Molecular Line and Continuum Modeling of IRDC Star forming Clumps

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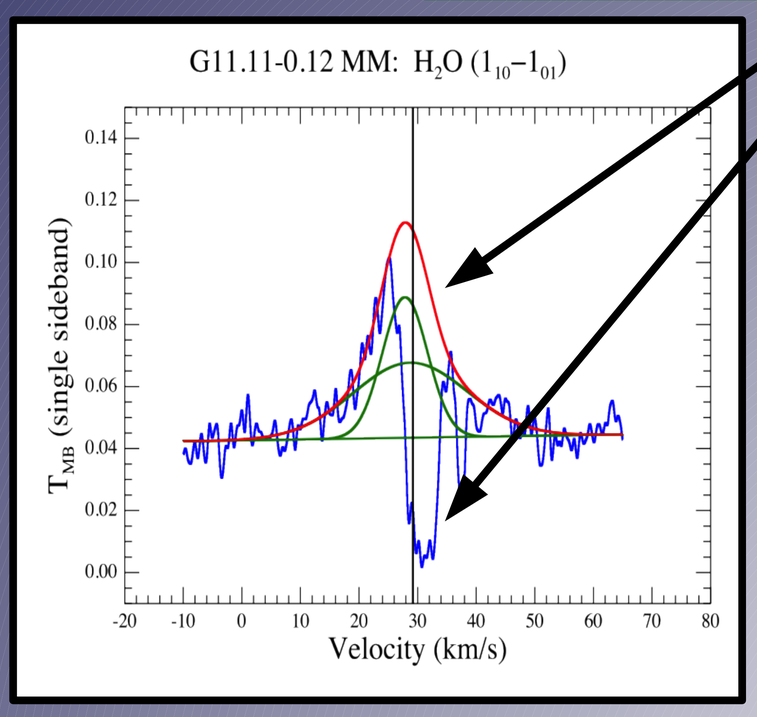
Goal of Project

Determine gas dynamics in earliest stages of high-mass star formation.
Model Herschel/HIFI observations of IRDCs

