# Herschel PACS and SPIRE Spectral Mapping of the OMC-2 Region: Tracing the Morphology and Spatial Distribution of Shocked Gas in Outflows

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## Introduction:

The OMC 2 region is an active star forming complex in the Orion A cloud which contains some of the most luminous protostars in the Orion molecular clouds outside the Orion Nebula, most notably OMC-2 FIR 3 and OMC-2 FIR 4. The low excitation (J < 3) CO observations show collimated outflow centred at FIR 3, with one lobe extending up to FIR 4. No evidence for an outflow from FIR 4 is seen in the low excitation CO maps. We have obtained Herschel PACS & SPIRE maps of the OMC 2 region, as part of the Herschel Orion Protostellar Survey (HOPS). FIR 3 (HOPS 370) and FIR 4 (HOPS 108) are the brightest line emitters in the entire HOPS sample. Here we present our analysis of the spatial distributions of high excitation (Jup = 4 - 43) CO, $H_2O$, OH and [OI] line emission which trace the currently shocked, hot gas in the OMC 2 region associated with FIR 3 & FIR 4.

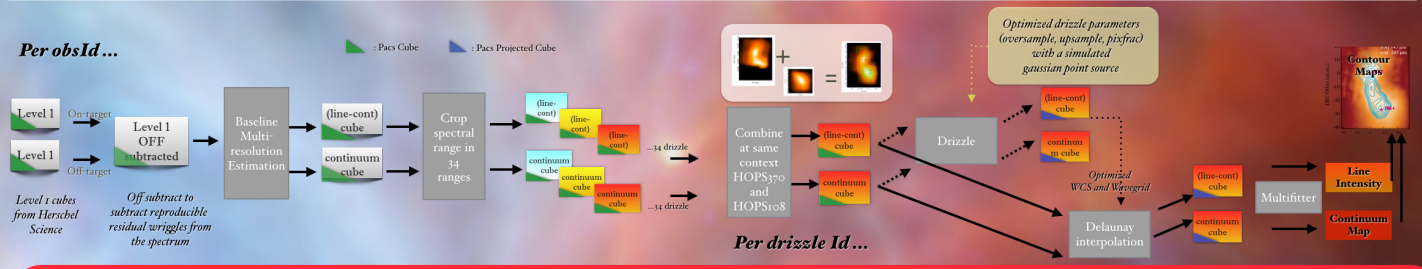
## Observations:

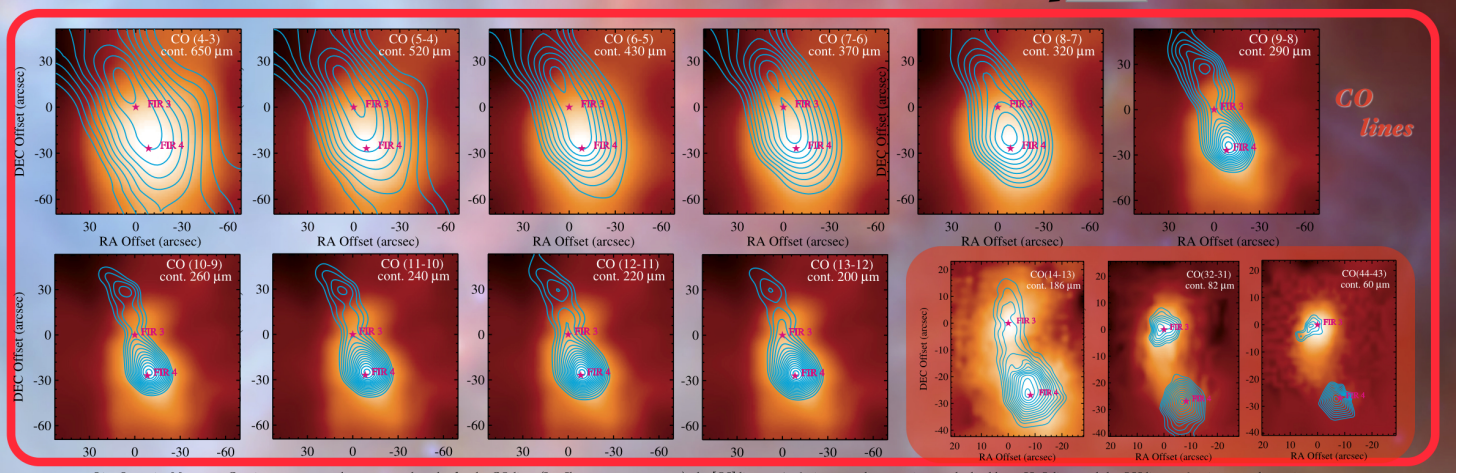
PACS unchopped range or SED (Spectral Energy Distribution) mode observations cover the range (57-198) microns (B2B/R1 & B3A/R1 spectral bands).

