A HIFI survey of water in massive star forming regions in the inner Galaxy

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Water is a key constituent of star-forming matter, but the origin of its line emission and absorption is not well understood. In particular it is not clear whether its abundance in gas phase is governed by sputtering of icy mantles or by high-temperature chemistry. WISH (van Dishoeck et al. 2011, PASP, 123, 138) investigated the excitation, abundance, and chemistry of H_2O over a broad range of luminosities and evolutionary stages in low-mass and high-mass YSOs. However, WISH targetted only important template sources. Here, we take advantage of the unbiased nature of the ATLASGAL (Schuller et al. 2009) dust continuum survey of the inner Galaxy to study the excitation, abundance, and chemistry of water in a statistical sample of 100 sources representative of the proto-cluster Galactic population.

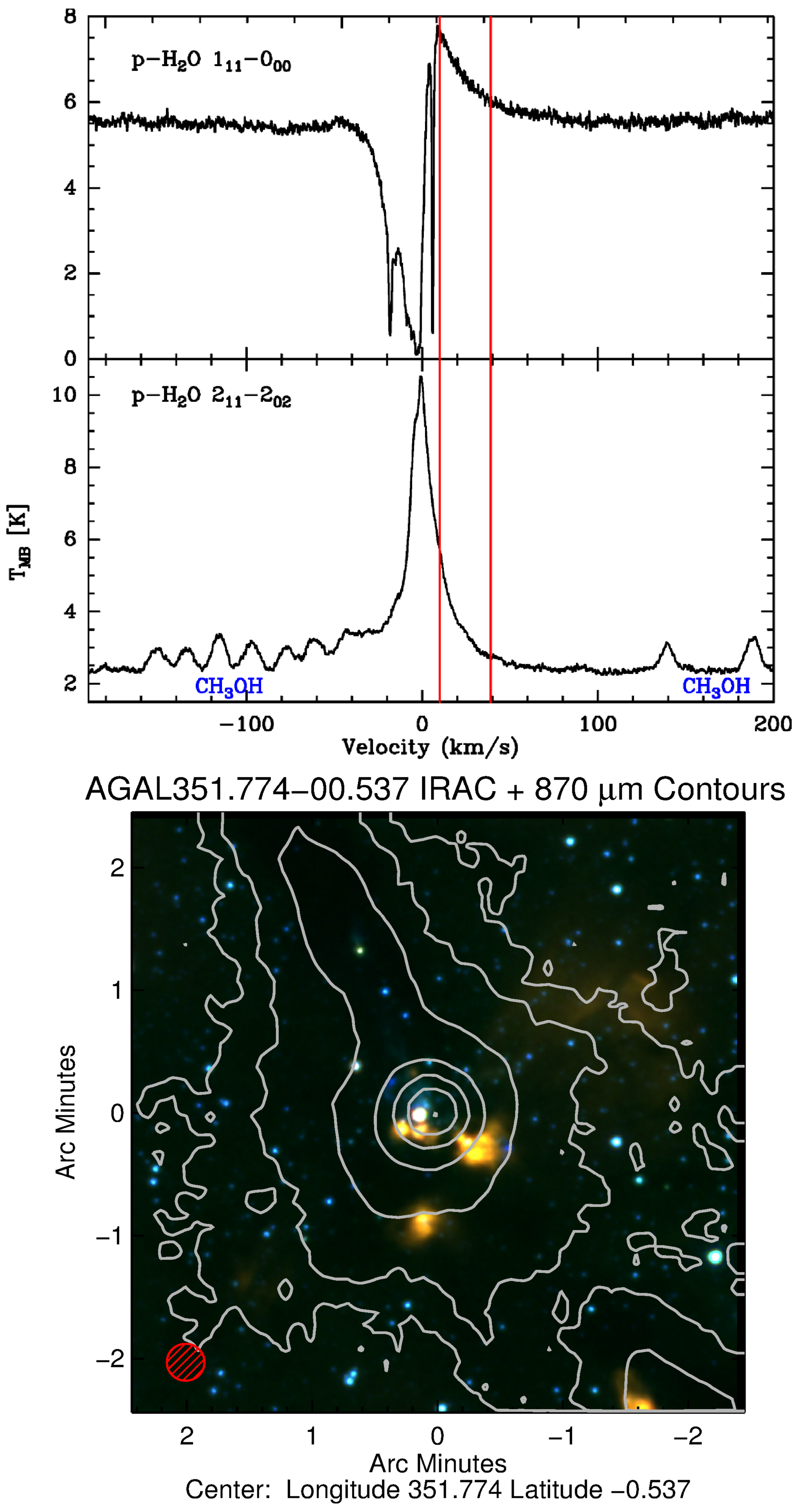

Figure 1: Example 1113 GHz and 752 GHz spectra (top, Leurini et al. 2014 , A&A, 564, L11) in one of the HII top-100 sources (bottom: LABOCA+4.5, 5.8 and 8 µm IRAC three band colour image)

The ATLASGAL top-100 sample

We selected a new flux limited sample of 100 ATLASGAL sources with a broad range of evolutionary stages and masses to be representative of the whole Galactic protocluster population. The are the 870 µm brighest:

- ❑ **HII regions and bright, luminous hot cores (IR bright and have cm continuum emission)**
