Herschel/PACS observations of Class 0/I low-mass young stellar objects

Agata Karska[1,2], G. Herczeg[1], E.F. van Dishoeck[1,2], L.E. Kristensen[2], S. Bruderer[1], R. Visser[3], S. Wampfler[4] and WISH team

[1]MPE, Garching, Germany [2]Sterrewacht Leiden, The Netherlands [3]University of Michigan, USA [4]ETH Zurich, Switzerland

Motivation

✧ We want to address the following questions: **how is energy deposited into the envelope of YSOs?** Is this energy transferred mainly through mechanical (shocks) or radiative (UV, X-ray heating, disk emission) processes? How does this affect the chemistry?

✧We present the results of far-IR Herschel/PACS observations of 16 **Class O/I YSOs** obtained in the **Water In Star-forming regions with Herschel** (WISH) key program

✧ Far-IR region contains main cooling lines of [OI], [CII], CO (up to J=48-47), OH and H_2O

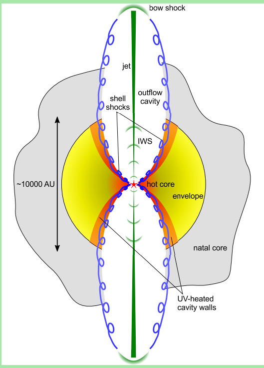

Fig.1. Physical structure of YSO

IRAS 4B / PACS Full Scan

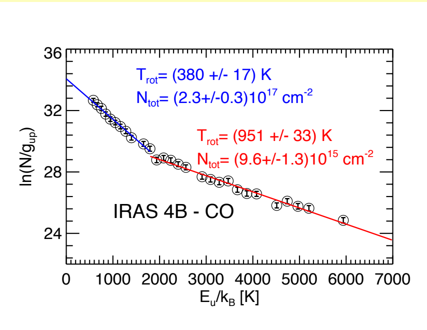

Fig.2. Rotational diagram of NGC 1333 IRAS 4B

✧ Full scan observations of the source show **two distinct components in CO rotational diagram** of T_{rot}=380±17 K for J=14-25 and T_{rot}=951±33 K for J=26-48

✧ Column densities were calculated for emitting area radius of 850 AU and T_{kin}=1000 K (see water modelling of IRAS 4B in Greg Herczeg+ poster!)

✧ Resulting **water and CO abundance ratio for IRAS 4B**: $X(H_2O)/X(CO)\approx 20$

Rotational temperatures

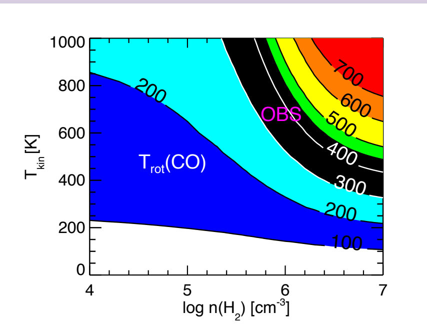

Fig.3. RADEX models vs. observations

✧ Plane-parallel slab models for densities log n=4-7 cm^{-3} and T_{kin}=10-1000 K in optically thin regime were calculated for CO J=14-25 using RADEX (van der Tak+07)

✧ Colored contours show rotational temperatures from the models

✧ Black area: results of PACS observations (IRAS 4B: 380 K, SerSMM1: 368 K, SerSMM3: 306 K, L1489: 452 K, IRAS15398: 300 K)

✧ **Range of observed "cold" T_{rot} is narrow (300-450 K)**

✧ **High densities and temperatures are needed to explain the observations**

Extended emission

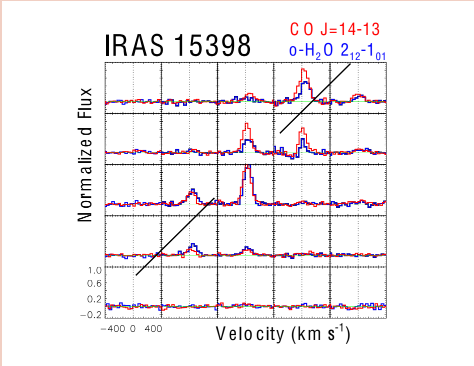

Fig.4. Spectral map of IRAS 15398-3359

✧ PACS offers 5x5 spaxels (9.4''x9.4'' each) mapping of sources

✧ Most objects in our sample show **extended emission in CO, H_2O, OH** that cannot be attributed to PSF

✧ **Water is often well-aligned with CO and outflow, but some differences are observed**

Cross-sample line survey

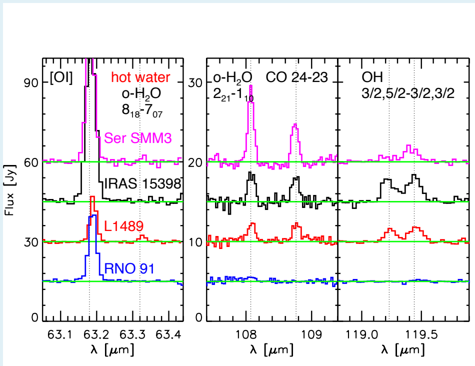

Fig.5. Line survey of Class O/I objects

✧ H_2O detected in all objects, but a wide range of intensities correlated with CO

✧ **No correlation of L_{bol} vs. H_2O and CO**

Conclusions

✧ **H_2O and CO emission is always detected in Class O/I objects** and is often extended along outflow, while hot water is detected only in a few sources (see S. Wampfler poster for comments about OH emission!)

✧ **Excitation diagrams show two components**; no single shock model can explain both of them; both C-shocks and PDR can play a role (Visser+ 2011)

✧ 1D modelling shows that in order to reproduce such T_{rot} **high densities and kinetic temperatures are required** (log n >5.5 cm^{-3} and T_{kin}>400 K)

✧ Water and CO line intensities, contrary to OH, don't seem to depend on L_{bol}

References

✧ Herczeg, G.+ poster and Wampfler, S.+ poster

✧ Visser, R., Kristensen, L.E., Bruderer, S., et al., 2011, A&A, submitted

✧ Van der Tak, F.F.S., Black, J.H., Schöier, F.L.,et al., 2007, A&A 468, 627-635