The background of the slide is an astronomical image of a nebula. It features a bright, blue, irregularly shaped core on the left side, surrounded by a diffuse, greenish-yellow glow. The rest of the image is filled with intricate, filamentary structures in shades of yellow, orange, and brown, set against a dark, almost black background. These filaments appear to be part of a larger cloud of gas and dust, possibly illuminated by a nearby star or cluster of stars.

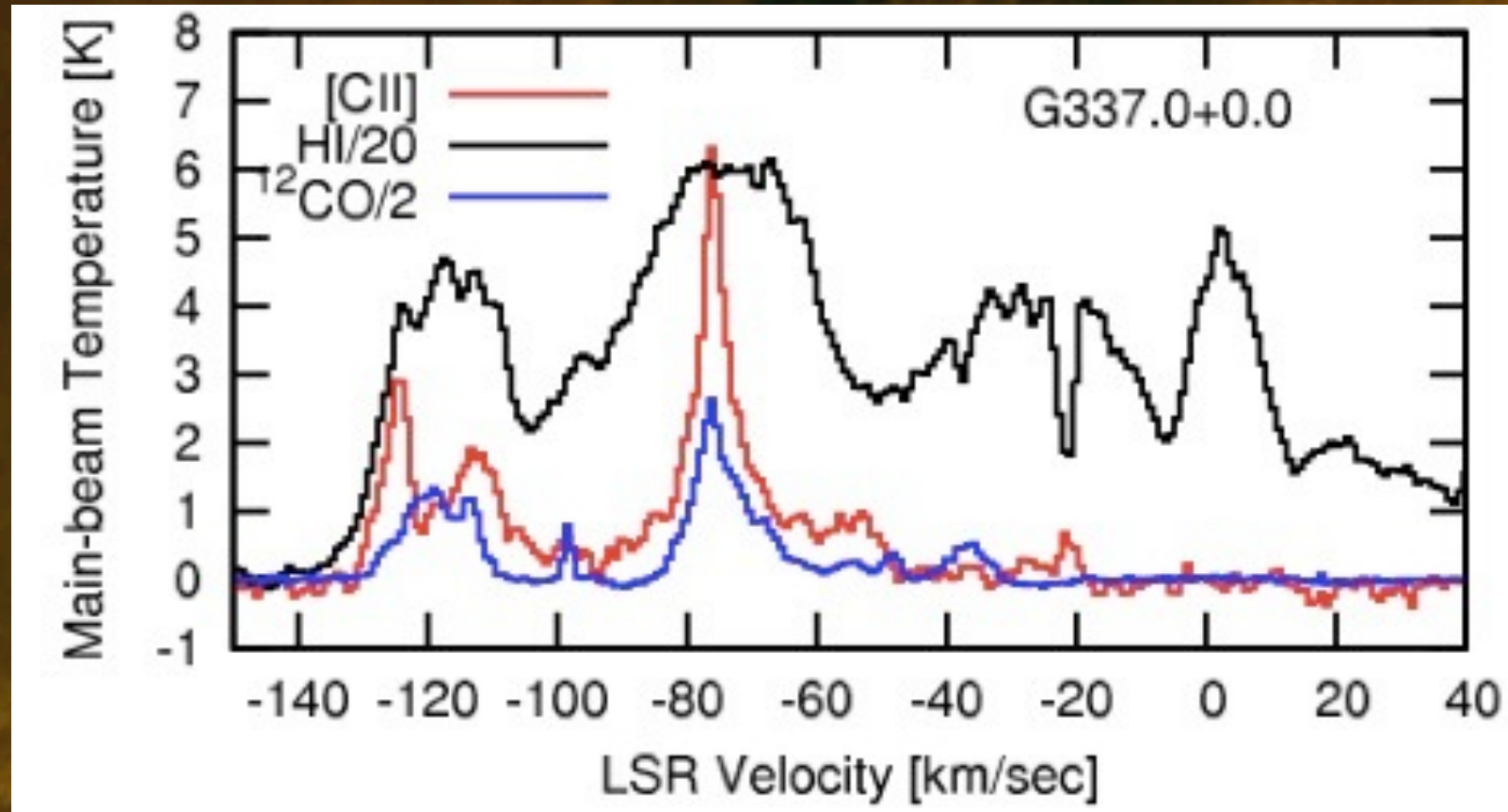
Water Astrochemistry ISM Physics

Fundamental Astronomy

- ISM constituents
- ISM dust formation
- Ionization rate through astrochemistry
- THE way to study objects in astronomy

