming instability, which causes further growth into planetesimals.

Modelling the CO emission of protoplanetary disks from the near-infrared to the millimeter.

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CO emissions from protoplanetary disks are observed from the UV to the millimeter. They trace different excitation conditions and thus different locations in the disks. Disk models that include rotational to rovibronic levels of CO are hampered by the incompleteness of the available collision rates (with H_2, H, He, and electron). We present the implementation of a large CO model molecule in the disk modelling code ProDiMo. The model includes direct calculation of the CO self-shielding, UV excitation from the ground-state to the electronic excited $A-$state, and extrapolations of existing collision rates to connect all the levels. We applied the model to a low- and a high mass disk around a Herbig Ae star to test for the possible effect of UV pumping on rovibrational transitions and IR pumping on the high-J rotational levels detected in disks by Herschel.

The disk around 51 Oph, a preculiar low-mass disk?

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The rapidly rotating southern B9.5V star 51 Oph located at 131 pc is a rare example of a pre-main-sequence star that is surrounded by a disk where most or all of the primordial gas has dissipated. The SED of the 51 Oph disk suggests a new category of disk. There is a near-IR excess and amorphous silicate in emission but the most stricking feature in the SED is the sharp drop in the continuum flux beyond 20 micron. In this poster, we will present a detailed analysis of the gas and dust components of the disk around 51 Oph using the codes MCFOST and ProDiMo. The far-IR fluxes have been obtained using the Herschel Space Telescope in the framework of the *Herschel-GASPS* survey of gas and dust in protoplanetary disks. In addition, our team has detected the spatially unresolved (on a scale of 10") 51 Oph disk emission at 1.2mm with a flux of 5 mJy using the MAMBO bolometer at the IRAM 30m telescope. This flux translates into a dust grain (with radii $<$ 1mm) mass of (1-2) 10^{-6} $M_\odot$ assuming Tdust= 50 K and the standard dust opacity. For the gaseous component, we have detected a strong emission by atomic oxygen at 63 micron but not

the emission from ionized carbon emission at 158 micron using the Herschel Space Telescope.

Do dust holes in transitional disks still contain cold gas?

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A central question in planet formation is how the optically thick protoplanetary disks around classical T Tauri stars evolve into the optically thin debris disks around older systems. The best test of formation scenarios is observing systems that are actively forming planets, the transitional disks: disks with large inner holes. Little is known about the gas inside dust holes, yet this gas significantly affects planet formation through gas-grain dynamics and planetary migration. We present our planned analysis for the approved ALMA Early Science program of Band 9 observations of the Herbig Ae star IRS 48 Oph in CO 6-5, $C^{17}O$ 6-5 and the millimeter continuum to provide the first deep searches for molecular gas inside a dust hole. IRS 48 is unusual in that it shows very strong PAH emission inside the hole, yet the mid-IR continuum and CO infrared lines show a ring with $\sim$30 AU radius (Geers et al. 2007, Brown et al. 2011) . However, to get a better understanding of the planet formation process, a statistical study of dust and gas properties of a large sample of transitional disks is required. Therefore, a sample of bright transitional disk candidates was constructed by using various selection criteria on the infrared photometric fluxes in the *Spitzer* c2d and Gould's Belt catalogs. The SEDs will be complemented with (sub)millimeter fluxes from several submitted observing proposals and far infrared PACS photometry from *Herschel* programs. With the complete SEDs (ranging from the optical to the millimeter) dust properties of the disks will be derived with the radiative transfer model RADMC-3D. The *Herschel* photometry will specifically constrain the hole size and disk structure (flared versus flat). This will help to select a robust sample for ALMA molecular line observations in future ALMA cycles. The huge leap in sensitivity provided by ALMA at high frequencies allows a large range of gas masses inside the hole to be tested, down to a fraction of a Neptune mass. This, in turn, allows the origin of the hole in this disk to be determined: substellar or planetary mass companions versus photoevaporation versus grain growth. The combination of gas and dust observations will provide a much better understanding of planet formation processes and disk evolution.

Signatures of dust evolution in protoplanetary disks – density profiles and transitional disks

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The global size and spatial distribution of dust is an important ingredient to the structure and evolution of protoplanetary disks and the formation of larger bodies, such as planetesimals. We develop a simple model which follows the upper end of the dust size distribution and the evolution of the dust surface density profile. We find very good agreement between the full dust evolution code and the toy model presented in this work. We derive analytical profiles which well describe the dust surface density and the dust-to-gas ratio in protoplanetary disks. We show that dust grain fragmentation is the dominating effect in the inner regions of the disk leading to a dust surface density exponent of -1.5 while the outer regions at later times can become drift dominated yielding a dust surface density exponent of -0.75. Our results show that radial drift is not efficient in fragmenting dust grains. This supports the theory that small dust grains are resupplied by fragmentation due to the turbulent state of the disk. We also discuss the observational significance of these results and the ability of grain growth and transport to produce transitional disks signatures.

Herschel/PACS SED spectroscopy of S CrA: a T-Tauri star within the DIGIT (Dust, Ice, and Gas in Time) key program

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S CrA (S Coronae Australis) is a variable T-Tauri star and one of the sources in the target list of the Herschel "Dust, Ice and Gas in Time" (DIGIT) key program. This star has a companion located at $5''$ and is associated with a Herbig-Haro object (HH82). Bright emission at short wavelengths was detected in the IRAS spectrum and CO lines were identified in high-resolution spectra obtained with CRIRES at the VLT. More recently, the measurement of scattered light echoes around S CrA suggest the presence of an incomplete dust shell or inclined torus at a radius of about 10 000 AU. This dust shell could be the remnant of the envelope from which the star or binary formed but the distance is remarkably similar to the nominal distance of the Oort cloud to the Sun. That is, the dust (or ice) particles scattering the light pulses might have been dynamically ejected from the star's disk through the process of planet formation originating an Oort cloud. Although S CrA has been the target of several studies, it is still poorly understood. Using the scan mode of PACS we obtained a full SED spectrum of S CrA, from 51 to 210 μm. Several atomic and molecular lines were discovered toward this source, including CO lines. In this poster we show the Herschel/PACS full spectrum of S CrA and describe the new observed features. We present also a preliminary analysis of the excitation diagram of the CO gas emission lines. The next step will be to model S CrA in detail using the thermo-chemical code ProDiMo (Kamp et al. 2010), so that we can better understand the intriguing circumstellar environment surrounding S CrA.

