Zeeman Observations towards High Mass Star Forming Regions using the CCAT

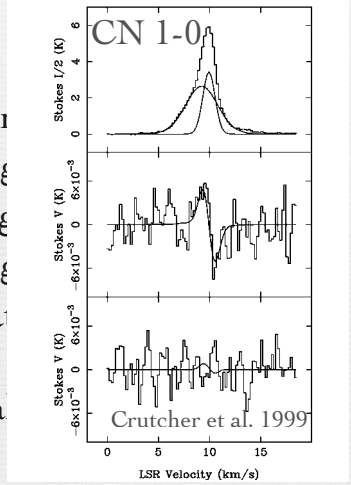
Hiroko Shinnaga
Caltech Submillimeter Observatory

Magnetic field and Massive Star Formation

- High mass star formation
  - No standard model yet
  - Evolution is poorly understood
    - It's not scale-up version of low mass star formation
  - Magnetic field may play a critical role on the formation of massive stars.
  - Need more detailed observational studies of magnetic field

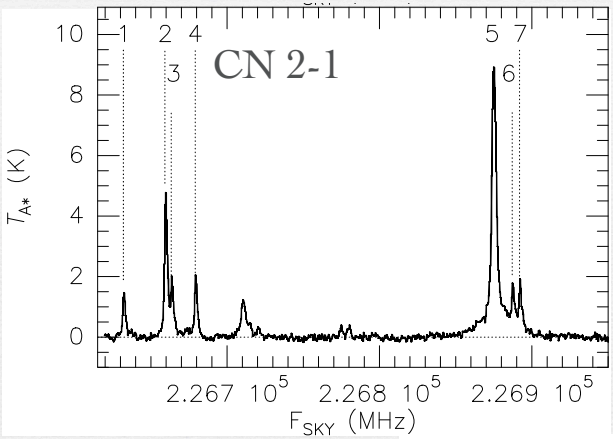
Magnetic Field and Massive Star Formation

- Observational methods
  - Polarimetry of dust continuu
    - --> Magnetic field morpholog
  - Goldreich-Kylafis effect using
    - --> Magnetic field morpholog
  - Zeeman observations using a lines
    - --> Magnetic field strength a sight



Crutcher et al. 1999

Zeeman observations using the CCAT



Shinnaga et al. in prep

Existing/Past/Potential Instruments to measure Zeeman effect at millimeter wavelength

- CSO 10.4m FSP-Pol / Nobeyama 45m Mm pol
- Pico Veleta 30m XPol (correlation polarimeter)
- CARMA dual polarization Rx at 1mm equipped on six 10.4m telescopes

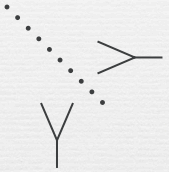
Instruments to measure Zeeman effect

CSO 1mm/NRO 45m 1-7mm

wave plate 

Wave plate
rotates
--->
RCP/LCP
alternatively
Backend: AOS/digital
spectrometer

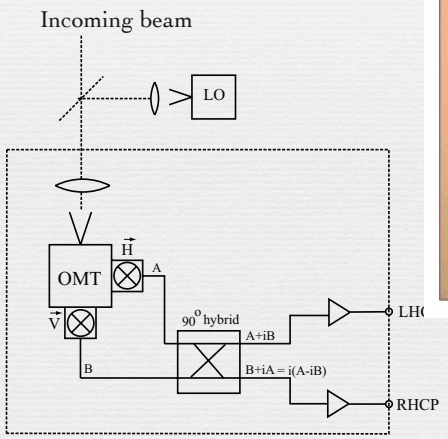
Pico Veleta 30m 1mm



Two channels for
H & V
--->
takes all four
Stokes
parameters
Backend: digital correlators

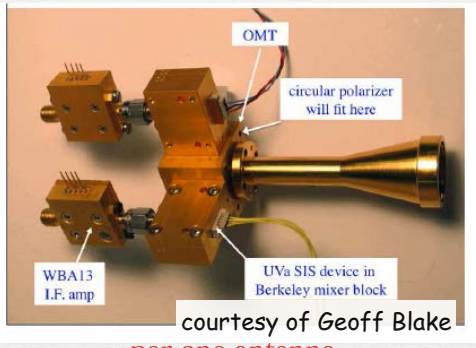
Instruments to measure Zeeman effect

CSO 1mm in future?



