Overview

- Science
- Instrument status since SDP workshop
- Commissioned observational modes and AOTs
- Problem areas and other issues
- Science highlights
The life-cycle of gas and dust in galaxies

ISM in the Milky Way
- Physical conditions
- Chemistry
- Energetics
- Dynamics
- Isotopic gradients

ISM in Galaxies
- Physical conditions
- Star formation

Star formation
- Physical conditions
- Chemistry
- Energetics
- Dynamics
- Role of Water

Solar System
- Water in Giant Planets
- Chemistry Martian atmosphere

Stellar evolution
- Mass loss
- Composition
- HIFI can be used for many astrophysical questions for which ultra-high spectral resolution is required
- This delivers:
  - Kinematics and dynamics
  - To avoid line confusion
  - To discriminate between emission and absorption
HIFI status

- August 2009: LCU (Local Oscillator Control Unit) anomaly
  - Single event upset in memory bank of LCU
  - Microcontroller confused and starts a “reboot”
  - The standby relay is switched
  - a diode failed in one of the DCDC convertors
- January 2010 and further
  - Restart of HIFI with redundant electronics
  - A short recommissioning is done of the redundant electronics
  - An accelerated Performance Verification is started
  - Double Beam Switch point modes are released
  - Priority Science Programme started
  - Other pointed modes released
HIFI Status (continued)

- We have experienced 4 SEU’s since the start-up in January
- Some time has been lost, but no harm is done to the instrument
- The instrument is never switched-off completely: the LCU is kept in a so-called dissipative mode

- Software is in place to detect SEU’s and to trigger actions in the instrument or of the MOC during the DTCP, HIFI personnel on stand-by
- We expect to do once every year a power cycle of the LCU
Performance Verification - AOT Schemes for Phase 3

Reference scheme

1 - Position Switch

- Mode I – 1
  - Position Switch

2 – Dual Beam Switch

- Mode I – 2
  - DBS or FastDBS
  - Continuum stabilization option

3 – Frequency Switch

- Mode I – 3
  - FSwitch
  - Sky reference option

4 – Load Chop

- Mode I – 4
  - Load Chop
  - Sky reference option

- Mode II – 1
  - OTF
  - Nyquist or lower sampling option

- Mode II – 2
  - DBS or FastDBS Raster
  - DBS or Fast DBS Cross
  - Continuum stabilization option
  - Nyquist or lower sampling option

- Mode III – 2
  - DBS or FastDBS
  - Continuum stabilization option

- Mode II – 3
  - OTF FSwitch
  - Sky reference option
  - Nyquist or lower sampling option

- Mode III – 3
  - FSwitch
  - Sky reference option

- Mode II – 4
  - OTF Load Chop
  - Sky reference option
  - Nyquist or lower sampling option

- Mode III – 4
  - Load Chop
  - Sky reference option
AOTs and mode release

http://herschel.esac.esa.int/AOTsReleaseStatus.shtml

Release notes are available
The noise in the measurements generally corresponds very well with the HSPOT predictions.
Pointing and beam properties

- HIFI measures two polarizations simultaneously in essentially one single pixel
- HIFI is not well suited for determining pointing offsets or drifts
  - No SIAM update done lately
  - Track this in routine calibrations
- Co-alignment between pixels is very good but not perfect → pointing towards synthetic aperture

