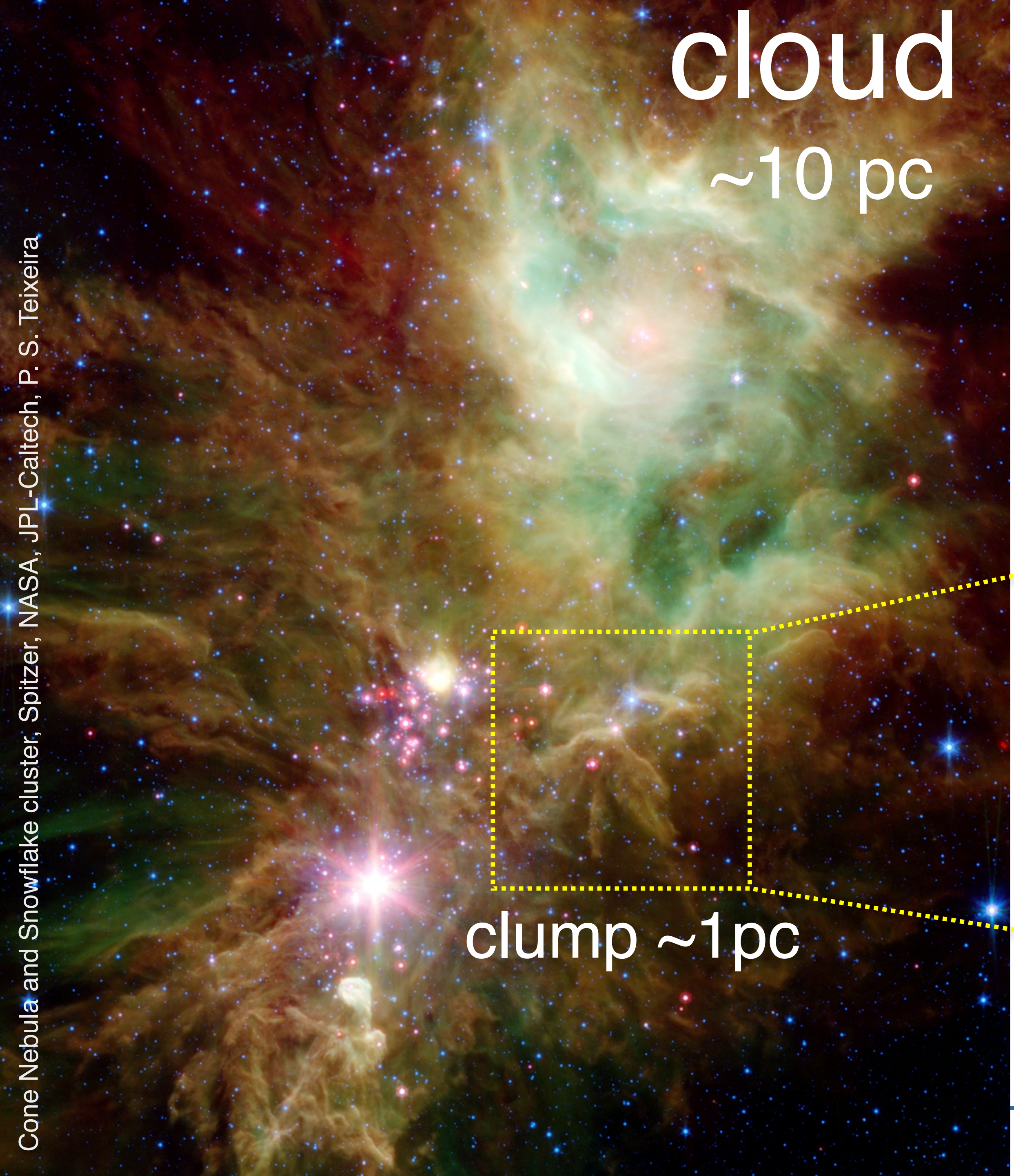
Fragmentation of molecular clouds: the role of magnetic field

Aina Palau Puigvert
a.palau@irya.unam.mx (Palau et al. 2020, submitted)
Instituto de Radioastronomía y Astrofísica - Universidad Nacional Autónoma de México