Dark H₂

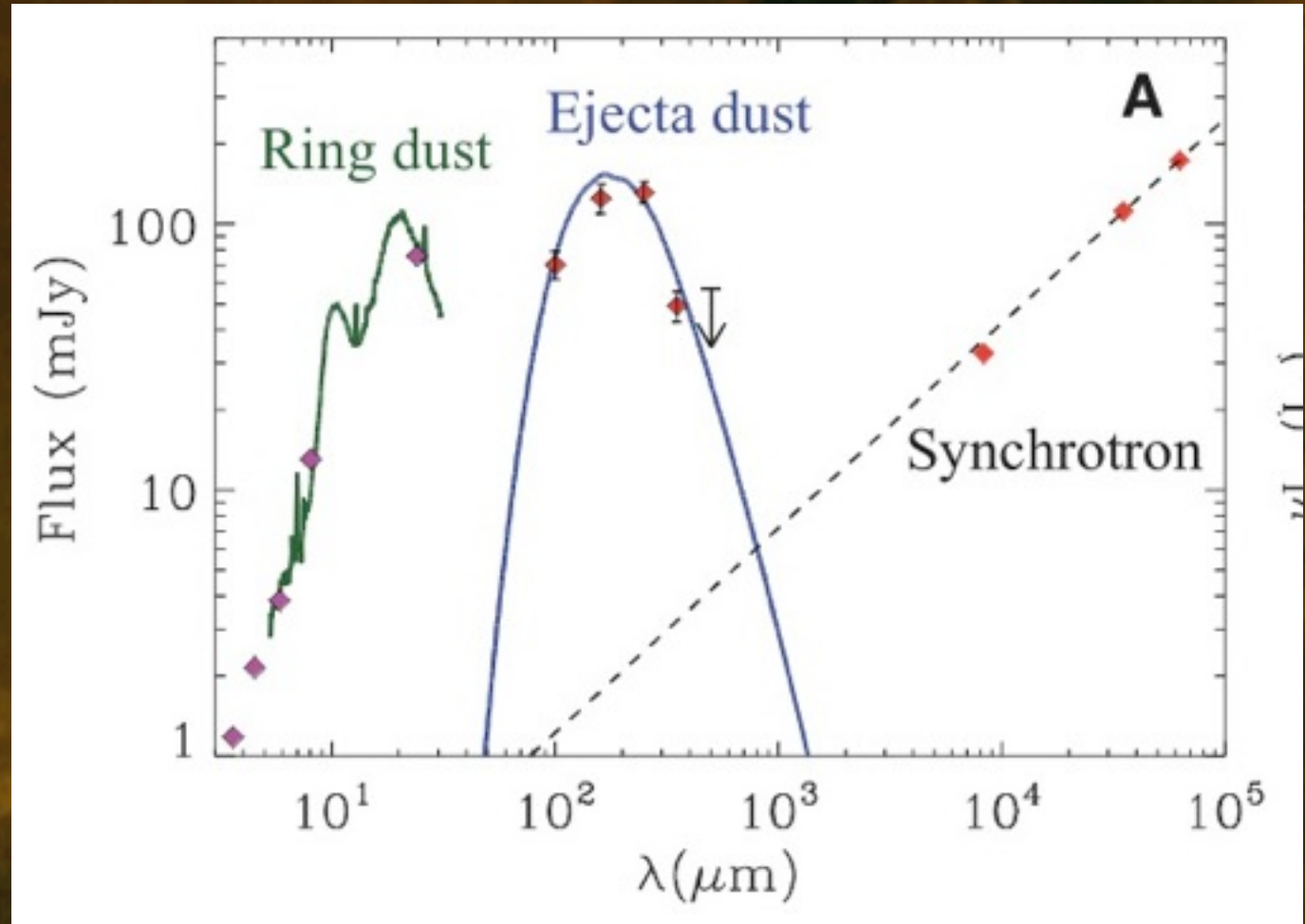
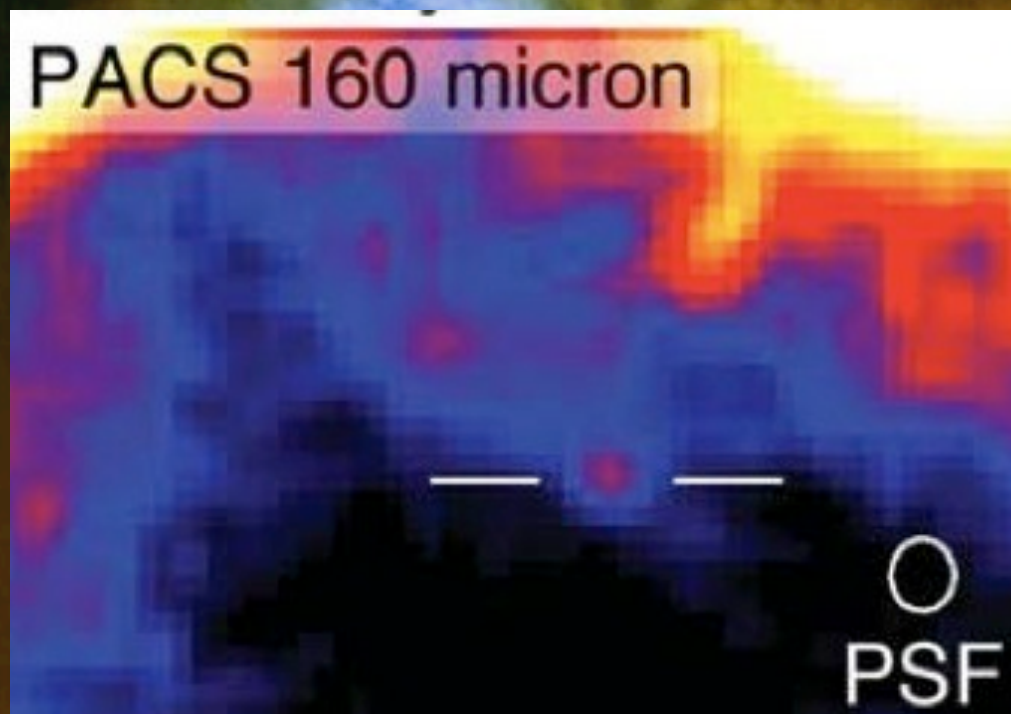
- C⁺, HF
- accounts for ~30% of the molecular mass of the milky way