Planet Gaps in the Dust Layer of 3D Protoplanetary Disks: Observability with ALMA

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We numerically model the evolution of dust in a protoplanetary disk using a 3D, two-phase (gas+dust) smoothed particle hydrodynamics (SPH) code, which is non-self-gravitating and locally isothermal. The gas and dust interact via aerodynamic drag, allowing the evolution of the dust distribution in protoplanetary disks to be followed. In this work, we present the evolution of a typical Classical T Tauri star (CTTS) disk comprising 1% dust by mass, which is gravitationnally affected by an embedded planet. We then vary the grain size (100 μm to 1 cm) and planetary mass (0.1 to 5 M_J) to see how they affect the resulting disk structure. We find that gap formation is much more rapid and striking in the dust layer than in the gas disk and that a system with a given stellar, disk and planetary mass will have a completely different appearance depending on the grain size. We then use the resulting dust distributions to produce synthetic images for ALMA and show that the gap carved by a 1 M_J planet orbiting at 40 AU will be much more visible than the well-mixed gas+dust assumption would predict. Conversely, in the case of a 5 M_J planet we clearly see a deficit in dust emission in the inner disk, however the resulting image is indistinguishable from that of a transition disk with an inner hole. We present optimized observing parameters to find these signatures with ALMA.

High-Resolution Near Infrared Spectroscopy of HD 100546: Analysis of Asymmetric Ro-vibrational OH Emission Lines and Ro-vibrational CO Emission Lines

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We present high-resolution near-infrared spectra of ro-vibrational OH emission and multi-epoch observations of ro-vibrational CO emission from HD 100546. Previous comparison of the line profiles of the ro-vibrational CO emission and [O I]λ6300Å line indicated that the inner disk may be filled with OH and depleted in CO. Direct comparison of the OH and CO line profiles indicate that the inner extent of the OH is the same as the inner extent of the CO. The origin of the [O I]λ6300Å emission from the inner disk is uncertain. We also find that the OH emission line is asymmetric. The line profile can be reproduced if the gas arises from an eccentric annulus. The ro-vibrational CO and OH emission lines can be fit simultaneously if the eccentricity falls more sharply than r^{-2} and the CO emission arises mostly from gas at large radii. We also present multi-epoch observations of CO and show that the flux, line-shape and spectro-astrometric signal of the v = 1-0 lines varies relative to the lines arising from $v' \geq 2$. We show that the observations of CO can be explained by a source of excess thermal emission just inside the innermost rim of the outer disk. We interpret these results in light of models of gas giant planet formation and planet disk interaction.

Upper Scorpius – from dust to planetesimals

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We present the results of a Herschel PACS survey for continuum and line emission towards 44 confirmed B, A, K, and M spectral type members of the Upper Scorpius association. Herschel PACS far-infrared and IRAM 30m millimeter photometry indicate the presence of one Minimum-Mass Solar Nebula equivalent mass disk, and only 3 additional sources retain disks of mass greater than 0.1 MMSN. Gas line observations complement this view. Only 2 of the 19 sources with the largest near-infrared excesses show emission in the [OI] 63 μm line. Comparison of [OI] and JCMT CO upper limits to the DENT grid of models suggests most disks in Upper Scorpius retain a gas mass of less than 2×10^{-4} $M_{\odot}$. In addition, SMA imaging shows that the brightest mm source in Upper Scorpius is a gapped transition object, which we infer has already formed one or more giant planets. These observations suggest that fewer than 2% of Upper Scorpius disks could form Neptune-mass planets if planet formation were to commence today. This fraction, approximately one-tenth the ~Neptune mass planet fraction observed in field stars, suggests that planet formation must be at an advanced state in Upper Scorpius.

Crystal clear: revealing dynamics of protoplanetary disks through the spatial distribution of crystalline dust

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Because of the constraints on how and where crystalline silicates can form from ISM grains, their spatial distribution provides insight into the heating and transport processes in protoplanetary disks. Therefore a key step in understanding the dynamics and structure of disks, which are important to theories of planet formation, is a detailed characterization of the radial and vertical extent of processed dust grains in disks. Recent studies using *Spitzer* IRS spectra suggest that crystals in the upper layers are distributed out to 50 AU in some young disks, farther than can be accounted for by current dynamical models. Over the *Herschel* PACS range, the continuum and solid state features probe colder dust in the outer hundreds of AU and in the midplane, much farther and deeper than with IRS. Through our *Herschel* OT1 program, 'Crystal clear', we are observing a sample of intermediate mass T Tauri stars with strong crystalline signatures in their IRS spectra to determine the crystalline extent in these disks; we present here the first results from this program. Combining our PACS spectra with multi–wavelength data from *Spitzer*, Magellan, and IRTF, we analyze both the dust composition and disk structure of our targets. Using spectral decomposition model fits, we identify the crystalline silicate species present and use this dust composition in our self–consistent, irradiated accretion disk model to determine the location of the crystalline grains. The 2D spatial distribution of crystalline silicates in these young disks provides a valuable constraint on the extent and timescale over which dynamical processes act in such systems.

Proto-planetary Herbig Ae/Be discs as seen with Herschel: atomic and molecular emission lines as tracers of the disc chemistry and physics.

Meeus, G.[1]; and the GASPS team[2]

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The mechanisms determining planet formation are not (yet) well-understood. Primordial proto-planetary discs consist for 99% out of gas, and only 1% out of dust. With time, those initially flaring discs are believed to evolve into a flat geometry, when the initially small dust grains grow to larger sizes and settle towards the mid-plane in which planets can form. In the mean time, the gas will disperse, until so little is left that giant planets no longer can form. As an important piece of the puzzle of planet formation, it is important to understand 1) the influence of the heating/cooling processes on the young disc structure, 2) the chemical composition and its evolution and, finally 3) how fast gas gets dispersed, and which mechanisms control this dispersion. In this talk, we concentrate on the proto-planetary discs around Herbig Ae/Be stars (HAEBE), young objects of intermediate mass, in the context of their gas content and properties. We compare our observations with those of young debris disc stars, for which the HAEBE stars are thought to be progenitors. We present new Herschel PACS spectroscopic observations for a sample of 25 stars that were obtained within the GASPS (Gas in Proto-planetary Systems, P.I. B. Dent) Open Time Key Project. We concentrate on the detection and characterisation of both atomic and molecular emission lines, tracing the disc at different vertical depths between 5 and 500 AU. Our spectra cover transitions of [O I], [C II], OH, H_2O, CH^+ and (mid to high J) CO, the most abundant components of the disc. We look for correlations between the observed line fluxes and stellar properties such as effective temperature and stellar luminosity, FUV and X-ray luminosities, several accretion diagnostics, as well as with disc properties: amount of flaring, PAH bands and (low J) CO transitions, tracing the cold gas (mass). We will present a few cases to illustrate how simultaneous modeling (using the thermo-chemical disc code ProDiMo) of the atomic fine structure and molecular lines can constrain the disc gas mass, once the disc structure is derived. We show the first solid detection of water and OH in a Herbig Ae disc, and discuss the presence (and absence) of these molecular lines in the context of the disc physics and chemistry.