Q. Zhang (CfA), J. M. Girart (ICE-CSIC), J. Liu (CfA, Nanjing Univ.), R. Rao (CfA), P. M. Koch (ASIAA), R. Estalella (UB), H.-R. V. Chen (Tsing Hua Univ.), H. Baobab Liu (ASIAA), K. Qiu (Nanjing Univ.), Z.-Y. Li (Univ. Virginia), L. A. Zapata (UNAM), S. Bontemps (Univ. Bordeaux), T.-C. Ching (ASIAA), H. Shinnaga (Kagoshima Univ.), A. Ahmadi (Leiden Univ.), H. Beuther (Max Planck IA)

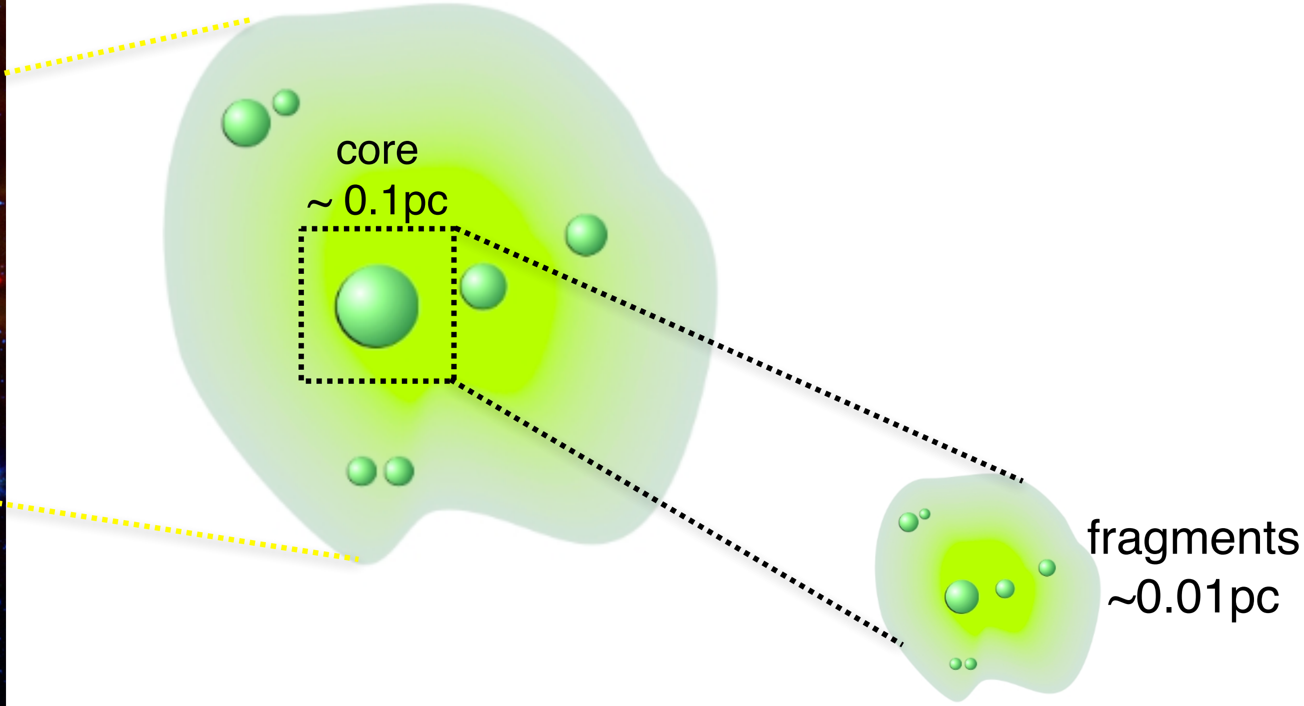
Theoretical and numerical works indicate that a strong magnetic field should suppress fragmentation in dense cores embedded in molecular clouds. However, this has never been tested observationally in a relatively large sample of fragmenting massive dense cores. Here we use **the polarization data obtained in the Submillimeter Array** Legacy Survey of Zhang et al. (2014) **to build a sample of 17 massive dense cores where both fragmentation and magnetic field properties are studied** in a uniform way. We measured the **fragmentation level, N_{mm}**, within the field of view common to all regions, of ~ 0.15 pc, with a mass sensitivity of ~ 0.5 M_{sun}, and a spatial resolution of ~ 1000 AU. In order to obtain the magnetic field strength using the Davis-Chandrasekhar-Fermi method, we estimated the dispersion of the polarization position angles, the velocity dispersion of the $H^{13}CO^{+}$(4–3) gas, and the density of each core, all averaged within 0.15 pc. The magnetic field strength was also inferred using the Angular Dispersion Function method. Surprisingly, we found **no apparent relation between N_{mm} and the magnetic field strength**, while a **possible trend of N_{mm} with the average density of the parental core** was found. In addition, the average masses of the fragments are comparable to the thermal Jeans mass. Therefore, our results suggest that **thermal fragmentation and gravity dominate the fragmentation process in this sample**. However, **when only cores with similar densities are considered, there are hints of a possible anticorrelation between N_{mm} and the magnetic field strength**, as expected from the theoretical and numerical work.



