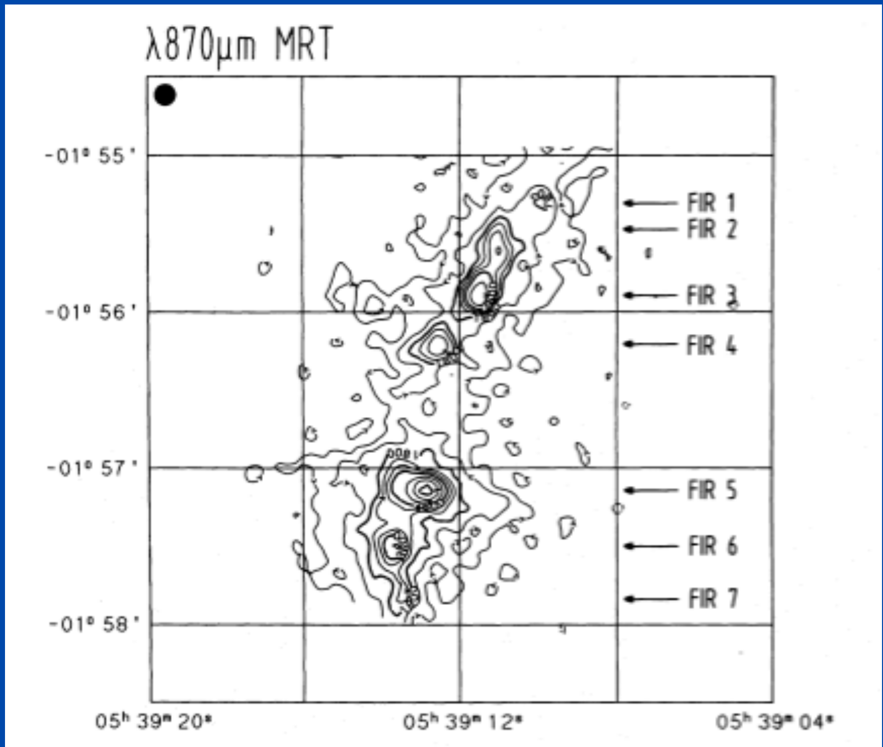
What happens at high density

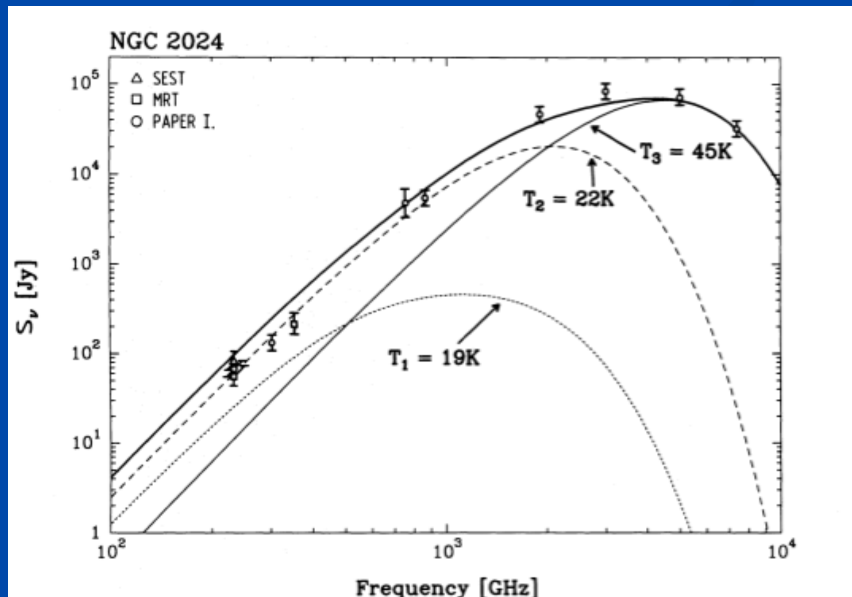
- M. Walmsley (INAF, DIAS)

Mezger et al. (1988-92)