- ❑ **Massive young stellar objects based on the Lumsden et al. (2002, MNRAS, 336, 621) MSX criteria (IR bright *with no cm continuum emission*)**
- ❑ **Sources on the verge of massive star-formation (ATLASGAL clumps dark in WISE at 24 µm dark clumps)**

The sample is fully characterised in terms of distances, masses and luminosities (Giannetti et al. 2014, A&A in press; Wienen et al. 2012 A&A, 544, A146; Wienen et al. 2014, subm., 2014; König in prep.).

Observations

- ❑ ***Herschel* HIFI in the three lowest energy para-H_2O lines** at 1113 GHz, 988 GHz and 752 GHz (see Leurini et al. 2014**,** A&A, 564, L11 for preliminary science and Fig.1);
- ❑ complementary line surveys with IRAM-30m, MOPRA (3 mm) and APEX (0.8 mm): these cover tracers of shocks, high-temperature chemistry, and photo-dissociation regions;
- ❑ complementary maps in several isotoplogues with APEX to investigate the morphology of high-velocity emission and the relation between H_2O and mid-J CO.

These data shed light on the kinematics, the physics and the chemistry of the sources as function of evolutionary phase and mass.

H_2O properties

✓ The profiles of the H_2O high excitation lines are dominated by high-velocity emission;

✓ The H_2O luminosity of the 988 GHz (L_{988GHz}) and 752 GHz (L_{752GHz}) lines increases with the bolometric luminosity (L_{bol}) of the source in the range 10–10^6 $L_\odot$ (Fig. 2a);

✓ The ratio of L_{752GHz} to L_{987GHz} increases as function of L_{bol} (Fig. 2b);