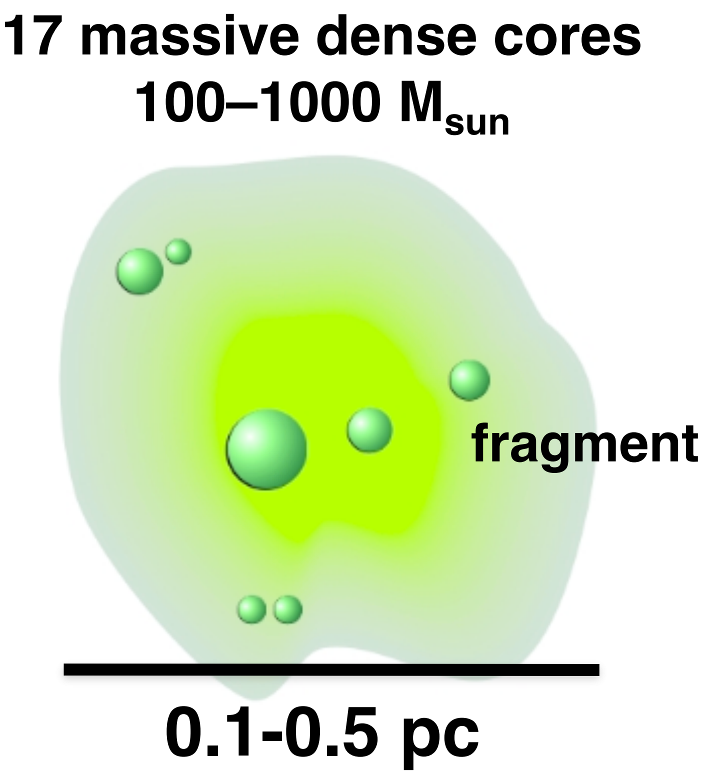
What determines the fragmentation of molecular clouds?
Density and temperature structure, turbulence, angular momentum, stellar feedback, magnetic field?

Wealth of theoretical and numerical work:
Magnetic field should suppress fragmentation