From monomers to pebbles: Theoretical point of view of dust growth in protoplanetary disks

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The growth of sub-micron sized particles to pebbles is the most critical stage of planet formation which contains different physical challenges. One of the essential mysteries is to understand how large grains can survive in the outer regions of the disk as it is observed at sub-mm and mm wavelengths. While theoretically, pebbles may not grow due to destructive collisions and radial drift due to their interaction with the gas. Different efforts have been aimed to explain how these two phenomena can be prevented, without a conclusive answer. We introduce how the presence of long-lived pressure bumps, with certain characteristics, moderate the rapid inward drift using a coagulation/fragmentation disk model. These pressure inhomogeneities allow the retainment of large dust particles on million years time scales. Observations at sub-mm and mm-regime provide information about the presence of pebbles in outer regions of disks. Additional observations with Herschel can definitely help us to constrain the physical properties of those pebbles better. Understanding if large particles are accompanied by smaller particles or not, we can determine the importance of bouncing and fragmentation in the growth process. Herschel can give us a deeper comprehension of the physics of dust growth and help us to resolve an old puzzle in planet formation field.

Combining dust and gas diagnostics of protoplanetary disks

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The gas and dust phases of protoplanetary discs are inextricably coupled. The gas controls the dynamics of small grains, resulting in vertical settling, radial migration and, in turn, accelerated grain growth. In parallel, the dust accounts for most of the disc opacity and controls the global disc thermal equilibrium. To better understand the respective evolution of the gas and dust components towards planet formation, it is now critically needed to combine diagnostics on both phases, and in various wavelength regimes. atomic and molecular layers of discs. Together with observations in the near-/mid-IR and in the (sub-)millimetre regimes, which probe complementary regions of the discs, they allow a more global understanding of discs. In this contribution, we will illustrate how the combination of molecular rotational lines, in particular CO lines, is required for a detailed characterisation of the physical and chemical properties of young stellar objects. We will present a selected sample of objects with complete data sets (including GASPS OTKP observations, PI: B. Dent), spanning the stellar mass spectrum and in the critical age range over which the discs appear to dissipate and planets form. Our simultaneous modelling of continuum and line observations (with the radiative transfer code MCFOST and thermal balance and chemistry code ProDiMo) allows us to establish quantitative constraints on the gas and dust properties as well as their interplay. We will discuss the implications of these results in the context of disc evolution and planet formation.

Herschel/PACS observations of young sources in Taurus: the far-infrared counterpart of optical jets

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The GASPS (GAS in Protoplanetary Systems) Herschel Open Time Key Project, devoted to study gas evolution in protoplanetary disks, include a number of jet sources, showing rich atomic ([OI], [CII]) and molecular (high-J CO, H_2O, OH) lines spectra. Previous ISO observations focused on outflows from young Class 0/I sources. Thanks to Herschel higher sensitivity and spatial/spectral resolution, the GASPS survey allow us for the first time to study the far-infrared counterpart of fast and collimated optical jets from evolved Class II sources and thus to obtain an evolutionary picture. The analysed GASPS/PACS observations show that the atomic and the molecular emission have different spatial and physical origin. The atomic emission (e.g., the [OI] 63 μm line) is correlated with the direction and velocity of the optical-jets/mm-outflows and dissociative J-shock model predictions further confirm a jet/shock origin. The molecular H_2O, CO emission, on the contrary, is originating from a compact region, unresolved with PACS. Thus its origin is less clear. Non dissociative C- or slow J- shocks with high pre-shock densities (10^5 - 10^6 cm^{-3}) can reproduce the observed H_2O, high-J CO line ratios and fluxes; these may occurr at the outflow cavities and/or at the disk surface. However, a disk contribution cannot be excluded. The inferred outflow properties highlight a clear evolutionary trend: outflow from evolved Class II sources show fainter and more compact atomic and molecular emission, and the estimated mass loss rates (10^{-7} -10^{-8} $M_\odot$ yr^{-1}) are one or two order of magnitudes lower than those estimated for Class 0/I sources. To further investigate the origin of the molecular component, in particular of the water lines, and discriminate between jet and disk emission in the unresolved circumstellar region higher spectral and spatial resolution are required. We present preliminary results from the analysis of recently acquired follow-up OT1-HIFI spectra and we discuss the potential of forthcoming ALMA observations. The latter will allow us to establish the rotation sense of the molecular jet and the disk, thus obtaining a crucial test of magneto-centrifugal jet acceleration.

Water in protoplanetary discs in Taurus.

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Herschel-PACS line spectra of 68Taurus members has been obtained with the instrument PACS. The systematic study of the spectra at the far-infrared has unveiled the presence of an unexpected line at 63.32 μm that we identify as ortho-H_2O. This discovery has triggered the study of the behaviour of this line and its relationship with other lines and stellar properties. The origin of the line has also been studied. Statistical methods have been applied to assess potential correlations with other lines and some stellar properties. We have detected the ortho-H_2O 63.32 μm line in eight out of 68 Taurus members, with a detection fraction of $\sim 13\%$. The H_2O line seems to correlate with the [OI] 63.18 μm line luminosity, the stellar continuum and the X-ray radiation field. This is the first time that this line of warm H_2O is detected in a protoplanetary disc. Although we cannot exclude that the line is formed in an outflow, we favour a disc origin. Sophisticated modeling of the line suggest a disc origin in the surrounding of the snow line, around three AU. If the origin is probed, this line can be the link between the hot water emission lines detected by *Spitzer* and the less successfully detected cold water lines with *Herschel* (see Hogerheijde et al. 2011, Kamp et al. in prep.).

Can giant planets form by gravitational fragmentation of protostellar discs?

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It has been claimed that giant planets may form by gravitational fragmentation of protostellar discs (e.g. Boss, Vorobyov et al., Boley et al., Inutsuka et al.). We ignore the issue whether such fragmentation is possible or not; we assume that planetary-mass objects form in the disc, as these models suggest, and we follow their evolution and their interactions with the disc, using 3D hydrodynamic simulations. We find that such ”proto-planets” accrete material from the disc and their mass grows above 13 M_J, unless the accretion of material is somehow suppressed, e.g. when a ”proto-planet” is ejected from the disc through dynamical interactions. Most ”proto-planets” end up with masses in the brown dwarf regime. We conclude that the formation of giant planets by disc fragmentation is unlikely.