SPIRE spectrometer mapping observation with full spatial sampling at high spectral resolution (1.2 GHz). The SPIRE spectrometer covers (400 - 1000) GHz frequency range. The design of the observations has been optimised for crowded field spectroscopy providing unique dataset of long range oversample mapping and pointed observations in the OMC2 region.

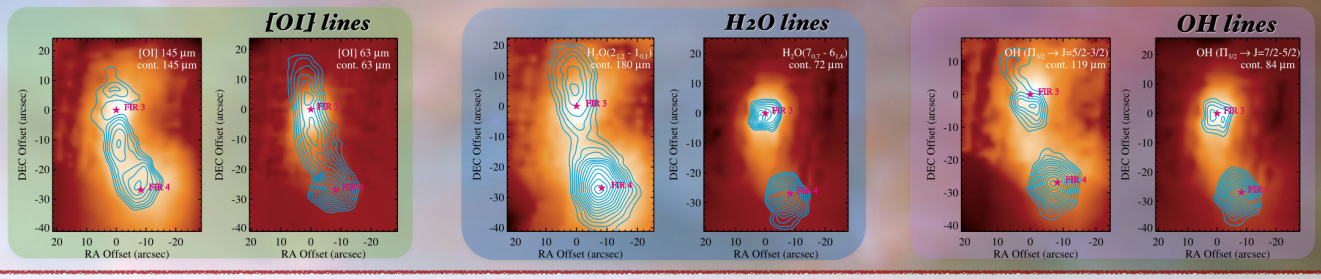
## Data Reduction:

Our aim is to reconstruct a hyperspectral cube (Ra,Dec,λ) of the mapped area. HIPE interactive pipeline (HIPE 12.0) is used for both PACS and SPIRE observations for flux- and spatial calibration. SPIRE processing was performed with the standard recipe until the maps generation and also PACS processing until the generation of Level 1 PACS Cubes (dot-cloud). Special steps executed to generate the PACS maps are detailed at the following **pipeline work flow:**




Line Intensity Maps over Continuum maps, at the same wavelength, for the CO lines (Jup-Jlow=44-43, 32-31, 14-13), the [OI] lines at 63.18microns and 145.52 microns, the backbone H2O lines and the OH lines at 84microns and 119 microns




**Summary:** We have presented the first far-IR emission line maps of the OMC 2 region. These maps show line emission from two sources OMC2 FIR3 and FIR4.

Low-J (Jup < 8) CO line emission, which is dominated by the warm molecular gas entrained by the jet, peaks at the location of FIR3. Emission in lines higher up in the CO ladder, which traces hotter, shock-heated gas, peaks at FIR 4. All the high excitation lines observed with PACS, peaks at the location of FIR 4.

An extended "jet" of emission is found centred on OMC 2 FIR3 (HOPS 370), a 300 solar luminosity protostar with an inferred infall rate of around $10^{-5}$ M⊙ per year (Adams et al. 2012); this jet appear to arise in outflow shocks from a previously known outflow (Shimajiri et al. 2008). In addition, very strong and compact emission is found centred on the deeply embedded protostar FIR4 (HOPS108). Due to the deeply embedded nature of the source, it's luminosity is uncertain but is less than 100 L⊙ and may be as low as 12-14 L⊙ (Furlan et al. 2014). The infall rates of this source are (1-10) times that of FIR3 (Furlan et al. 2014). The line emission probably arises in outflow shocks produced by this deeply embedded protostar (Manoj et al. 2013); this is strong evidence that this protostar is producing a very compact, but very powerful molecular outflow.

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