But lack of observational constraints

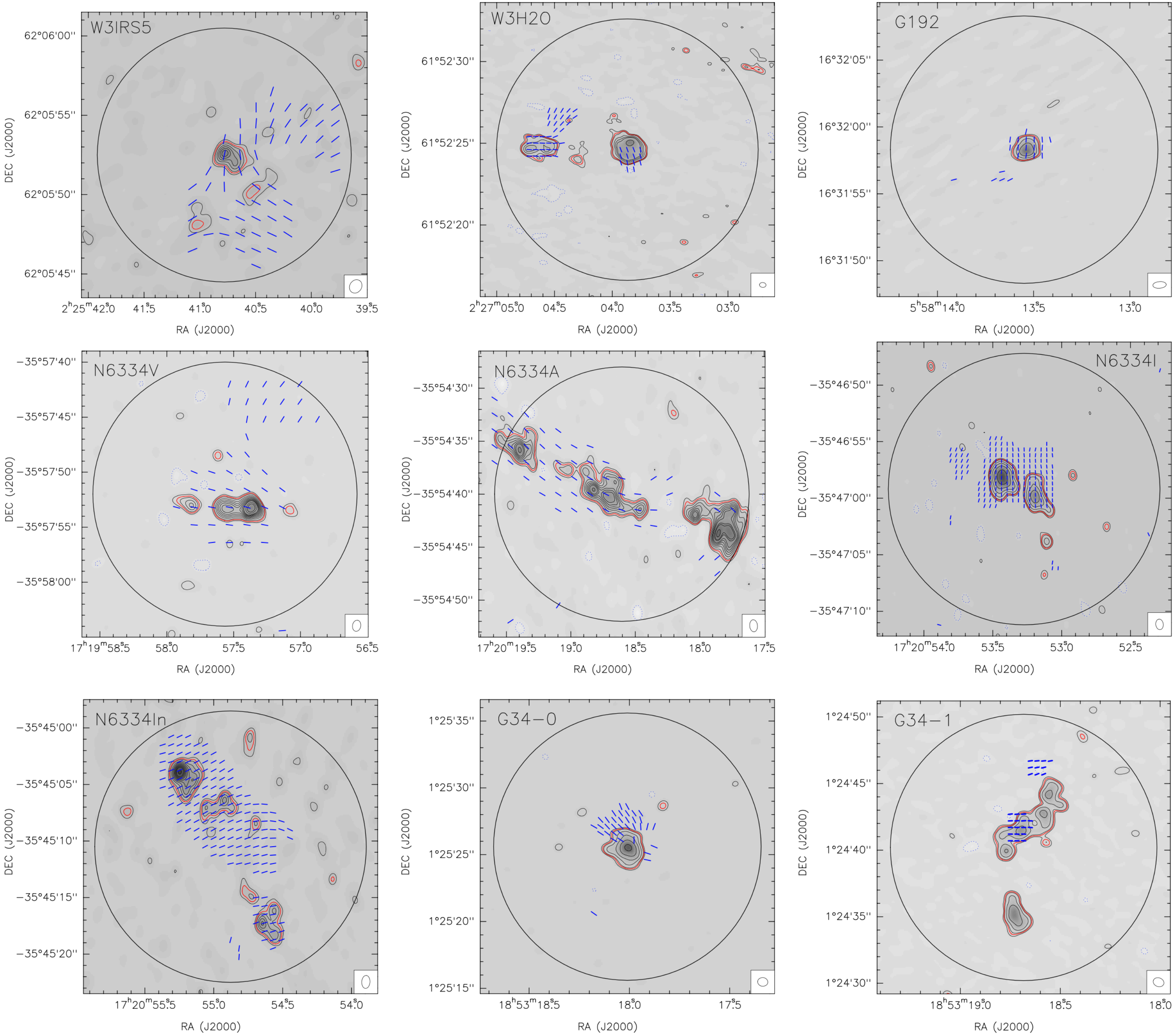


Observational approach: observe a sample of 17 massive dense cores (~>100 M_{sun}, ~0.1 pc) down to ~1000 AU and ~0.5 M_{sun} at millimeter wavelengths: assess fragmentation AND study the submillimeter polarization emission



Use of submillimeter interferometers:

Submillimeter Array Legacy (Zhang+14): study dust polarization properties to infer magnetic field strength in the plane of sky, B_{pos}, complemented with PdBI/NOEMA observations



Fragmentation level N_{mm}: compact millimeter continuum sources within the common field of view of all regions

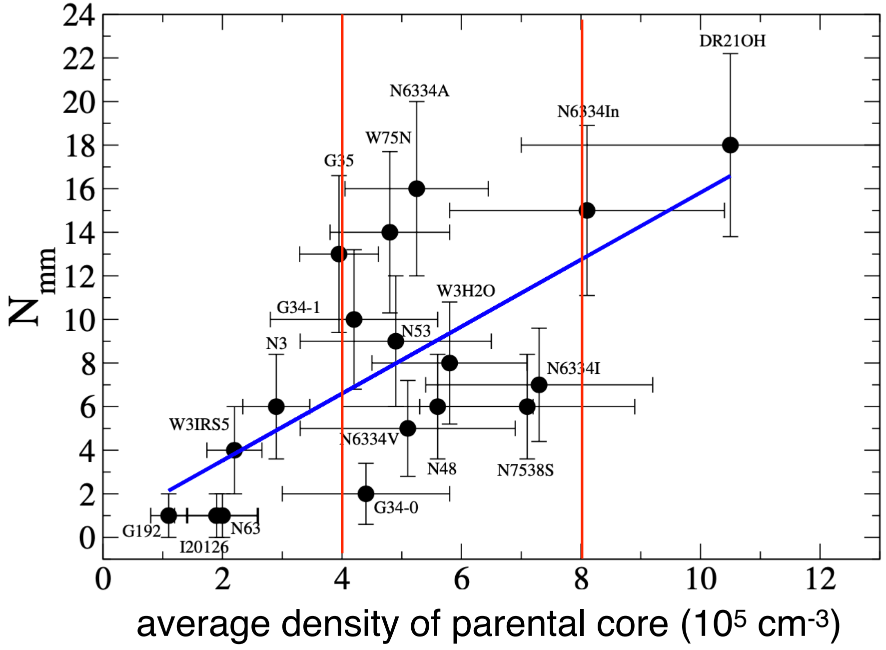
Magnetic field strength B_{pos}, two methods:

1) Davis-Chandrasekhar-Fermi method
(Davis 1951, Chandrasekhar & Fermi 1953)

$$B_{pos} = A \sqrt{4\pi\rho} \frac{\sigma_{vel,los}}{\sigma_{PA}}$$

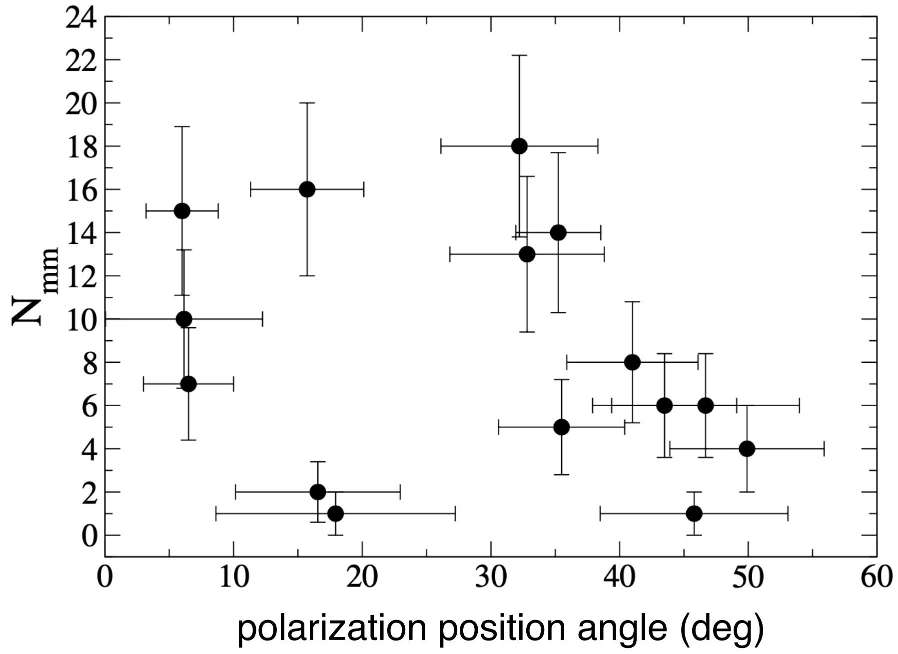
Need: density, velocity dispersion, polarization position angle dispersion

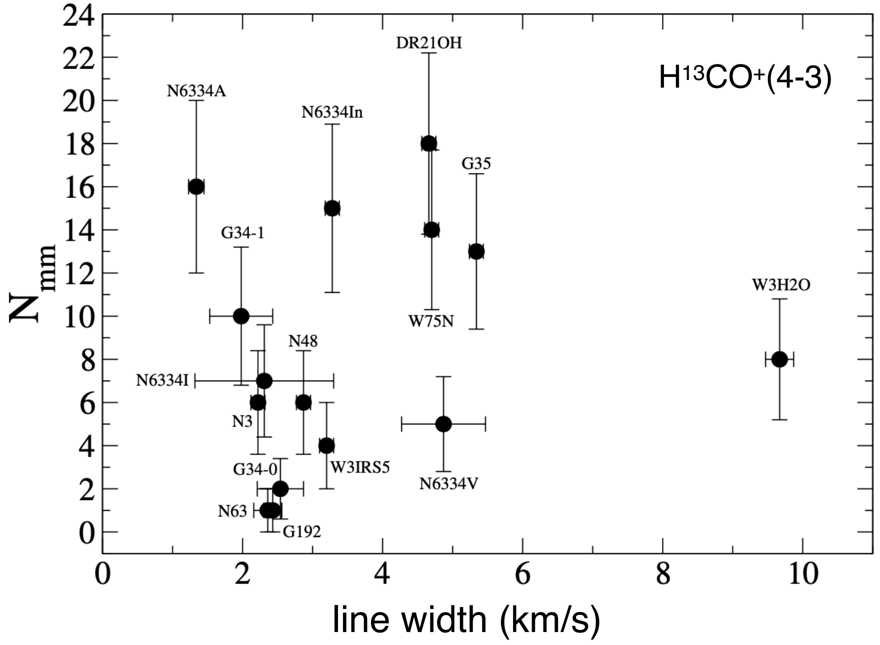
2) Angular Dispersion Function method
(Houde+2009)