EX Lupi from Quiescence to Outburst: Opening a New Window on Chemistry and Dynamics of Volatile Species in Planet-Forming Circumstellar Disks.

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The quest for water in star and planet forming regions is now at its apex with the *Herschel* mission. Recently, archival spectra from the *Spitzer* satellite have been reanalyzed, opening a new window on the study of warm volatile emission in the inner regions of circumstellar disks that is nicely complementary to the cold emission probed by *Herschel* in earlier evolutionary stages as well as in outer regions of disks. In this presentation we show what we can learn from *Spitzer* spectroscopy that can trigger new modelling efforts for the higher-resolution observations taken with *Herschel*. We compare two *Spitzer* spectra of the strongly variable T Tauri EX Lupi, observed before and during its exceptional outburst in 2008. This event has provided the unique opportunity of studing molecular emission in one system where one parameter dramatically changes: the star+accretion illumination of the disk. Monitoring such variability, which is present in all T Tauri stars on smaller scales, can be extremely important for constraining the chemical and physical evolution of volatile species in disks. Focussing on the water-related species, in EX Lupi we detect a dense forest of H_2O rotational emission lines from levels with energy $E_u \sim$ 900-6000 K, as well as highly rotationally excited OH lines with E_u from 420 K up to more than 20,000 K. We show how we find strong evidence of a non-LTE excitation of the observed emission from both H_2O and OH. Moreover, comparing quiescent and outburst detections we find that the H_2O column density decreases in outburst while OH increases. This suggests a key role for UV radiation in the disk surface chemistry where OH is produced via H_2O photodissociation. Our study points to the strong need of non-LTE disk models accounting e.g. for variable UV radiation and to the great potential of high-resolution monitoring of T Tauri stars. For instance, multi-epoch observations with *Herschel* (and ALMA) may provide a complementary study of variations in outer disk properties and enable the connection between the cold and warm chemistry outward and inward of the snowline. Moreover, the analysis of velocity-resolved observations can finally enable the connection of chemistry and dynamics of volatiles in disks at radii relevant for planet formation that *Spitzer* alone cannot provide.

Characteristics of the DK Cha protoplanetary disc

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We present high resolution imaging at 3 mm and radiative transfer modelling of DK Cha. DK Cha is a Herbig Ae star, believed to be transitioning from an embedded class I to a revealed class II, with a near face-on orientation providing a clear view of the protoplanetary disc. It is the brightest source in the infrared and sub-millimetre bands located in Chamaeleon II cloud at 178 pc. Observations from Herschel PACS have revealed a rich chemical environment of CO, OH, and H_2O gas tracing the temperatures present in the disc. High resolution imaging at 3 mm with additional 7 and 15 mm temporal monitoring with Australia Telescope Compact Array (ATCA) were performed, along with modelling using the radiative transfer code `MCFOST`, to determine the structure and grain sizes of this protoplanetary disc. The temporal monitoring was used to rule out potentially varying non-disc emission mechanism enhancing the flux at 7 and 15 mm. Preliminary results show that with a beam size of 1.14 by 1.13 arcsec the disc is clearly resolved at 3 mm and there is some evidence of inner disc clearing. The temporal monitoring results at 15 mm suggest the flux is from non varying thermal dust emission, and the 3 to 15 mm observations suggest grain growth up to cm-sizes.

SOFIA -followup opportunities for Herschel

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I give a short review of SOFIA, the Stratospheric Observatory for Infrared Astronomy, and what we can offer to astronomy community. SOFIA is the only far infrared mission after Herschel for quite a few years. Several of the SOFIA first generation instruments are very complimentary to Herschel. SOFIA is a joint project of NASA and DLR. It is a modified Boeing 747-SP airplane with a 2.5 m telescope, designed to operate at altitudes from 12 to 14 km and wavelengths from 0.3 micron to 1.6 mm over a 20 year lifetime. The telescope is diffraction limited at wavelengths beyond 15 micron. At 100 micron the resolution is 10”, which is comparable to the angular resolution of large ground based telescopes in the mm/sub-mm such as IRAM, JCMT, and CSO. SOFIA has seven science instruments and is expected to add or upgrade instruments every few years. The second generation US instrument(s) will already have been chosen by the time of this conference. SOFIA has already completed it's early science cycle, which was open to the astronomy community, but with rather limited observing time and only two science instruments. The two science instruments were FORCAST and GREAT. FORCAST is a facility instrument, a dual channel infrared camera covering 5 - 25 and 25 - 40 micron with a set of wide and narrow-band filters. GREAT (German PI instrument) is a heterodyne receiver, which in its early science configuration covered 1.25 - 1.5 and 1.82 - 1.92 THz. I will present highlights from the SOFIA early science for both FORCAST and GREAT. SOFIA will be down for upgrades this winter and we are in the process of commissioning the remaining instruments. The call for cycle I is to be issued in mid-November with proposals due by mid-January. In cycle I (July 2012 - July 2013) we also offer prisms for FORCAST, GREAT, HIPO, a high speed optical photometer, and FLITECAM, a near-IR facility camera, also with grisms. SOFIA will be fully operational in 2014.

[Ne II] emission in young stars: mid-infrared and optical observations with the Very Large Telescope.

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The [Ne II] line (12.81 μm) is proposed to be a good tracer of the gas content in proto-planetary disks. However, its origin is still matter of debate since it can be explained by different mechanisms: jets in outflows, photo-evaporative disk winds driven by stellar X-rays and/or EUV, and in the X-ray irradiated proto-planetary disk atmosphere. Statistical studies based on large samples of young stars with *Spitzer*/IRS observations gave hints toward the neon emitting mechanism by looking into correlations between the line luminosity and properties of the star-disk system. The general conclusions of such studies indicate that neon emission is related to accretion and outflows, with some influence of X-rays. But in order to determine the origin of the [Ne II] emission, high-spatial and spectral resolution observations are crucial. This motivated our study of gas emission in proto-planetary disks, focusing on the [Ne II] emission line in the mid-infrared and in optical forbidden lines such as [O I], [S II], and [N II]. We looked into line shifts and profiles that can provide clues on the origin of the emission. Furthermore, by comparing the mid-infrared and optical lines we aim to better constrain the emission mechanism. For this purpose we obtained high-resolution ground-based observations with VISIR-VLT for 15 stars and UVES-VLT for three of them. The [Ne II] line was detected in 7 stars of the sample, including the first confirmed detection in a Herbig Be star. The line profiles and shifts show different characteristics, and therefore indicate different emitting mechanisms: four stars show a line with large velocity shifts towards the blue, a clear sign of jet emission. In two stars, the small shifts, the broader and asymmetric profiles indicate an origin in a photo-evaporative wind. One star shows a small shift, and a symmetric line profile with broad wings extending up to ~ 100 km/s, suggesting that the emission comes from the disk. For the stars with VLT-UVES observations we found that, in general, the optical line profiles and shifts are very similar to the profile of the [Ne II] line, suggesting that the lines are emitted in the same region.