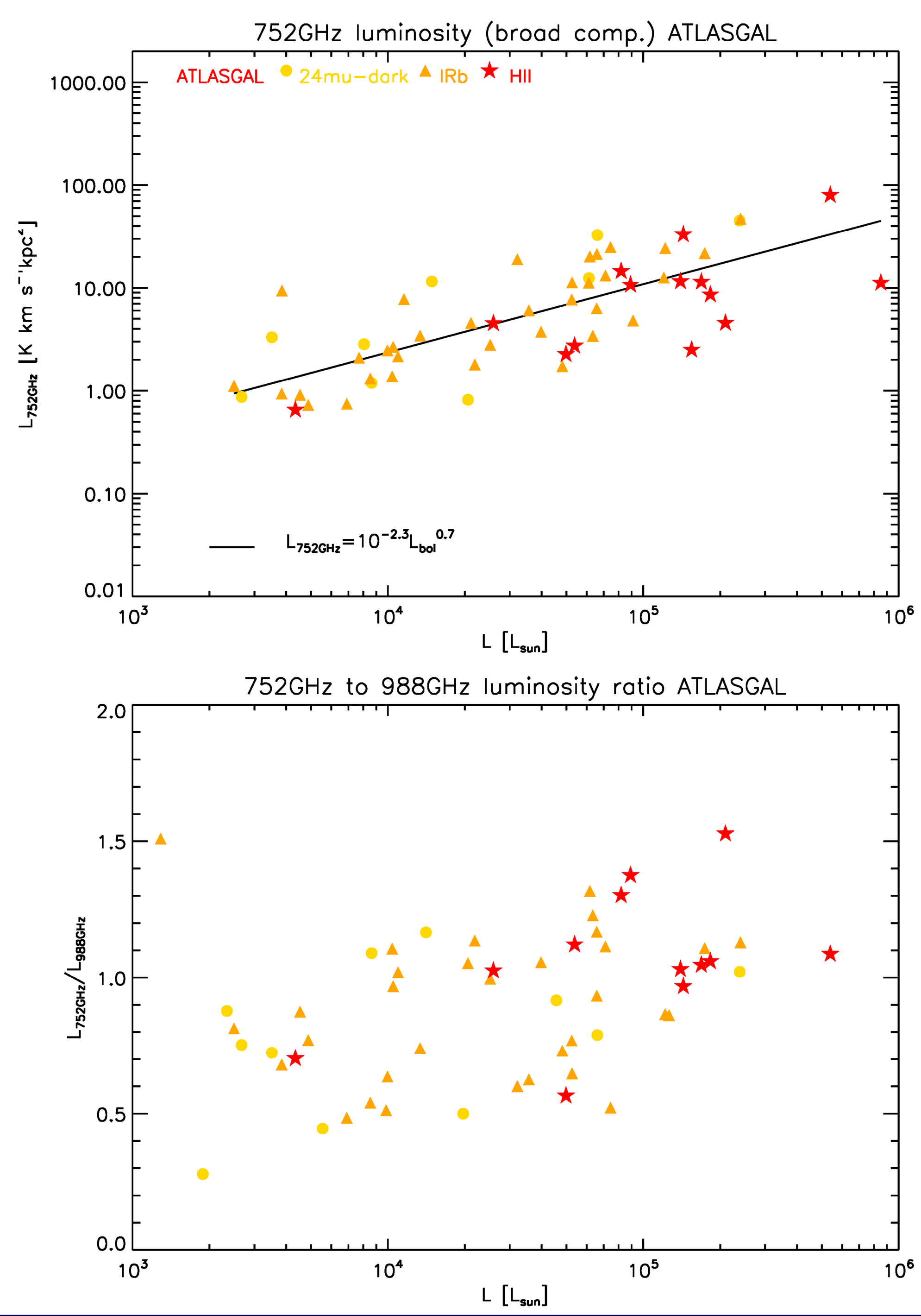

Figure 2: The luminosity of the 752 GHz line in the top-100 sample (top) and the ratio of the 752 GHz to 987 GHz areas as function of L_{bol} (bottom)

Chemistry

The ancillary observations allows us to investigate whether sputtering of icy mantles or high-temperature chemistry dominate the production of water by comparing the behaviour of different species as a function of the source luminosity (Fig. 3) and mass with that of water. The luminosity of methanol, for example, increases with L_{bol} as for H_2O but in a less steep way.