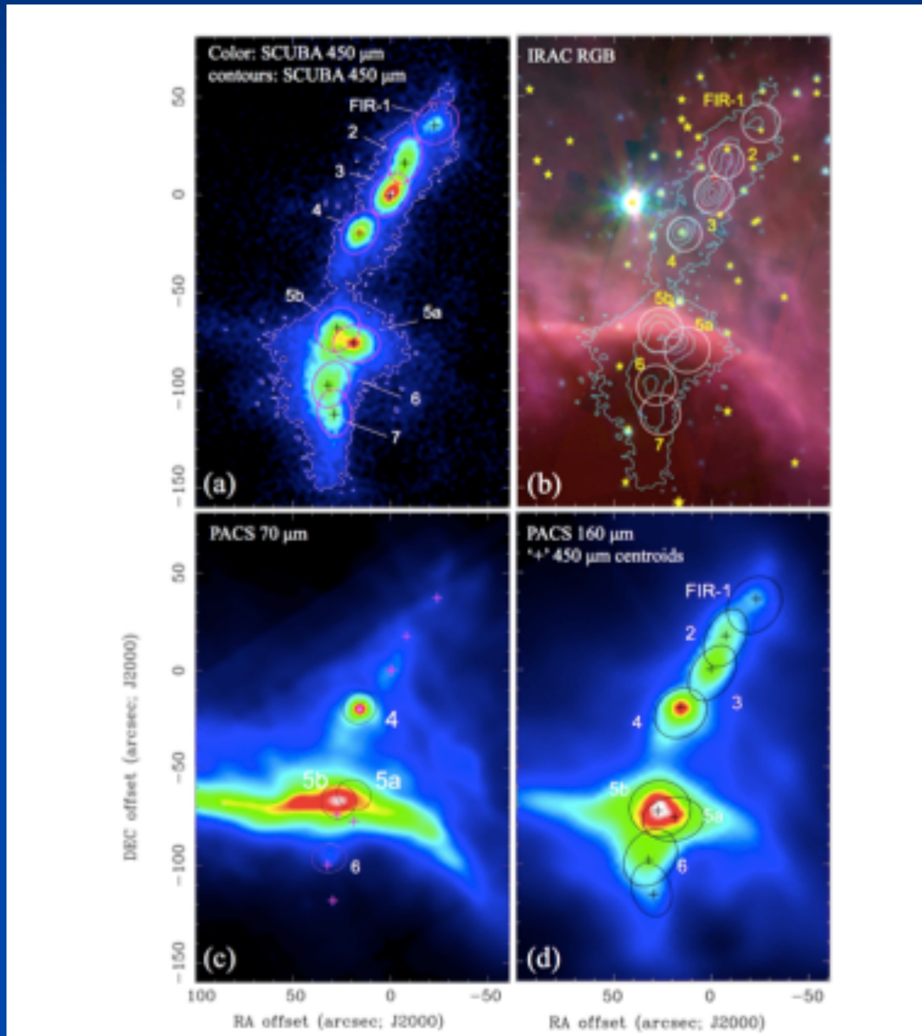
- Started operating bolometer (Kreysa) on various telescopes including the new IRAM 30m
- Towards high mass star forming regions such as NGC 2024 (D=440 pc)discovered "cores" whose relationship to HII region is still unclear
- Mezger called these cores "virgin protostars" (sometimes called isothermal protostars)

Mezger et al. 1992 30m-map at 870 microns and SEDs of the whole structure





Herschel Images of NGC 2024 (Ren Li)



Mezger et al. Results

7 “cores” (3000 AU) in about 0.5 parsec!!

The cores had low T of order 20 K (much lower than the surroundings)

Core density and column density high (10^8 cm^{-3} and 4 10^{24} cm-2 !)

Molecules apparently depleted!!

Some cores with “embedded protostars”

The isothermal core controversy

- Mezger's claims caused a controversy
- As time went on, it became clear that some of the isothermal cores harbored YSOs (an outflow, H2O masers etc)
- In more recent times (Spitzer etc), mid IR sources were discovered
- Core 3 (FIR3) remains without obvious signs of YSO however (15 M(sun))
- The basic idea however is not necessarily wrong

Two phase model of high mass star forming clumps

- High mass star formation typically involves formation of many more low mass stars than high (clusters of thousands of stars)
- YSOs produce outflows and it seems likely that many regions of star formation are in reality the superposition of hot low density gas from many outflows on dense condensations
- This may produce a high T low density intercore medium which compresses cores (a pressure blanket P_{ext})

Luminosity of a very young protostellar cluster

- The luminosity could be dominated by accretion (i.e no massive YSO on ZAMS)
- Then luminosity is an integral over the accretion rate convolved with the IMF
- The outflow rate is thought to be roughly proportional to accretion rate
- Thus it makes sense to look for correlations of L with CO outflow rate