Pineda et al. 2013

- context:
 - ➔ Molecular hydrogen halo's without CO around CO-traced molecular cloud
 - ➔ formation/destruction of molecular clouds

SN 1987A



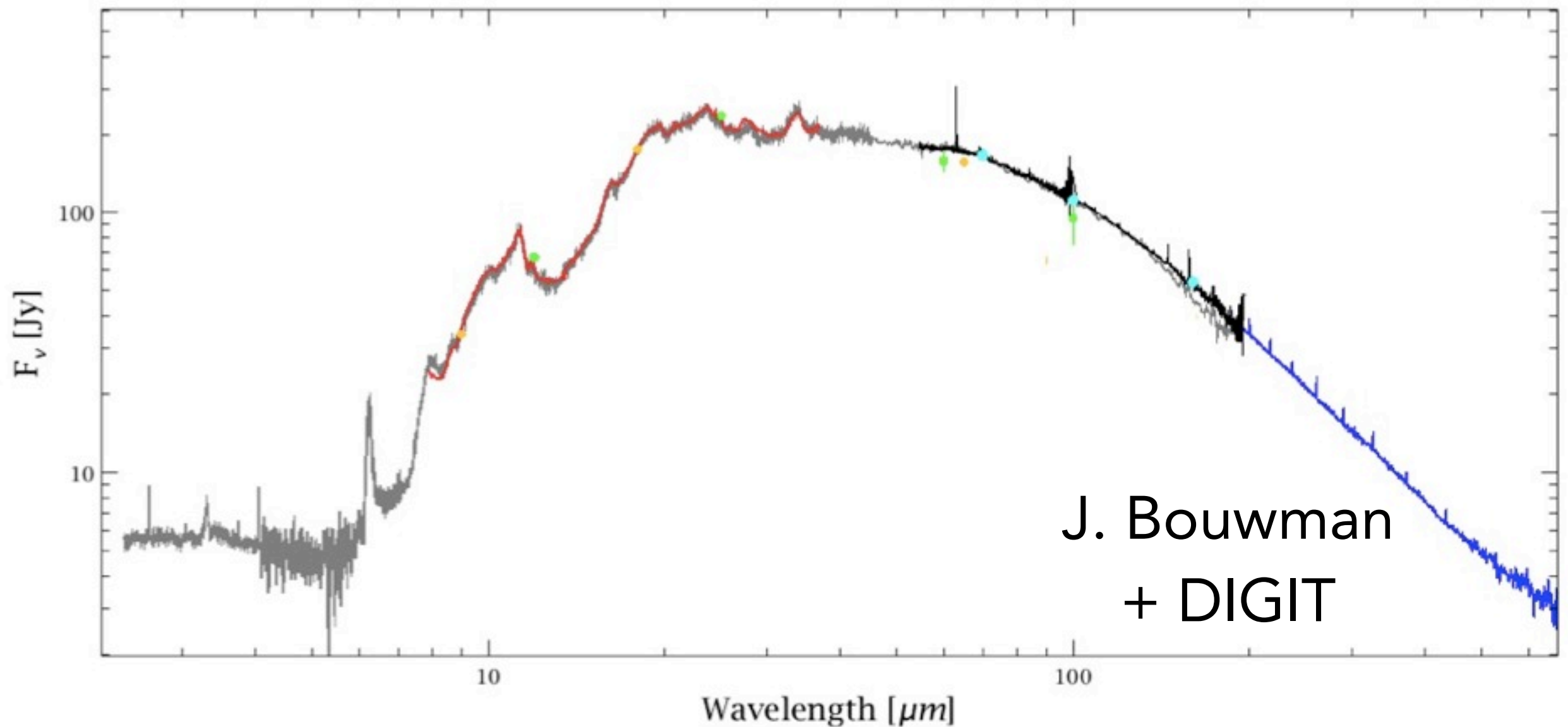
- 0.4-0.7 solar masses of dust made in ~20 years!