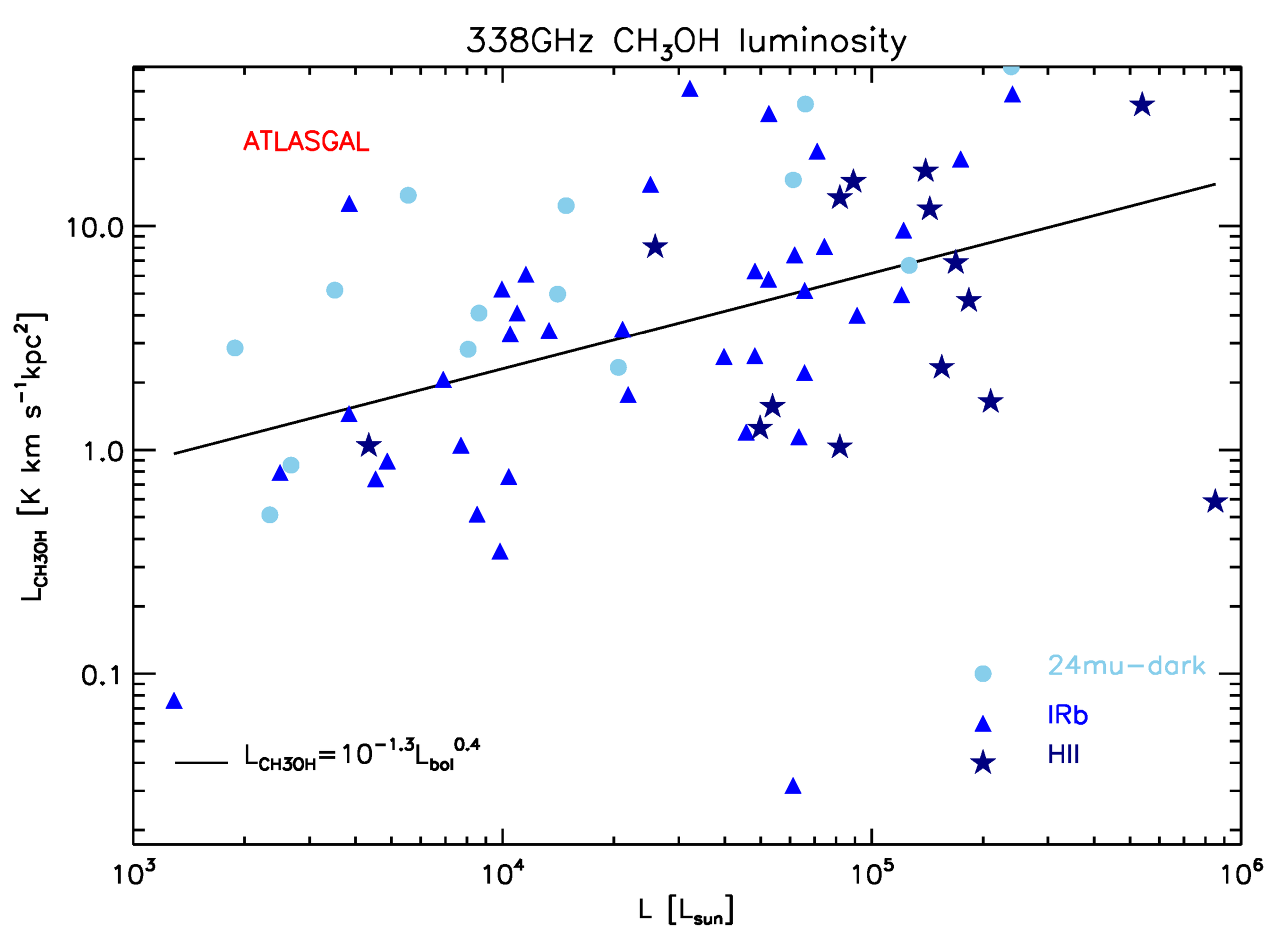

Figure 3: The luminosity of methanol at 338 GHz in the top-100 ATLASGAL sample

Outlook

- To investigate the chemistry of other molecular species and compare with H_2O;
- To compare H_2O with mid- and high-*J* CO lines;
- To derive H_2O abundance at high-velocity and compare outflow energy, momentum and mass in water compared to other tracers.