TOPIC 4 – **Debris Disks and Exoplanets** *Posters*

Polarimetric survey of candidate stars for debris disks with modeling

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We present the results of a polarimetric survey carried out at the 1.6 m Ritchey-Chrétien telescope of the Mont-Mégantic Observatory. We observed approximately 120 stars with the purpose of finding polarization due to circumstellar matter. The observations were done in a wide band centered on 766 nm. Our targets, which form a sample of the Herschel DEBRIS survey, are the closest stars evenly distributed along the spectral types A, F, G, K and M. One previously detected star was confirmed, but with a lower polarization, suggesting variability in the disk density close to the star. We also have an upper limit on the polarization of HR 8799. We perform a statistical analysis of the polarization data of our data, complementing with published measurements. We also model the polarization expected from debris disks for various configurations and grain properties.

DUst around NEarby Stars : Dynamical Modeling of the Disk of ζ^2Reticuli Searching for a Planetary Companion

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Recent Far-IR observations of the debris disk surrounding ζ^2Reticuli, obtained with the Herschel Space Observatory as part of the Open Time Key Programe DUNES, reveal an asymmetric double-lobed circumstellar feature interpreted as a ring-like structure seen almost edge-on with an elliptical shape with minimum eccentricity 0.3. Our basic assumption is that this asymmetry is due to planetary perturbations. We also assume that the asymmetric structure of the dust distribution is due to an already existing similar asymmetry among the planetesimal population that continuously produces the observed dust via a collisional process. Through N-body dynamical modeling, we aim at constraining the orbital parameters of hypothetical planets that could induce perturbations on the disk compatible with the observational constraints. We integrate with a symplectic N- body code the motion of an initially axisymmetric ring of planetesimal orbiting a star, and perturbed by a planet. We apply this methodology to the ζ^2Reticuli case, extending the integration over 1 Gyr. We explore various planetary configurations, masses, periastron and eccentricities values, and we consider both internal and external planets to the disk. We further assume coplanarity of the system. We present in this poster the results of this work. We derive strong constraints on the main hypothetical planetary candidate that could account for the observed asymmetric structure.

Tracing Remnant Gas in Evolved Circumstellar Disks

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To understand the composition of forming planets, we need to study the structure and composition of the gas and dust in disks from which they form. One key aspect that constrains the formation of gas/ice giants vs. rocky planets is the timescale for gas clearing in a disk. Recent studies of gas emission lines with Spitzer and sub-mm telescopes have shown that 10–100 Myr old stars with debris disks have too little gas left to form Jupiter like gas giant planets. Whether enough gas, of order 10 $M_\oplus$, remains in these systems to form ice giant planets, such as Neptune and Uranus, is still unanswered. We present results from our Herschel PACS program to trace the remnant [OI] gas in six well characterised 10–100 Myr circumstellar disks that harbour suspected planets and/or show signs of an evolved dust disk structure. We use thermo-chemical disk models by Gorti & Hollenbach to model the gas emission, using constraints on the [OI] 63 micron, and available literature constraints to derive gas mass upper limits and constrain gas-to-dust mass ratios. For two sources, HD 377 and HR 8799, we find gas mass upper limits of 0.1–20 $M_\oplus$. For a younger ($\sim$ 10 Myr) third source, RXJ1852.3-3700, we find two distinct disk scenarios that could explain the detection of [OI] 63 micron and CO(2–1) upper limits.

A COLD DEBRIS DISK AROUND THE PLANET-BEARING M-STAR GJ581 RESOLVED BY HERSCHEL

Lestrade, J.-F. and the DEBRIS Team

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In the course of the Herschel OTKP DEBRIS, a debris disk has been discovered around the multiple planet-bearing, old (2-8 Gyr), low-mass M-dwarf GJ581. The disk has been resolved at 70, 100 and 160 microns by PACS. We use a parametrised-model to fit these images and extract the main geometric properties of the disk. By simulating data, we test how robust the determinations of its inner radius and plane inclination to the sky are. The inner radius provides the scale of the hosted planetary system, and the inclination yields true planetary masses from their radial velocity measurements allowing for caracterisation of the dynamical stability of this multiple planet system (at least 4 planets). Debris disks around low-mass M-dwarfs have been elusive, we discuss our finding for GJ581 in this context.

3 mm imaging of four debris disks

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Since the discovery of the “Vega phenomenon” by *IRAS*, we know that a relatively large number of old stars harbour optically thin, and sometimes large (several 100 AU), dusty disks. These debris disks are believed to result from the collisions and/or evaporation of a reservoir of unseen planetesimals. Since different wavelengths probe different dust temperatures and therefore different regions of the disks, millimetre observations are required to detect the cold, large grains, i.e., dust populations unobservable at shorter wavelengths. Therefore mm observations are the best tracers of the outer edge of the planetesimal population. Here we present 3 and 7 mm imaging observations of four southern debris disks with the Australia Telescope Compact Array (ATCA): β Pictoris, Fomalhaut, HD181327 and HD172555. Our 3 and 7 mm observations of β Pic show evidence of structure within the dust and directly detect

inner disk clearing, in agreement with recent SMA 1.3 mm observations (Wilner et al. 2011). Our 7 mm Fomalhaut image clearly shows two emission peaks about 15″ from the star, similar to the JCMT/SCUBA 450 and 850 μm maps (Holland et al. 2003). HD18132 is resolved at 3 mm and the disk extent is of a similar scale to the *Herschel* PACS 70 μm image (Lebreton et al. 2011). We obtain a 3σ detection of HD17555 at the location of the star (and well interior to the "intriguing structures" seen in the 870 μm APAX/LABOCA map by Nilsson et al. 2009). These ATCA data complement the *Herschel* PACS and SPIRE infrared and APEX/LABOCA, JCMT/SCUBA and SMA sub-millimetre data to provide complete wavelength coverage of the spectral energy distribution, as well as to provide the additional insights into the morphology of the disk and grain properties.