Short-lived Ions as probes

- detection of OH^+ , H_2O^+ - completely new and provides a unique measurement of the ionization rate of the diffuse ISM --- CH^+ not new but now spectrally resolved
- key points:
 - ➔ ions are short lived with a lifetime of $30 \text{ yrs} \times [1 \text{ cm}^{-3}/n(\text{H}_2)]$
 - ➔ needs high production rate -- if you know $n(\text{H}_2)$ you can estimate the formation rate, i.e. ionization rate or trace energy
 - ➔ direct link between extragalactic and galactic science -- this is from the diffuse ISM which fills a telescope beam

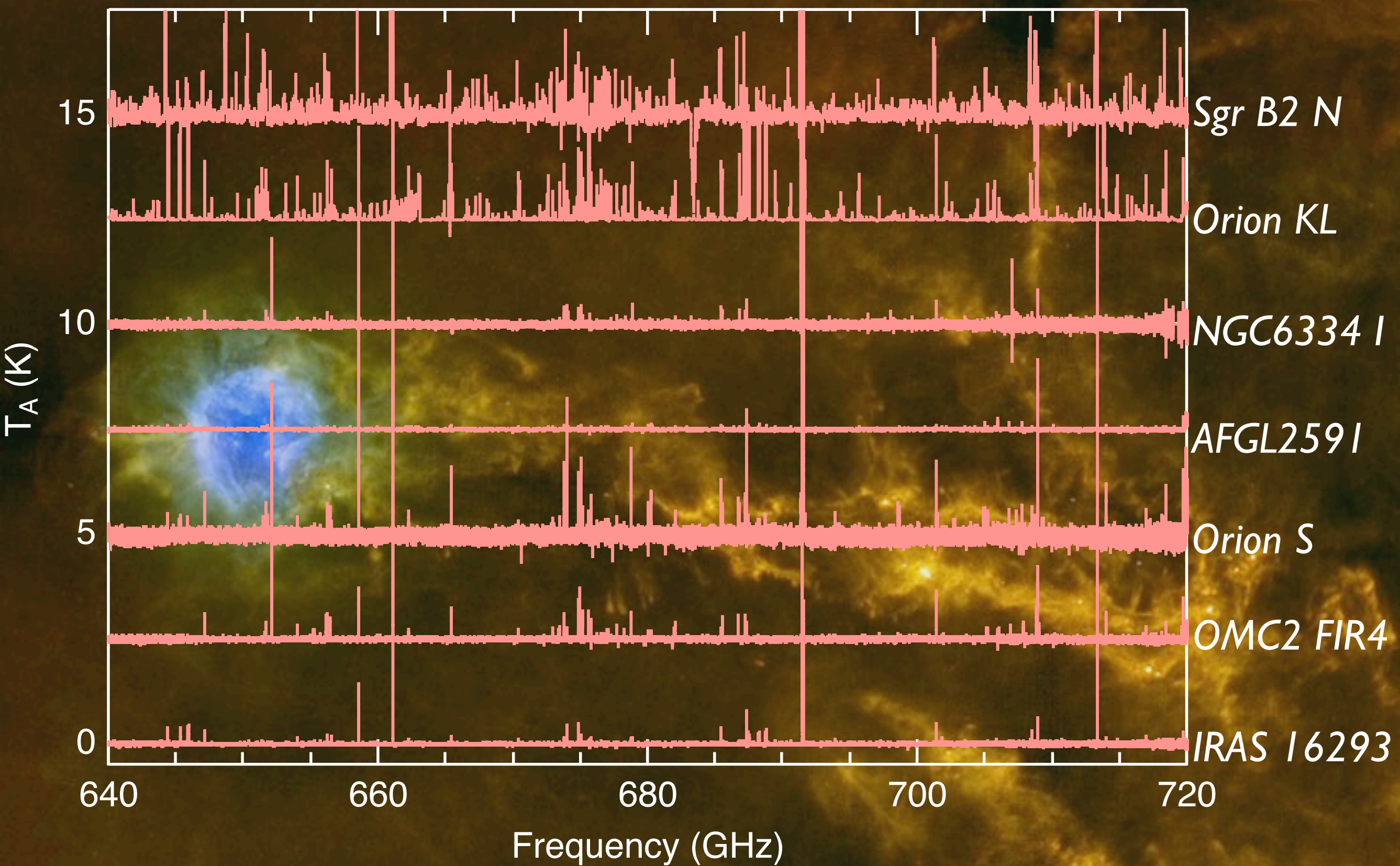
THE way to understand...