<table>
<thead>
<tr>
<th>Band</th>
<th>f (GHz)</th>
<th>λ (mm)</th>
<th>FWHM (&quot;)</th>
<th>ΔHV_{ILT} in Y; Z (&quot;)</th>
<th>ΔHV_{COP} in Y; Z (&quot;)</th>
<th>Coupling loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>480</td>
<td>0.625</td>
<td>44.3</td>
<td>-14.5; +1.5*</td>
<td>-6.2; +2.2</td>
<td>0.8</td>
</tr>
<tr>
<td>2</td>
<td>640</td>
<td>0.469</td>
<td>33.2</td>
<td>-4.3; -1.5</td>
<td>-4.4; -1.3</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>800</td>
<td>0.375</td>
<td>26.6</td>
<td>-5.1; -4.3</td>
<td>-5.2; -3.5</td>
<td>1.9</td>
</tr>
<tr>
<td>4</td>
<td>960</td>
<td>0.312</td>
<td>22.2</td>
<td>-1.5; -2.2</td>
<td>-1.2; -3.3</td>
<td>0.9</td>
</tr>
<tr>
<td>5</td>
<td>1120</td>
<td>0.268</td>
<td>19.0</td>
<td>+1.5; +3.6</td>
<td>0.0; +2.8</td>
<td>0.8</td>
</tr>
<tr>
<td>6</td>
<td>1410</td>
<td>0.213</td>
<td>15.2</td>
<td>+0.7; 0.0</td>
<td>+0.7; +0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>7</td>
<td>1910</td>
<td>0.157</td>
<td>11.2</td>
<td>+0.7; -1.5</td>
<td>0.0; -1.0</td>
<td>0.2</td>
</tr>
</tbody>
</table>
HIFI apertures on M3 (pick-off mirror)

HIFI Apertures

Nominal

Chopped

θ$_1$ [arcsec]

θ$_2$ [arcsec]
Beam maps and beam profiles

- Measurements have been made on Mars for every HIFI band a few weeks ago and analysis is ongoing

Band 1 spectra (left), simple triangulation (below, left) and residual after Gaussian beam subtraction (below, right)
Beam efficiencies

- Observations were confronted with Mars model
- Forward efficiency = 0.96
- Beam efficiency = 0.657±0.015
- Aperture efficiency = Beam efficiency/1.015
Polarization

- HIFI’s H and V polarization do not always yield the same intensities
- Due to the source or to the instrument?
- We have not found any instrumental polarization (yet)
- All (but one) can be explained by source structure and the not perfect co-alignment
Beam efficiencies and beam widths

- Beam width fitted very well by theoretical predictions, but with a 9.7dB edge taper rather than the expected 11dB.
- Why is the residue in Band 5 so low?
Frequencies and IF effects

- Generally HIFI’s frequency calibration is excellent!!
- In data processing, we only see problems in spectral scans where bulk velocity shifts are occurring
  - Cause unknown and under investigation – likely a data processing problem
- Note that diplexer bands have higher noise at IF edges – understood - etalon or FP effect
- In areas where high Tsys is seen in the IF, strange baseline effects occur – cause unknown and under investigation – stability problem?
Spurs and impure LO

- HIFI has several areas in which the Local Oscillator is giving an extra signal

- These areas you find in HSPOT when observations are planned
- Generally these areas can be avoided, except in spectral scans, where data need to be masked-out, before further processing is done.

- In total less than 2% of the frequency range available to HIFI has problems like spurs or IF effects

- Bands 3B, 5A, 5B, 6AB, 7AB have some areas with an impure LO
  - Band 5B is not currently used
  - Some areas in bands 6 and 7 are not scheduled yet
Stability

- HIFI is susceptible to (electronic) drifts
- Observing modes are tailored to suppress these drifts as much as possible – observing modes always include a REFerence
- For Bands 6 and 7 we decided that fast chopping is mandatory to reduce drifts – generally the overheads increase with a few percent
- For wide lines fast chopping is recommended also in the SIS bands
- Observing without regular checks of a REF should be avoided (also because of standing wave issues)
Standing waves

- Optical:
  - Towards the internal cold load (~100 MHz)
  - Towards the Herschel secondary mirror (~25 MHz), but to a very low level thanks to a scatter cone
  - Towards the diplexer roof top mirrors (~650 MHz) in bands using Martin-Pupplett for LO injection
  - Towards the LO horns (~94 MHz) – this modulation is observed on the mixer current (LO power modulation), esp. in HEBs