Predicting the imprint of a debris disk dynamically excited by an object on a Sedna-like orbit

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Herschel and ALMA are providing unprecedented sensitivity and angular resolution to observe cold dust of debris disks in the far-IR and submillimetric domains.

The mechanism responsible for the production of the observable dust is thought to be related to collisions between planetesimals in a dynamically excited disk. Potentially, structures seen in high angular resolution images are clues to this mechanism. We have studied the imprint of a debris disk dynamically excited by an object on a Sedna-like orbit (high eccentricity and periastron in the disk). A catalogue of images has been produced for ranges of the object mass, orbit inclination and object/star mass ratio. We show that AU-scale structures can be formed that match the angular resolution of ALMA for nearby stars.

A Unique Gas-Rich Debris Disk: Herschel Imaging and Spectroscopy of 49 Ceti

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Gas-poor debris disks represent a fundamentally different class of circumstellar disk than gas-rich protoplanetary disks. Their gas probably originates from the same source as the dust, i.e. planetesimal destruction, but the low gas densities make it difficult to detect. So far, Herschel has detected far-IR gas emission from only one or two debris disks, Beta Pictoris being one of them. Here we present Herschel GASPS observations of a well-known debris disk system, 49 Ceti. The dust disk is spatially resolved in thermal emission at 70 μm. Most interestingly, weak far-IR gas emission is detected. Preliminary modeling suggests that reconciling the sub-mm CO emission seen from this system with the far-IR gas detection and upper limits requires a low gas-to-dust ratio and possibly an unusual gas composition.

Herschel-PACS observation of gas lines from the disc around HD141569A: Constraining the disc gas content in a low-mass disc.

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The gas and dust dissipation processes in discs around young stars remain uncertain. At the distance of $\sim 99\pm3$ pc, HD141569A is one of the nearest HerbigAe stars that is surrounded by a tenuous disc, probably in transition between a massive primordial disc and a debris disc. We have detected the fine-structure lines of [OI] at 63 and 145 μm , and the [CII] line at 157 μm with the *PACS* instrument on board the *Herschel* Space Telescope as part of the open-time large programme GASPS. We complemented the atomic line observations with imaging and photometric continuum data and ground-based ^{12}CO 3–2 observations. We used the HD 141569A observations as a modelling test-case by performing an independent blind fitting of the *Herschel* and CO lines with two physico-chemical codes: *ProDiMo* by P. Woitke and co-workers and *c & t* by S. Bruderer and co-workers. The results of this comparison work and on the HD141569A disc properties will be shown in this poster.

Modeling the HD 32297 Debris Disk with Far-IR Herschel Data

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SED modeling of debris disks is an important tool for revealing information about disk structure and the dust composition. Combining SED modeling and resolved imaging can constrain disk parameters and break degeneracies that plague SED modeling efforts. This allows us to constrain the location of the planetesimal belt and determine the composition of the dust grains. We apply these techniques to the disk of HD 32297. HD 32297 is a 30-Myr-old A0 star 112 pc away with a nearly edge-on debris disk that extends hundreds of AUs from the star. The HD 32297 debris disk has been resolved at several wavelengths (near-IR with HST NICMOS, mid-IR with Gemini South, and millimeter wavelengths with CARMA). We combine resolved imagery of the disk with archive data from Hipparcos, 2MASS, WISE, Spitzer, and IRAS to model the disk. Additionally, we use Herschel PACS data from the Gas in Protoplanetary Systems (GASPS) Open Time Key Programme to further constrain the SED.

Stellar multiplicity and the debris disk phenomenon: analysis for the unbiased DEBRIS sample

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Stellar multiplicity is an ubiquitous outcome of star formation, which naturally leads to the question of the influence of a stellar companion on the planet formation process. By now, many planets and debris disks are known in multiple systems, so these phenomena are not mutually exclusive. Yet, the dynamical influence of a stellar companion can hardly be entirely negligible if it resides relatively close from a forming planetary system. Preliminary trends have been reported when studying the stellar multiplicity of planet host stars, with a mild deficit of planets in tight binary systems (< 100 AU). However, tackling this problem from the angle of mature planetary systems may yield a biased

picture since systems in which the planet formation system has stopped short prior to producing giant planets are not considered. Another, arguably less biased, approach consists in comparing the stellar multiplicity and debris disks phenomena since the latter only requires the formation of planetesimals, an earlier stage in planet formation. Previous *Spitzer* studies have suggested a trend whereby intermediate separation binaries show a deficit of detected debris, although the debate is still ongoing. To draw a more coherent picture on this question, we take advantage of the DEBRIS dataset, a volume-limited survey for debris disks around 446 A- through M-type stars. We combine a thorough literature search for multiplicity information with a systematic adaptive optics imaging with the Shane-3m telescope at Lick Observatory (for the Northern part of the DEBRIS sample) to derive more stringent conclusions on the relationship between stellar multiplicity and the occurence of debris disks, and indirectly on the planet formation process.

Observations and modeling of planet-disk interaction in debris disks - From *Herschel* to ALMA

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We will present several aspects of observations and modeling of the spatial structure of debris disks. (A) Combined multi-wavelength modeling of high quality, high spatial resolution data at optical/near-infrared and millimeter wavelengths as well as a well-sampled SED of the debris disk around the solar-type star HD 107146 reveals a broad, featureless ring of dust. The origin of this dust is attributed to a birth ring scenario. Signposts of a tenuous disk component inside the outer dust ring are revealed by our modeling. This is attributed either to small particles produced in the outer disk and dragged inwards through Poynting-Robertson drag or to a multi-ring structure. (B) The potential discovery of a new class of faint, peculiar debris disks through high sensitivity photometry obtained in the context of our *Herschel* open time key project DUNES is presented. The SEDs of these three nearby, spatially unresolved sources ($d \sim 20$ pc, spatial extent ≤ 156 AU) exhibit a very steep decrease from 70μm to 160μm. The unique shape of the SEDs can be interpreted in the context of grain segregation and dust trapped into resonance by a giant planet few tens of AU from the star. (C) Finally, the results from a systematic study of the structures induced in debris disks due to planet-disk interaction are presented. We employ N-body simulations to demonstrate that these structures allow one to detect and to study planets in a regime of mass and radial distance from the star not accessible to other techniques. Furthermore, they allow one to put strong constraints on the planetary/planetesimal system present. From the synthetic images derived, detailed simulations of observations with present and future instruments are carried out. It is demonstrated that future instruments like ALMA or the JWST will provide unique opportunities to reveal the features in debris disks induced by planet-disk interaction. In particular, a combination of high sensitivity, high spatial resolution observations in both the (sub-)mm and mid-infrared wavelength regime will allow one to strongly constrain the properties of a system.