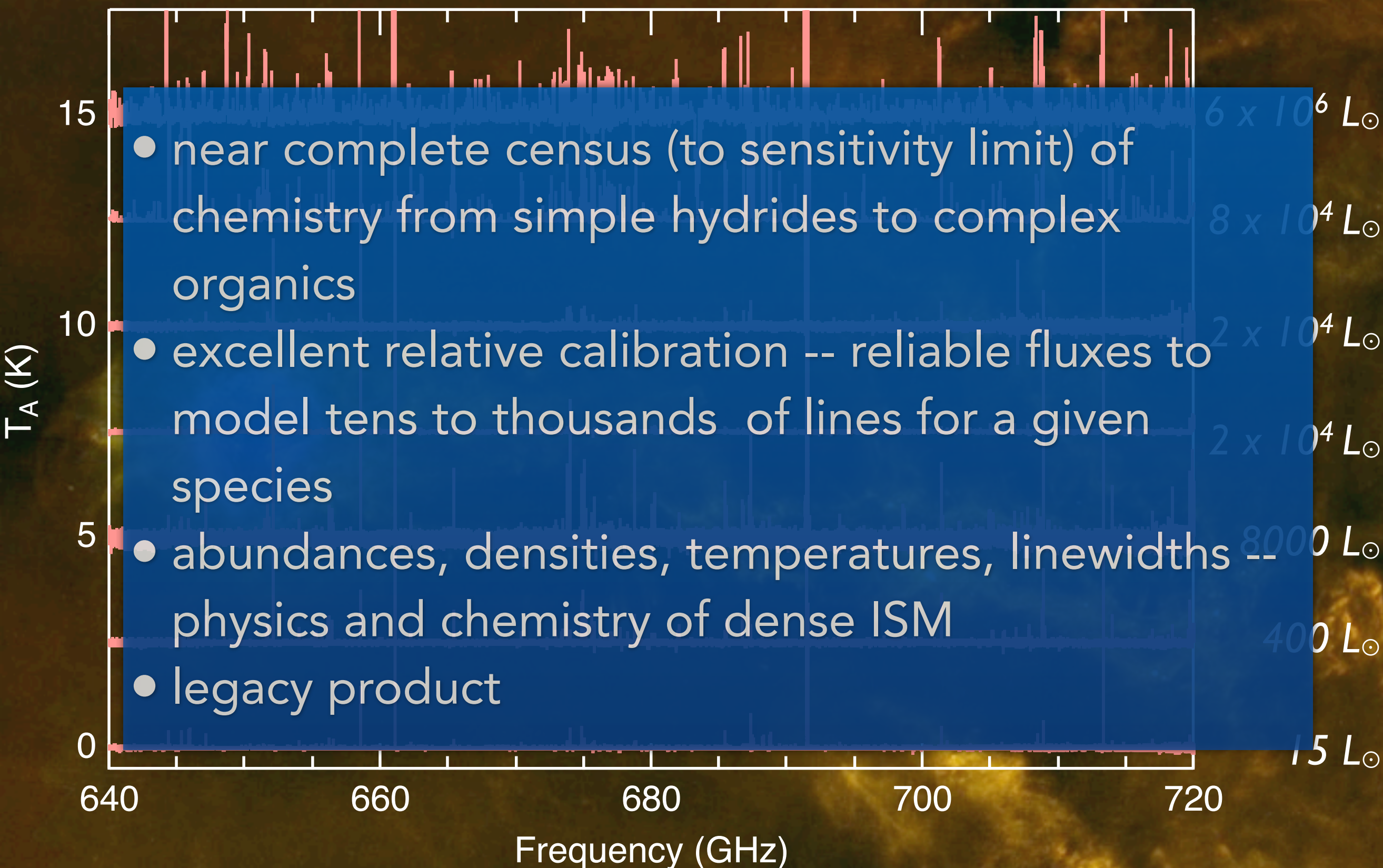
HD100546 observed on OD211



J. Bouwman
+ DIGIT

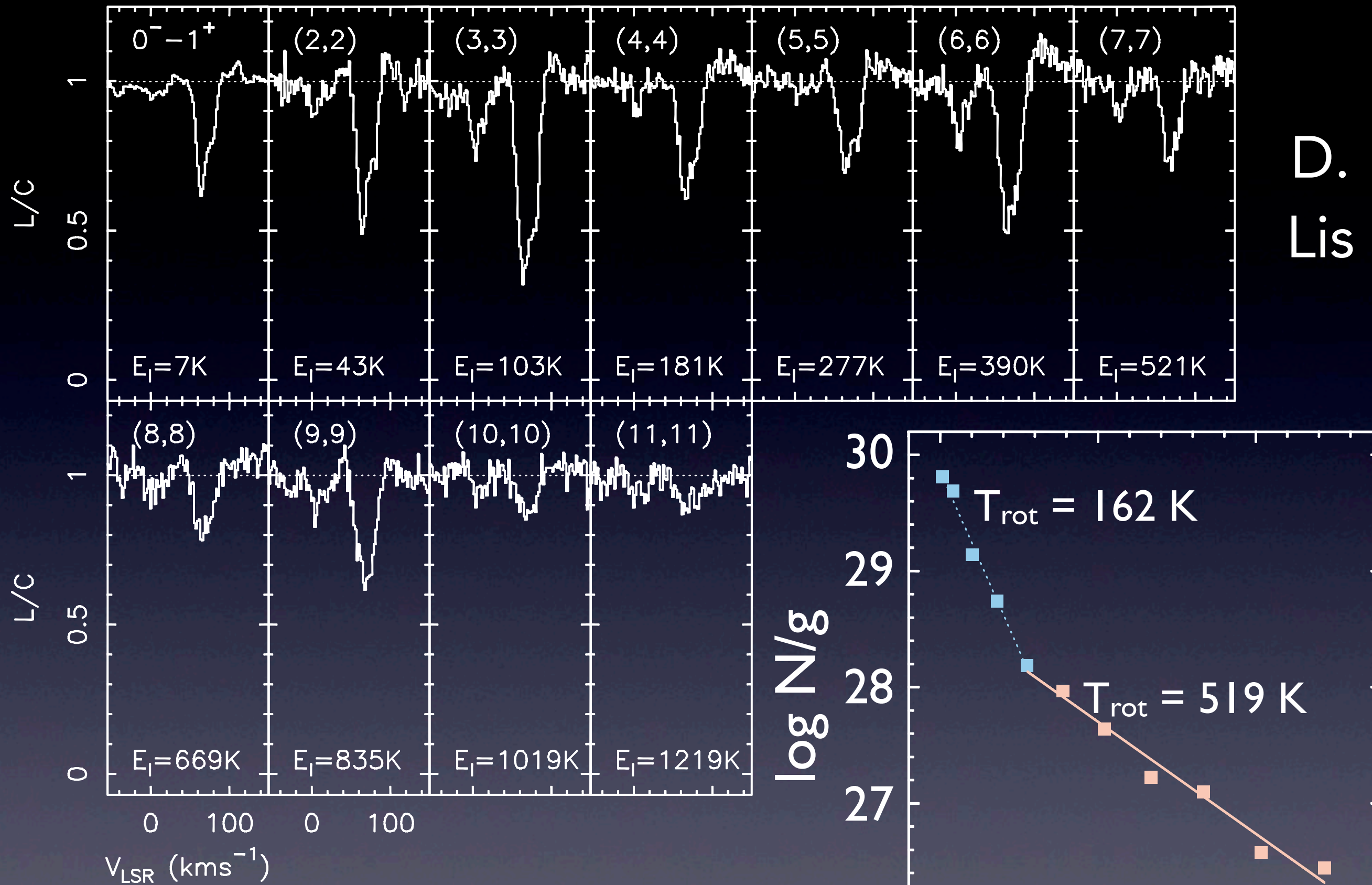






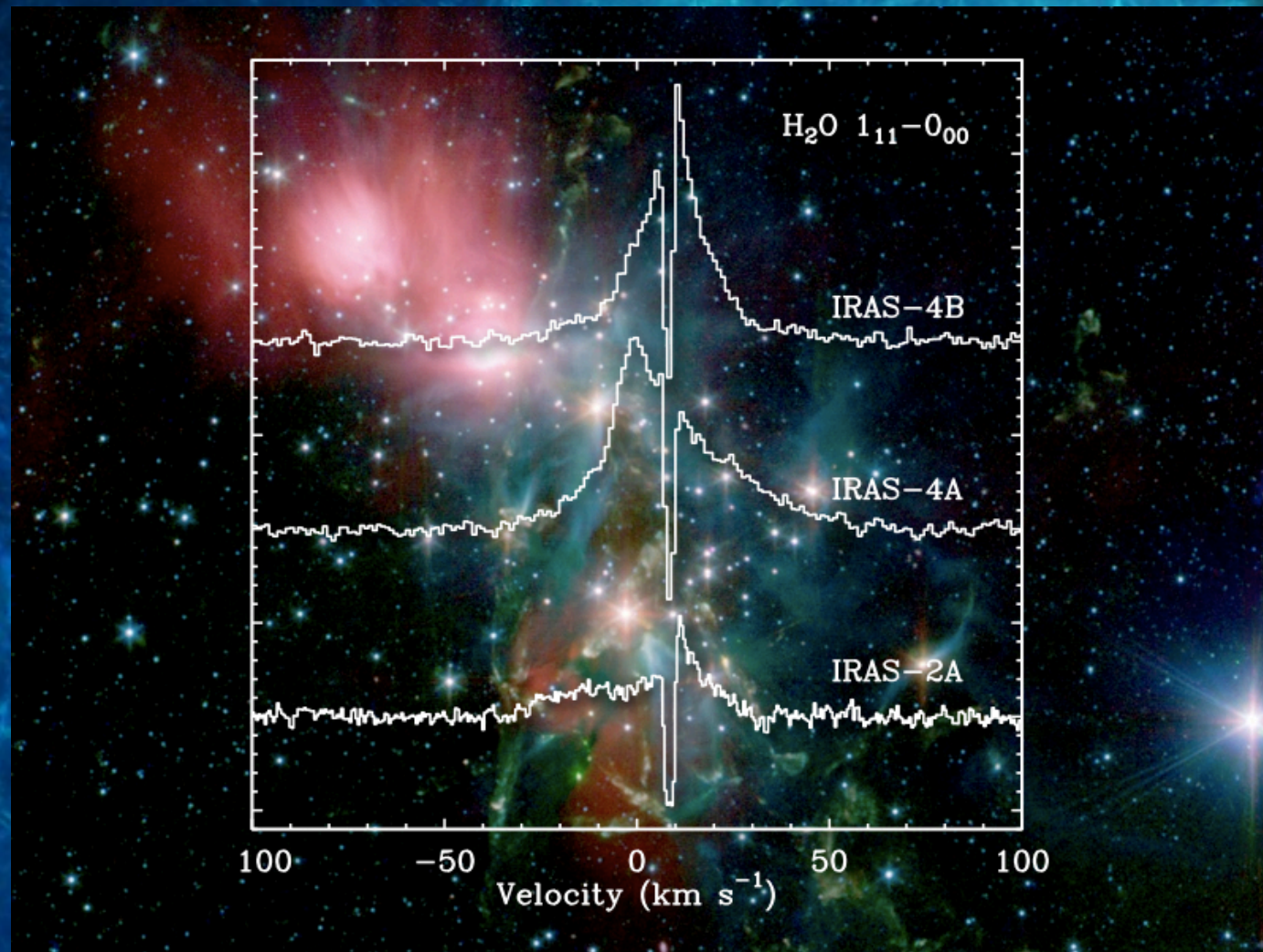
New Physical Insights

- molecular excitation - formation pumping
- SF energy output - CO ladder