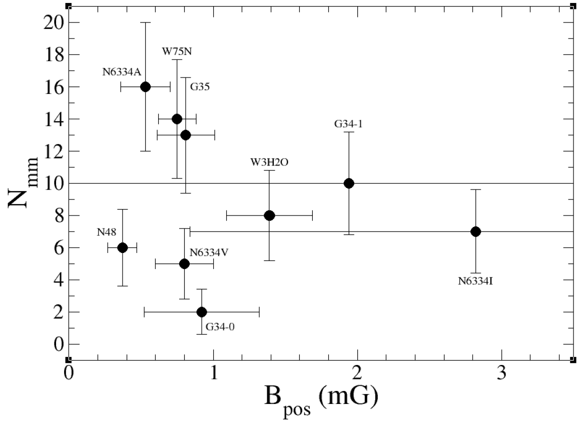


Possible correlation of fragmentation level N_{mm} with average density of the parental core

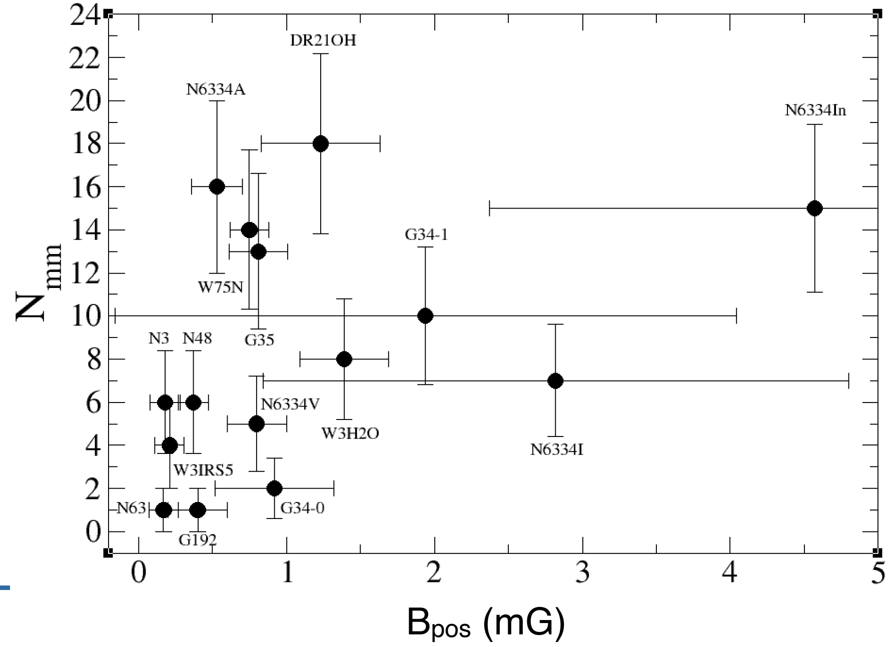
However, if only cores with similar densities are considered, there are hints of an anticorrelation of N_{mm} with B_{pos}







only cores with densities (4-8)x10^5 cm^{-3}



Impact and prospects

The **fragmentation** and **magnetic field** properties of a **sample of 17 massive dense cores** were studied with submillimeter interferometers (SMA, PdBI/NOEMA).

No clear correlation was found between the fragmentation level of massive dense cores **N_{mm} and the magnetic field strength** in the plane of sky, B_{pos}.

A **possible correlation of N_{mm} with the average density of the parental core** was found. In addition, the mass of the fragments are comparable to the Jeans mass. These findings suggest that **thermal Jeans fragmentation and gravity dominate the fragmentation process** in this sample, consistent with previous works (e.g., Gutermuth et al. 2011, Palau et al. 2015, Pokhrel et al. 2018, Mendigutía et al. 2018, Sanhueza et al. 2019).

However, when **only cores with similar densities** are considered, we found **hints of a possible anticorrelation between N_{mm} and B_{pos}, as expected** from theoretical and numerical work, suggesting that the magnetic field is playing a secondary but non-negligible role in the fragmentation process of this sample.

Clearly, future works with **larger samples and more sensitive interferometers** such as ALMA are required to confirm these findings.