Credit: Kooi (2008)

CARMA 1mm



per one antenna

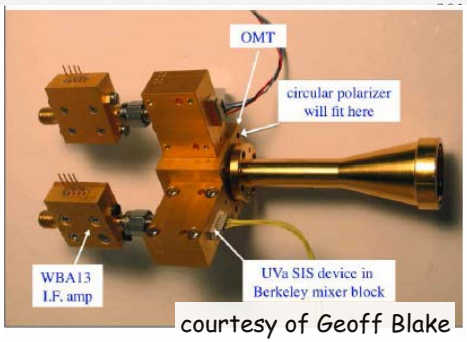
six 10.4 m antennas total

single-dish mode

Backend: digital correlators

H. Shinnaga

Zeeman observati

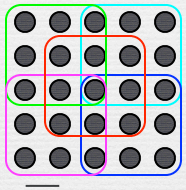


courtesy of Geoff Blake

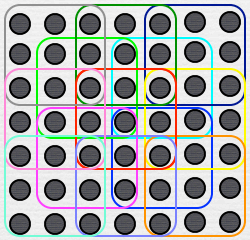
- CCAT, a high precisio
  - Large dish
  - Better observing s
  - Dual polarization array receiver
    - No one has ever build dual polarization receiver array before
- If we can combine all together, a dream instrument to measure magnetic field strength may become reality!

Zeeman observations using the CCAT

- Array receiver configuration -- example



Nyquist
sampling



Covers... 24" x 24"

5 x 5 channels x 2 (RCP/LCP)
--> 50 outputs

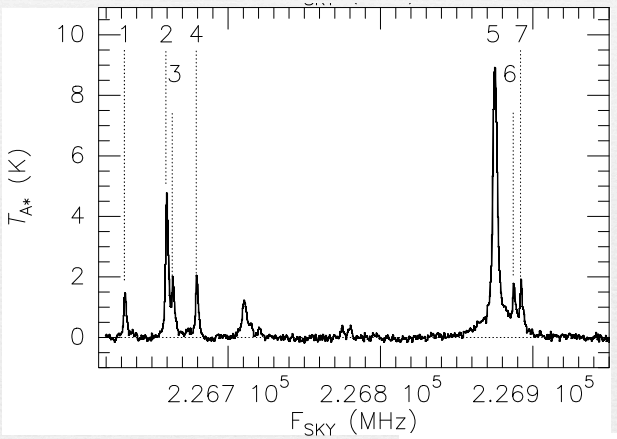
36" x 36"

7x 7 channels x 2 (RCP/LCP)
--> 98 outputs

Zeeman observations using the CCAT

CN 2-1 spectrum of OMC1n

narrow and intense line profile ---> good candidate for successful Zeeman measurements



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Zeeman observations using the CCAT

CN 2-1 spectrum of OMC1n

Estimated integration time ...

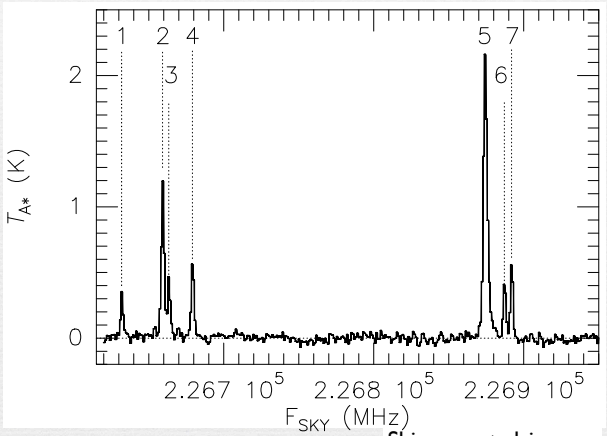
- about 10 hours if it has single channel
- about 3 hour if we take an average of 9 channels together

Zeeman observations using the CCAT

CN 2-1 spectrum of IRAS 20126+4104

narrow and intense profile

---> may be good candidate for successful Zeeman measurements



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Zeeman observations using the CCAT

CN 2-1 spectrum of IRAS 20126+4104

Estimated integration time ...

- about 20 hours if it's single channel
- about 4 hours if we take an average of 25 channels together
- about 2.8 hours if we take an average of 49 channels together
- ---> becomes realistic to make maps of magnetic field strength towards multiple sources.

Zeeman observations using the CCAT

- What about ALMA?
- CCAT Zeeman receiver system probably does better job compared with ALMA's system
  - large, high precision, single dish
  - with interferometer, harder to detect Zeeman effect because emission is extended
    - Zeeman observation done with BIMA

Summary

- It would be very helpful if CCAT team/science committee could consider possibility of equipping dual polarization array receiver system for CCAT.
- It will open a new path towards more detailed studies on the physical processes of high mass star formation including effects of magnetic field.