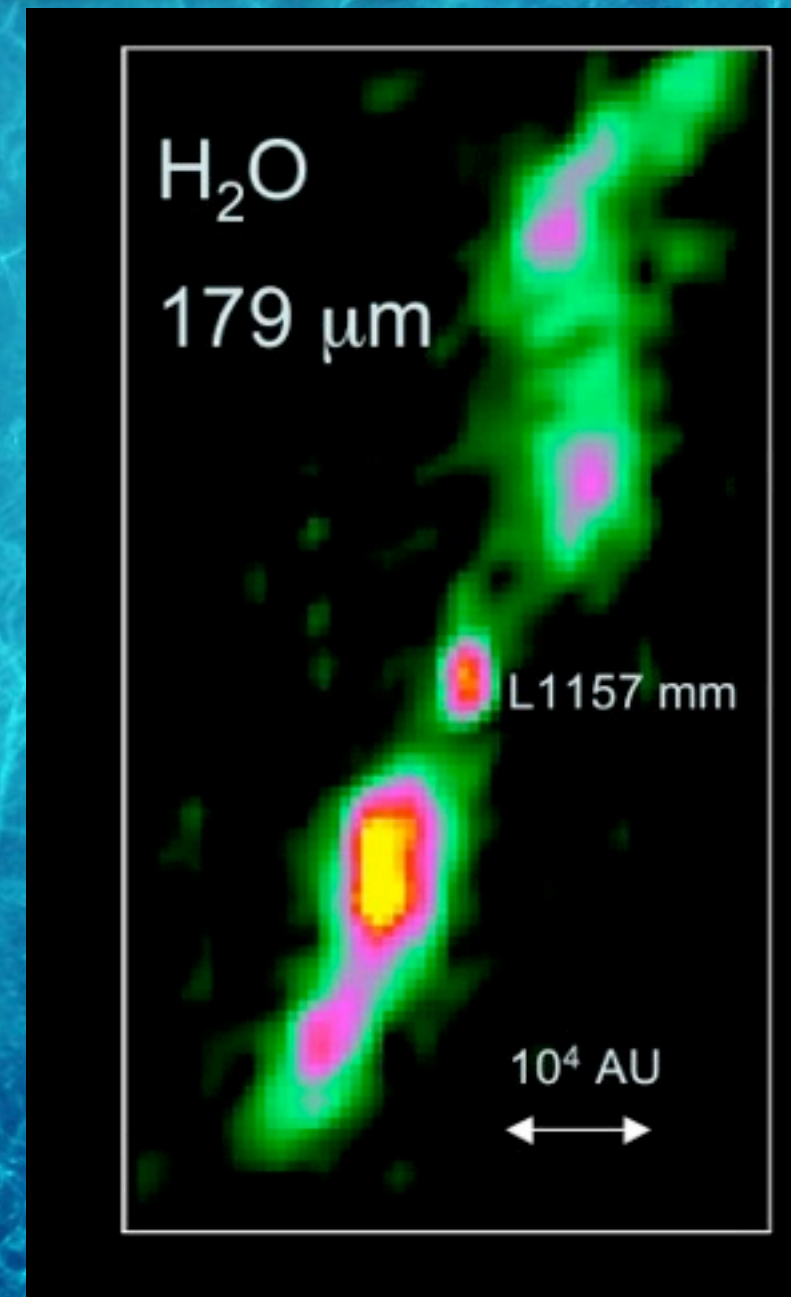
H_3O^+ - Formation Pumping

Water and Dynamics



Kristensen et al. 2012, 542, 8

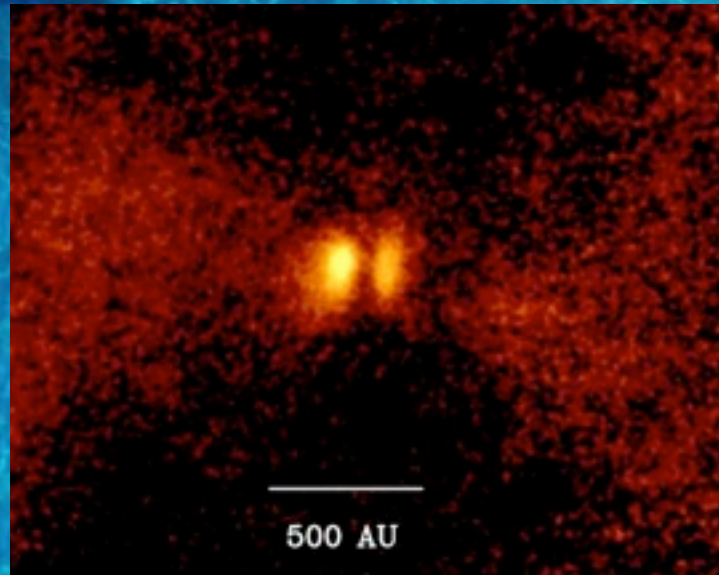
- Dominates emission: key part of the water story in the interstellar medium
- tracer of dynamics more broadly -- infall from prestellar to low mass to high mass (Caselli - Mottram - Herpin)



Nisini et al. 2010
A&A, 518, L120,
Codella+ 2010



1. Water is made in prestellar phase under cold conditions as ice, D enrichments implanted.



2. Collapse seeds disk with water ice. initial suggestions are this is mostly unaltered.



3. Water vapor is readily detected on disk surface in inner and rarely in outer disk. Seen as ice in outer disk - midplane remains hidden.



Herschel has made a large part of the water trail clear.

Still need to characterize the young forming disk - the missing stage and see the midplane