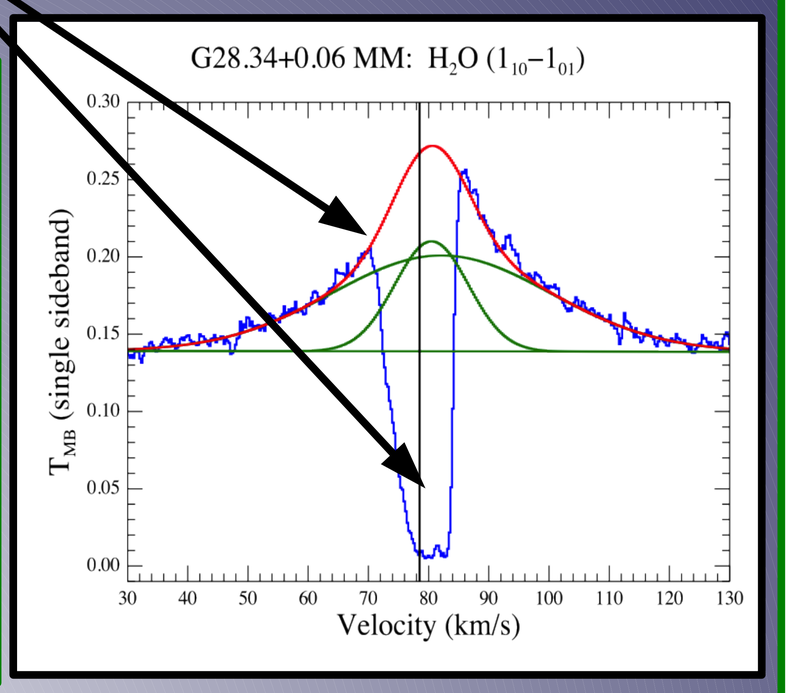


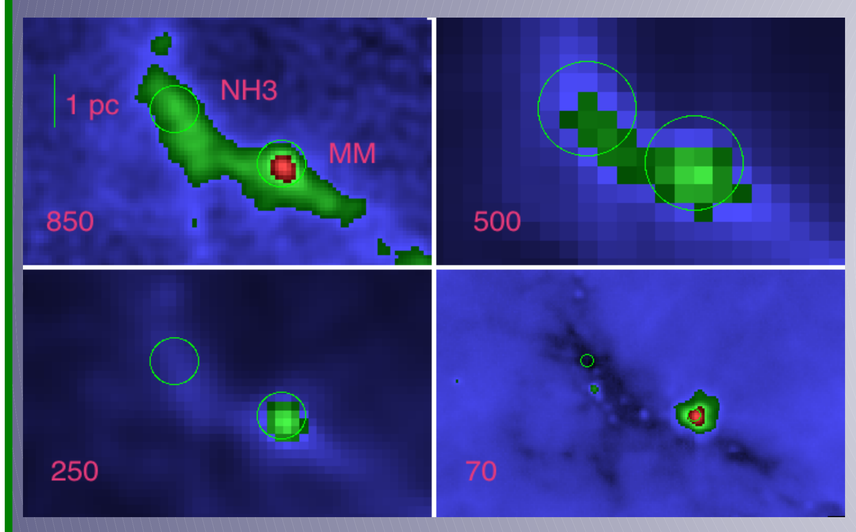
Approach

Infrared Dark Clouds (IRDCs) seen in silhouette against Galactic Mid-IR emission but seen in emission in sub-mm. Cores in IRDCs are young and massive.
(Beuther et al. 2007)

Determine **physical 1D structure** of IRDC clumps from dust continuum between 70 to 850 microns
(Whitney et al. 2013, ApJS, 207:30)

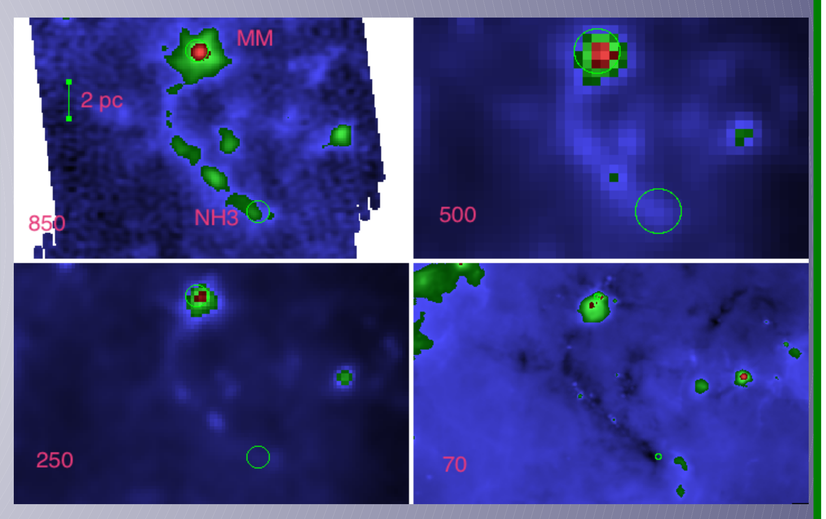
Ratran modeling molecular emission/absorption
(Hogerheijde & van der Tak (2000, A&A 362, 697)
HIFI and APEX: H_2O, $H_2{}^{18}O$, N_2H^+, $C^{17}O$, CH_3OH, $C^{34}S$