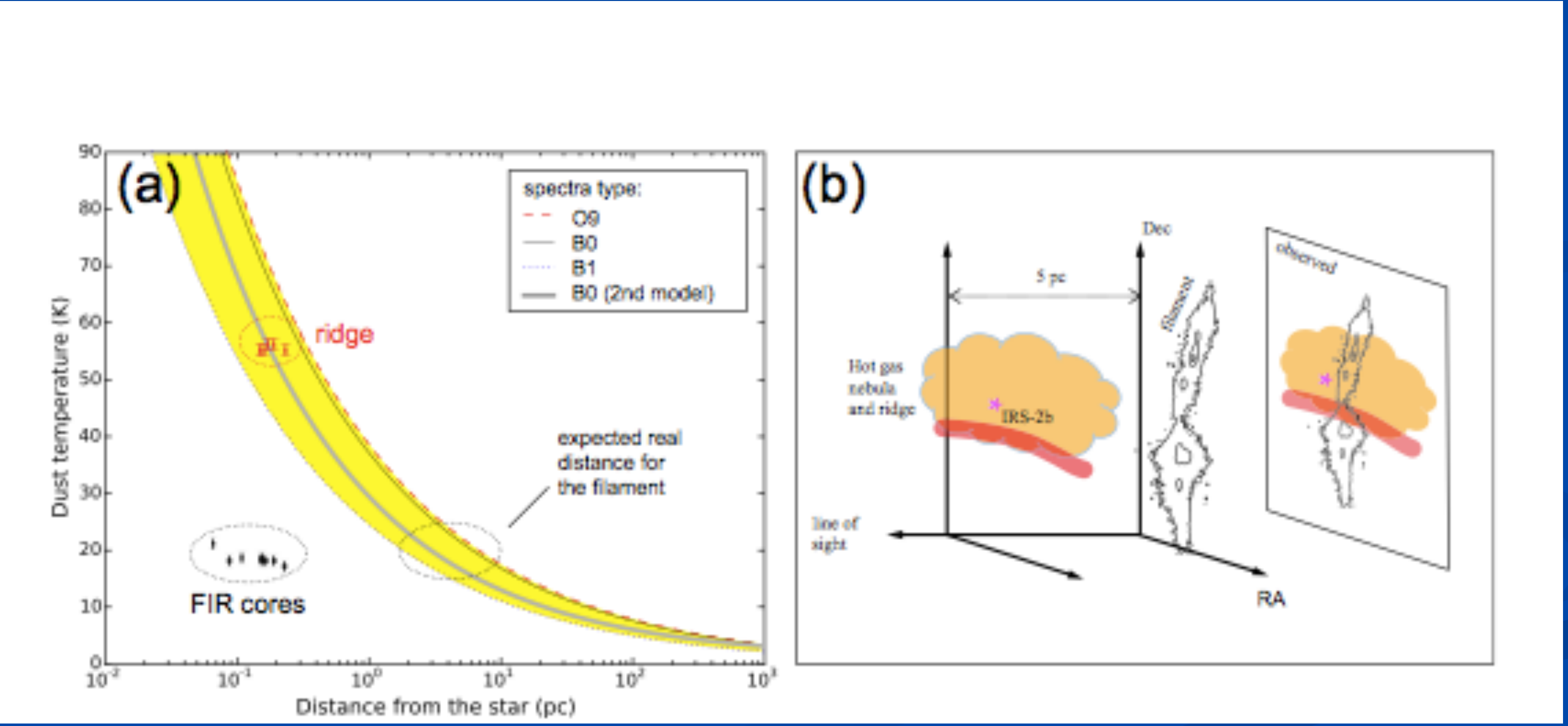
Curiosities of the Virial Theorem

- In a model with a hot "intercore" medium of pressure P_{ext} , individual cores have the same column density proportional to $\sqrt{P_{ext}}$ if P_{ext} is uniform
- On the other hand, the core RMS turbulence σ_v is proportional to $(P_{ext} R_{core})^{0.5}$ (a sort of "Larson law")
- And mass accretion rate is prop. to σv^3 or $M_{core}^{0.75}$ (timescale prop.to $M^{.25}$)

Ren and Li recent 2024 study

- They use Herschel to derive dust T and theVLA to derive gas T for FIR 2 and 3
- Their inferred dust T for cores confirm Mezgers result
- With the VLA (NH3) , they find a T peak in FIR3 suggesting internal heating
- They suggest that the Mezger filament (FIR sources) is several pc to rear of HII region (not heated by HII region exciting star)

Ren Li estimate of dust T as fn of distance from HII region exciting star. The FIR dust cores have much lower T than “ridge” dust assoc. with ionised gas



Conclusions

- Outflow rates and luminosities of cores in a two phase system will depend on core mass in ways which can be tested
- NGC 2024 cores are a puzzle worth focusing on (especially because distance is small)
- ALMA observations of the N2024 FIR cores might tell us a lot (Fractionation?)
- Probably no starless ("isothermal") cores in 2024