Resolved circumbinary debris disks: Signatures of star and planet formation.

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We present resolved *Herschel* images of circumbinary debris disks in the 99 Herculis and HD13161 systems. In both cases the binary orbit is well characterised, allowing a comparison of the disk and binary orbital planes. The disk and binary orbital planes in the HD13161 system are probably aligned, suggesting that the system was coplanar when it formed. For 99 Herculis we conclude that the disk is misaligned with the binary plane. Two different models can explain the observed structure. The first model is a ring of polar orbits that move in a plane perpendicular to the binary pericenter direction. We favour this interpretation because it includes the effect of secular perturbations and the disk can survive for Gyr timescales. The second model is a misaligned ring. The misaligned ring, interpreted as the result of a recent collision, is shown to be implausible from constraints on the collisional and dynamical evolution. Because disk+star systems with separations similar to HD13161 and 99 Herculis should form coplanar, possible scenarios for the 99 Herculis misalignment involve either a close stellar encounter or binary exchange in the presence of circumstellar and/or circumbinary disks. Discovery and characterisation of systems like those presented here will help understand processes that result in planetary system misalignment around both single and multiple stars.

A young Kuiper Belt analogue around the young star HD 181327

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To draw a complete picture of planetary systems as a whole, one needs to study all their constituents, from the largest gas giant planets to the smallest dust particles. Continuously replenished by collisions between planetesimals, these so-called debris disks represent large reservoirs of material way beyond the snow-line, that may impact the later evolution of terrestrial planets. HD 181327 is an example of a young Sun-like (F5.5V, 12 Myr) planetary system, member of the β Pictoris moving group, that we see only through its optically thin circumstellar disk of dust, presumed to result from collisions in a population of unseen planetesimals. As part of the GASPS open time key program, we obtained Herschel/PACS far-IR photometric and spectroscopic observations of the debris disk, that we complemented by new 3.2 mm observations carried with the ATCA array. Using the GRaTeR radiative transfer code, we perform a detailed analysis of the dust grains by coupling multi-wavelengths flux measurements with HST/NICMOS constraints on the geometry of the narrow belt. A Bayesian statistical approach leads to a precise estimation of the grain sizes and composition, the ice content in particular. We discuss additional evidence for the fluffy nature of the dust particles. We attempt to detect oxygen and ionized carbon fine structure lines in order to assess the gas-to-dust ratio in this young debris disk. Based on non-detections, we use the thermochemical code ProDiMo to solve the photochemistry and energy balance in the disk. We find weak constraints on the mass of the diffuse gas disk, and we make predictions on the CO line fluxes detectable by ALMA. Overall, we demonstrate that the system hosts a population of icy planetesimals, that may be a source for the future delivery of water and volatiles onto forming terrestrial planets. Our study illustrates that the combination of HST scattered light images, with spectral data from Herschel allows to break the model degeneracies and to properly characterize the dust, its dynamics and the possible link with planets.

On the relationship between debris discs and planets.

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Debris discs are, strictly speaking, signatures of planetesimals material, the building blocks of planets. Therefore, it is interesting to compare the properties of these stars with those known to harbour planets. We use high-resolution spectra to derive homogeneous metallicities of stars with/without debris, unlike the case of stars with planets we do not find a correlation between the presence of debris discs and high-metallicity, although it may be a deficit of stars with debris at low metallicities. Of particular interest are the properties of stars hosting both planets and debris discs. The number of such systems has increased notably in the recent years. We find that stars hosting both debris discs and planets have higher metallicities than those stars hosting only debris discs, showing a metallicity distribution which matches that of stars harbouring cool distant Jupiter planets. The implications of these findings will be discussed in this contribution.

Resolved Debris Discs in the Herschel DUNES Survey

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Circumstellar debris discs are composed of dust grains sized from microns to millimetres that are the byproduct of the destruction of larger bodies. These dust discs are analogous to the Edgeworth-Kuiper belt, the cold dust belt beyond the orbit of Neptune in our Solar system. The *Herschel* Open Time Key Program DUNES has detected emission attributable to the presence of a circumstellar debris disc around 38 nearby Sun-like stars. More importantly, we have also resolved the emission from the dust in sixteen of these systems. By resolving the disc in these systems at one or more wavelength we can calculate model fits to the disc spectral energy constrained by the radial location of the dust, better constraining the range of dust model parameters. In this talk a summary of the resolved debris discs observed by DUNES will be presented, concentrating on those that have been newly resolved by *Herschel*. The presentation will focus on the analytical approach to determining the strength and location of the excess emission around the star from the PACS images and, following this, the interpretation of the resolved emission through the tools developed by the DUNES modelling team.

Warm dust around warm debris disks

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Debris disks trace remnant reservoirs of leftover planetesimals in planetary systems. Thanks to mid-infrared observation campaigns, they have been detected around hundreds of Main Sequence stars of various ages. Most of them are found to be Kuiper belt-type disks, containing cold dust grains. However, mid-infrared spectroscopic observations have revealed the existence of a handful of warm debris disks. These very rare objects ($\sim$2% of all debris disks) display strong emission features, associated with μm-sized silicate dust grains. Given the ages of the host stars, the survival of these grains is intriguing and this questions their origin. A first step toward a better understanding of these objects is to determine the dust mineralogy via spectral decomposition. We developed a powerful radiative transfer code dedicated to model the dust mineralogy in the optically thin regime. I will present new results obtained for several warm debris disks observed with Spitzer/IRS. For instance, based on recent laboratory measurements of various dust species, we are able to constrain the iron fraction in olivine crystalline grains. These results provide new insights on the crystallization processes at stake in these rare objects. The dust mineralogy of these exo-zodiacal belts can be compared with the composition of Solar System bodies and potentially offers a glimpse of the history of our planetary system.

Debris Disks around Sun-like Stars: Results from the DEBRIS Survey

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The DEBRIS survey is a Herschel key program searching for evidence of debris disks around 446 nearby stars, 274 of which are "Sun-like", i.e., of spectral type FGK. We present statistical results for our ensemble of flux-limited observations toward these targets, including evolution of these disks over time and variance of rates of disk detection with binarity, metallicity and other parameters. We will highlight the techniques we have used to enhance our sensitivity to disks within our dataset and discuss the significant issue of confusion within Herschel PACS data at our sensitivity levels. We will highlight statistical trends within this sample of stars and between the FGK population and earlier and later type stars within the DEBRIS survey. Finally, we will show several new and newly resolved disks detected around stars in our FGK population, some of which exist around recently identified planet hosts.

