Water profiles of Intermediate Mass YSOs from *Herschel*-HIFI

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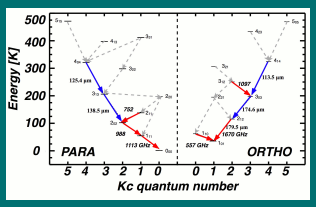
We present H_2O profiles observed toward Intermediate Mass YSOs with HIFI onboard *Herschel*. The data presented has unprecedented resolution at these wavelengths and constitute a part of the legacy of the Water in Star Forming Regions with Herschel (WISH) Key Program. Intermediate Mass YSOs exhibit properties common to both low- and high-mass stars and can act as a nearby, more easily observable proxy to high-mass star formation but can also elucidate the differences between low- and high-mass star formation, and under what conditions these differences occur. Our sources have been chosen to encompass a range of properties in order to investigate what water can tell us about these important objects and include; Class 0 and Class 1 objects; those forming in isolation and in clustered environments; and, sources with or without known outflow. In this presentation we compare and contrast water profiles among our sources. The observations were made toward the YSO but the H_2O profiles are dominated by the outflow rather than the central envelope and can be modelled as consisting of a broad component due to the outflow, a medium component due to the envelope and, in the case of the ground state lines a narrow component in absorption resulting from self-absorption by the cold outer envelope. Despite this commonality, the set of observed profiles are distinct from source to source indicating that information about individual sources can be discerned from the data. Work is underway to investigate correlation of line properties with source characteristics.

Water in Star Forming Regions with Herschel (WISH) is a Key Program of the *Herschel Space Observatory* aimed at studying the physical and chemical properties of YSOs. Water and related molecules are observed in order to trace abundances and conditions at all important phases of star formation from envelope collapse to disk formation[1].
The WISH source list includes YSOs of a wide ranges of masses and evolutionary state. This poster deals with *Herschel*-HIFI observations of Intermediate Mass YSOs.

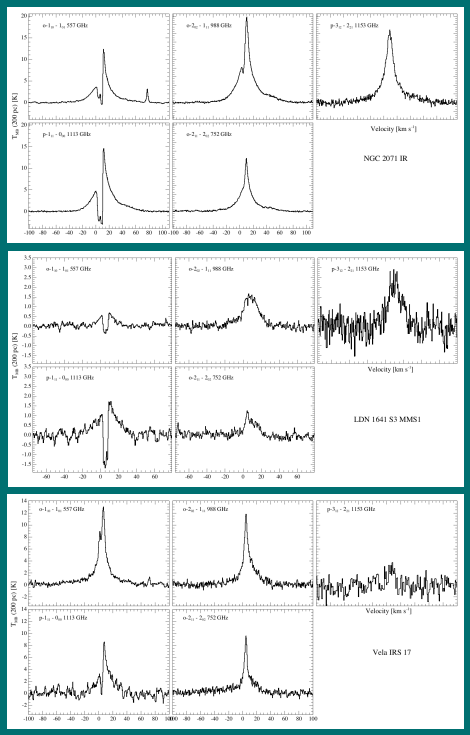


The abundance of water can vary by orders of magnitude between warm and cold regions[2,3]. Therefore, it is an excellent tracer of any process by which energy is deposited into the gas.
The plot above shows the H_2O lines observed in the WISH program with HIFI (red) and PACS (blue)

Source	Lbol ($L_\odot$)	Class	d (pc)	V_{LSR} (km/s)
NGC 7129 FIRS 2	430	0	1250	-9.8
NGC 2071 IR	520	0/I	422	9.6
L1641 S3 MMS 1	70	0	465	5.3
Vela IRS 17	715	I	700	3.9
Vela IRS 19	766	I	700	12.2
AFGL 490	2000	II	1000	-13.5

WISH Intermediate Mass sources.

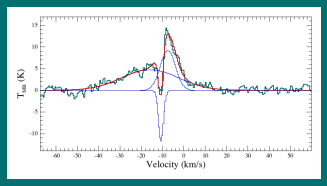
Examples of variety in H_2O profiles from Intermediate Mass YSOs



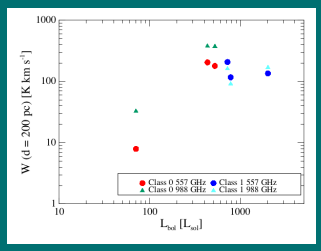
For ease of comparison, spectra have been scaled to a distance of 200 pc

- Self-absorption is always deeper in the 1113 GHz line than in 557 GHz, indicating the envelope is cooler than 50 K. The self-absorption in Class I sources, e.g Vela IRS 17, is less pronounced as expected for less embedded sources.
- Emission coming from cold clumps along the line of sight is especially notable in the 1113 GHz profiles
- Line profiles are all similar widths: outflows dominate. However, the 988 GHz line is typically the narrowest nearest the line centre and may provide more information about the envelope while the 752 GHz line is typically displays the broadest line wings and appears more sensitive to the outflow.
- The relative strength of the 1153 GHz line compared to other transitions is the varies most among our sources, it is possible that this indicates the presence of a hot core.

Work is underway to investigate correlations between line properties and source characteristics.



Here the 557 GHz profile of NGC 7129 is shown in dark green. It can be reproduced with a model (red line) comprising three Gaussians (blue lines) representing the outflow, the envelope and an absorption due to the envelope[4].



Integrated fluxes of the 557 GHz and 988 GHz lines (scaled to 200 pc) plotted against L_{bol}. The expected trend with evolution is seen for both transitions.

Observations and Data reduction:
Data were obtained in Point DBS mode except for the 557 GHz and 1113 GHz transitions, which were taken in Point mode Load Chop with sky reference due to concerns about potential emission in chop positions. NGC 7129 FIRS 2 and NGC 2071 IR were observed using DBS mode at 1113 GHz during PV and SDP , and did not suffer from contaminated chop positions.
Data was reprocessed using HIPE 7 RC 3. Data reduction, involving baseline removal, conversion to T_{MB}, line fitting and production of plots, was performed using HIPE 8.0.

References:
[1] van Dishoeck et al., 2011, PASP, 123, 138
[2] Cernicharo et al . 1990, A&A, 231, 15
[3] van der Tak et al., 2006, A&A, 447, 1011
[4] Johnstone et al., 2011, A&A, 521, 41