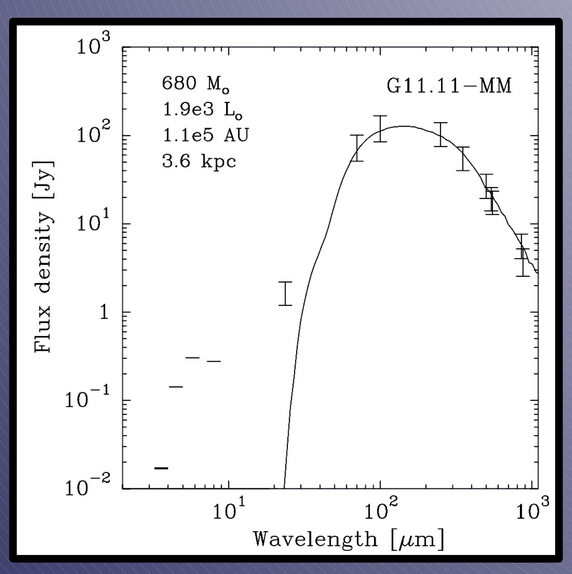


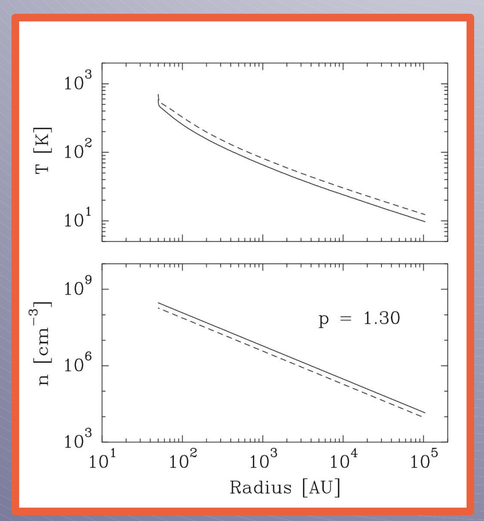
Sources

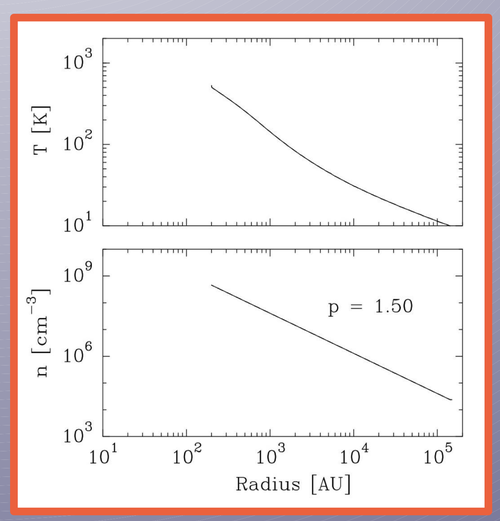
- Two clumps in two IRDCs (G28.34+0.06, G11.11-0.12)
  - 2x Millimeter peak positions: **signs** of star formation
  - 2x NH_3 peak positions: **no signs** of star formation

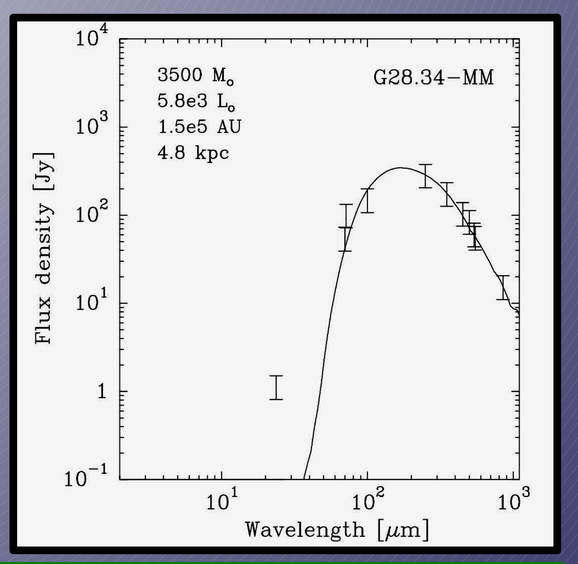


Temperature and density profiles



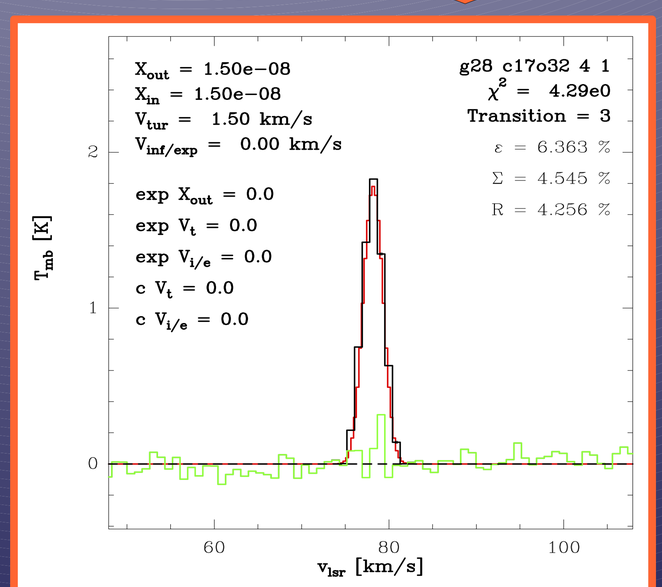






- **Initial Results: estimate MM clump mass and mass averaged dust temperature**
  - G28.34
    - This work: <Td>=13.5K, L=5800 $L_\odot$, M=3500 $M_\odot$ (d=4.8 kpc)
    - Ragan: Td=20K, L=2950 $L_\odot$, M=534 $M_\odot$ (d=4.52 kpc)
  - G11.11
    - This work: <Td>=13.0, L=1900 $L_\odot$, M=680 $M_\odot$ (d=3.6 kpc)
    - Ragan: Td=24K, L=1444 $L_\odot$, M=80 $M_\odot$ (d=3.4 kpc)

SED fitting underestimates mass of IRDCs. **Radiative Transfer is a must**. (See Jiali Zhu Mohai Huang A&A 2014, 564, A111)



Initial Modeling

Temperature/density profiles feed into Ratran
- estimate molecular abundance
- description of velocity structure.

Next Steps

- Model H_2O an $H_2{}^{18}O$ for mm positions
- Model other lines
- Model continuum of NH_3 positions
- Model H_2O an $H_2{}^{18}O$ for NH_3 positions