A Resolved Debris Disk Around the Nearby G Star HIP 32480

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The Herschel Space Observatory is providing unprecedented sensitivity and angular resolution in the far-infrared. The DUNES Key Project (DUst around NEarby Stars, PI Carlos Eiroa) has finished its survey of 133 FGK stars within 25 pc of the Sun using the PACS photometer at 100 and 160 microns. We report the detection of a resolved debris ring around HIP 32480, a G0 star 16.5 parsecs distant. The ring is almost 300 AU in diameter and inclined 30 degrees from edge-on. We present a thermal emission model for the system that fits the Spitzer spectroscopy and Herschel images of the system. We find a minimum grainsize of 4 microns in the main ring and a distinct warm dust population interior to it. Faint detached emission features just outside the ring may trace a separate, more distant ring in the system. The non-detection of the ring in archival HST/ACS coronagraphic images limits the dust grain albedo in the ring to be no more than 10%.

How do we explain the presence of large quantities of exozodiacal dust observed in many exoplanetary systems?

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Herschel has provided many images of cold, Kuiper-like, dust belts orbiting main sequence stars. Interferometric images in the optical and near-IR complement these Herschel images of cold dust with detections of warm, close-in

dust belts, known as exozodi. Such warm dust belts are so bright that material in them is rapidly ground down by collisions. They cannot have survived for the age of the system in their current state without replenishment of material. One potential source of material is the cold, Kuiper-like disc further out in the planetary system. I discuss the potential of this explanation, considering both non-gravitational processes and the scattering of particles by planets that orbit between the belts. Using dynamical arguments, both analytical and computational (N-body simulations), I attempt to constrain the presence and orbits of planets in such systems.

Constraining Debris Disc Radii with Resolved Images from the DEBRIS Survey

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The Herschel DEBRIS survey is a volume-limited survey of 446 of the closest stars at wavelengths of 100 and 160 microns. Many of the discs detected with Herschel were previously detected with Spitzer but the superior angular resolution of Herschel has allowed us to resolve more than 20 of the largest of these discs and for the rest it provides photometry at longer wavelengths, thus allowing us to better constrain the SEDs. Resolved imaging can reveal gaps within debris discs from which the location of potential planets can be constrained, particularly when the disc emission is confined in narrow rings. Without resolved images, an estimate of disc radius can be made from flux density measurements at only two wavelengths given a simple assumption of blackbody grains. However, dust grains in debris discs are not blackbodies, which becomes obvious when the discs are resolved since the resolved images typically show a larger radius to that expected based on the blackbody assumption and an SED. By combining constraints from SEDs with resolved images we can constrain the particle properties. I will present images and model fits of newly resolved discs and discuss what these images reveal about disc and dust properties.

Resolving the multi-temperature debris disk around γ Doradus with *Herschel*

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The *Herschel* DEBRIS (Disk Emission via Bias-free Reconnaissance in the Infrared/Submillimetre) survey is an unbiased, flux-limited survey of 446 nearby main-sequence stars designed to detect and characterize debris disks. One of its science goals is to resolve disks in order to better understand their structure and morphology which depend on the properties of the dust in the disks and are shaped by the presence of large bodies (planets and planetesimals). Resolving debris disks and therefore measuring their physical size helps to constrain degeneracies that exist between disk size and dust grain properties. I will present the first resolved images of the disk around γ Doradus, an F-type star. Detections with both the PACS and SPIRE instruments better sample and constrain the spectral energy distribution (SED) revealing that multiple dust temperatures exist within the disk. *Herschel* also provides the first submillimetre fluxes of this target which we use to estimate a dust mass of $7 \times 10^{-3} M_{\oplus}$. It is unclear from the SED whether the range in dust temperatures is likely due to a spatial distribution of dust or a size distribution of the dust grains. Given the observed shape of the SED, it is not even possible to distinguish between different proposed spatial distributions without the resolved images provided by *Herschel*, as a model of two narrow dust rings reproduces the SED as well as a model of a single wide dust belt does. The resolved images also show dust emission extending beyond the extent of either of the SED models of different spatial distributions, if it is assumed that the dust grains emit like perfect blackbodies. This is a typical result for debris disks since the realistic dust grain properties cannot be determined from the SED alone. Therefore, we must use the resolved images to constrain models of the disk structure and dust properties. I will present our best results for the combined modelling of the SED and resolved images and discuss their implications for our understanding of this planetary system.

SKARPS: The Search for Kuiper belts Around Radial-velocity Planet Stars

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SKARPS is a Herschel survey of debris disks around solar-type stars known to have orbiting planets. When complete, the 100-star SKARPS sample will be large enough for a meaningful statistical comparison between the disk properties of stars with and without planets. (The control sample of stars not known to have planets has already been observed by the Herschel key programme DUNES - DUst around NEarby Stars.) Initial results include previously known disks that are resolved for the first time and newly discovered disks that are fainter and colder than those typically detected by Spitzer. As of November 2011, with only half of the sample in hand, there is no measured correlation between inner RV planets and cold outer debris. While this is consistent with the results from Spitzer, it is in contrast with the relationship suggested by the prominent debris disks in systems with directly imaged planets.

Warm Debris Disks Around Transiting Planetary Hosts

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We have bandmerged candidate transiting planetary systems (from the Kepler satellite) and confirmed transiting planetary systems (from the literature) with the recent Wide-field Infrared Survey Explorer (WISE) preliminary release catalog. We have found 11 stars showing infrared excesses at 12 mic and 2 showing excesses both at 12 and 22 mic. Without longer wavelength observations it is not possible to conclusively determine the nature of the excesses, although we argue that they are likely due to debris disks around the stars. The ratios between the measured fluxes and the stellar photospheres are generally larger than expected for Gyr-old stars, such as these planetary hosts. Assuming that the emission comes from large dust particles, we derive estimates for the disk radii. These values are comparable to the planets' semi-major axes, suggesting that the planets may be stirring the planetesimals in the system.

PIONIER: a four-telescope instrument for the VLTI

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The Precision Integrated-Optics Near-infrared Imaging ExpeRiment (PIONIER) combines four 1.8 m Auxilliary Telescopes or four 8 m Unit Telescopes of the Very Large Telescope Interferometer (ESO, Paranal). Since November 2010, this instrument designed, built and operated by IPAG provides very high angular resolution imaging studies at an unprecedented level of sensitivity. In this paper, we shortly present the PIONIER project, the instrumental concept and the typical on-sky performance. We then present the preliminary results of our on-going programmes, putting a special emphasis on the circumstellar disks around young stars, the hot debris disks and the searches for faint companions and planets.