- Electrical
  - Due to the lacking Isolator between the mixer and low noise amplifier in HEBs
  - Shows up as a ~320 MHz standing wave, but structure more complex than simple sine wave
  - Amplitude scales with mismatch of mixer current between ON and OFF phases (impedance change)
Standing waves - examples

Standing waves stronger in V – FitFringe removes most of them very well
Conclusions

- All pointed and raster map modes are released
- Band 5B not offered and some impure regions not scheduled
- Frequency switch not in Bands 6 and 7
- DBS Cross removed for OT AO – solving the last issues needs more time
- OTF
  - On-the-fly mapping is a sort of scan-map in which observing (integrating) is done, while moving the telescope
  - It crucially depends on timing between instrument and telescope
  - We are close too finalizing the last issues with this mode, but have not yet released it

- In general: HIFI works very well
Science high-lights

Outflowing hot material in CRL 618
HF and para-water

HF $J=1-0$
para-$H_2O$ $1_{11}-0_{00}$
Hydrides in High-mass Star Forming Region

CH

NH

SH⁺

OH⁺
A high-mass star forming region
A low mass star-forming region
Conclusions II

- HIFI is working very well
- A lot of new molecules are already discovered
- The spectral shapes vary from very predictable to very awkward

- The molecules first probe the chemistry of the region, but the fact that they are there; and the use of the spectral shapes allow a physical interpretation to be made of the state and evolution of the regions under study
People and institutes instrument development/ICC


And many people in the workshops of all the institutes involved

SRON Netherlands Institute for Space Research; Leiden Observatory, University of Leiden; Joint Alma Observatory, Santiago; Physics Department, California Institute of Technology, Pasadena; KOSMA, I. Physik. Institut, Universit¨at zu K¨oln, K¨oln; Centre d'Etude Spatiale des Rayonnements, Universite de Toulouse [UPS], 31062 Toulouse; CNRS/INSU, UMR 5187 Toulouse; Observatorio Astron 9mico Nacional (IGN), Madrid; 9 Observatorio Astron 9mico Nacional de Yebes, Guadalajara; Chalmers University of Technology, Goteborg; Astronomical Institute, ETH, Zurich; Jet Propulsion Laboratory, Pasadena; Universite de Bordeaux, Laboratoire d'Astrophysique de Bordeaux, Bordeaux; CNRS/INSU, UMR 5804, Floirac; MPI fur Radio Astronomie, Bonn; Istituto Fisica Spazio Interplanetario INAF, Roma; Department of Physics and Astronomy, University of Waterloo, Waterloo; MPI fur Sonnensystemforschung, Katlenburg-Lindau; Laboratoire d’Etudes du Rayonnement et de la Matiere en Astrophysique, UMR 8112 CNRS/INSU, OP, ENS, UPMC, UCP, Paris; LERMA, Observatoire de Paris, Paris; 21 Institut fr Hochfrequenz Techniques, ETH, Zurich, Zurich, Switzerland ETH HF; Department of Astronomy, Stockholm University, Stockholm; Space Research Center of the Polish Academy of Sciences, Warsaw; University of Massachusetts, Astronomy Dept., Amherst; N. Copernicus Astronomical Center, Torun; Experimental Physics Department, National University of Ireland, Maynooth; Netherlands Organisation for Applied Scientific Research (TNO); Applied Physics Department, Delft University; Northrop Grumman Aerospace Systems, Redondo Beach; Centro de Astrobiologia (INTA-CSIC), Madrid; Institut de Radioastronomie Millimetrique, IRAM, St Martin d'Heres; Osservatorio Astrofisico di Arcetri-NAF Florence; European Space Astronomy Centre, ESA, Villanueva de la Canada; European Organisation for Astronomical research in the Southern Hemisphere, Garching
HIFI Spectrum of Water and Organics in the Orion Nebula

© ESA, HEXOS and the HIFI consortium

E. Bergin