



Magnetic Activities of Protostars

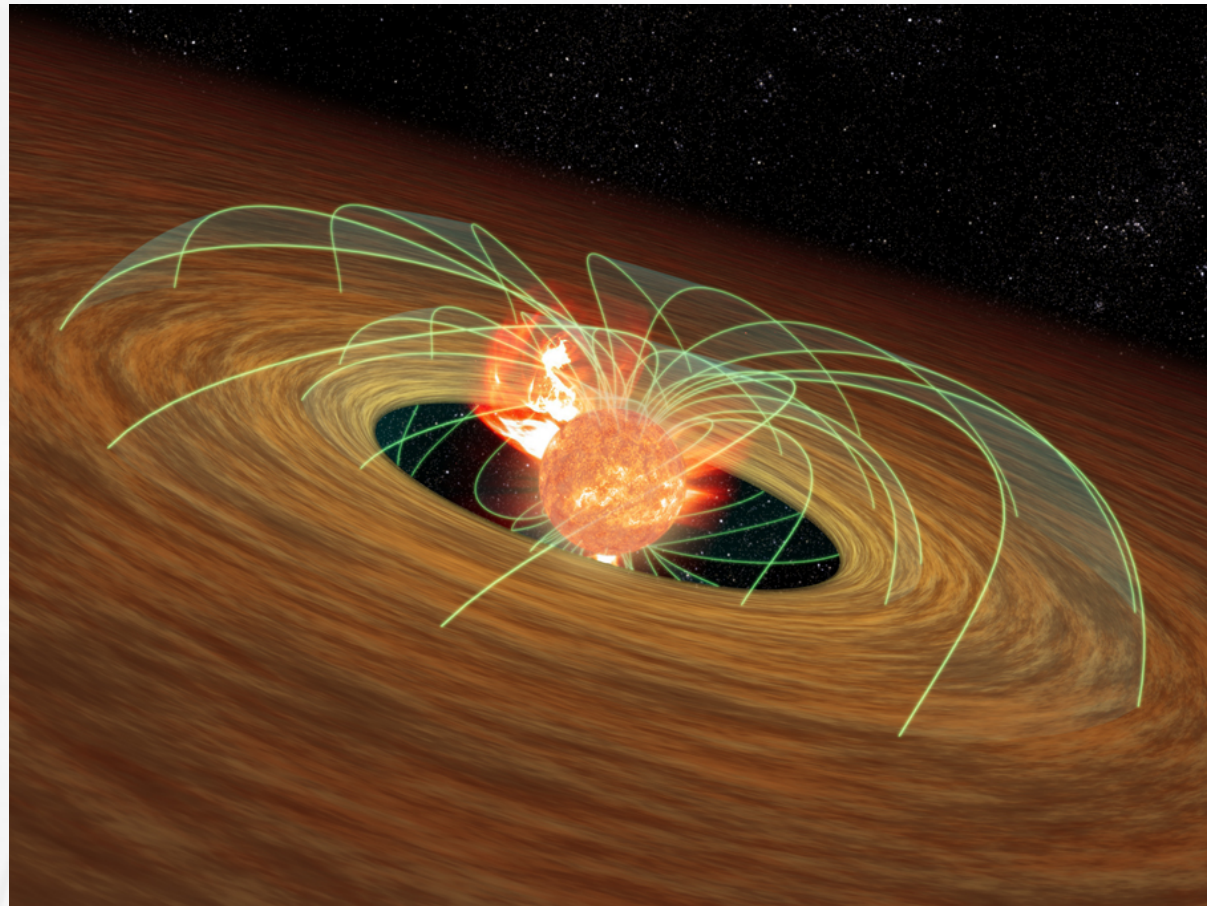
Minho Choi (KASI)

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Magnetic Fields and Star Formation

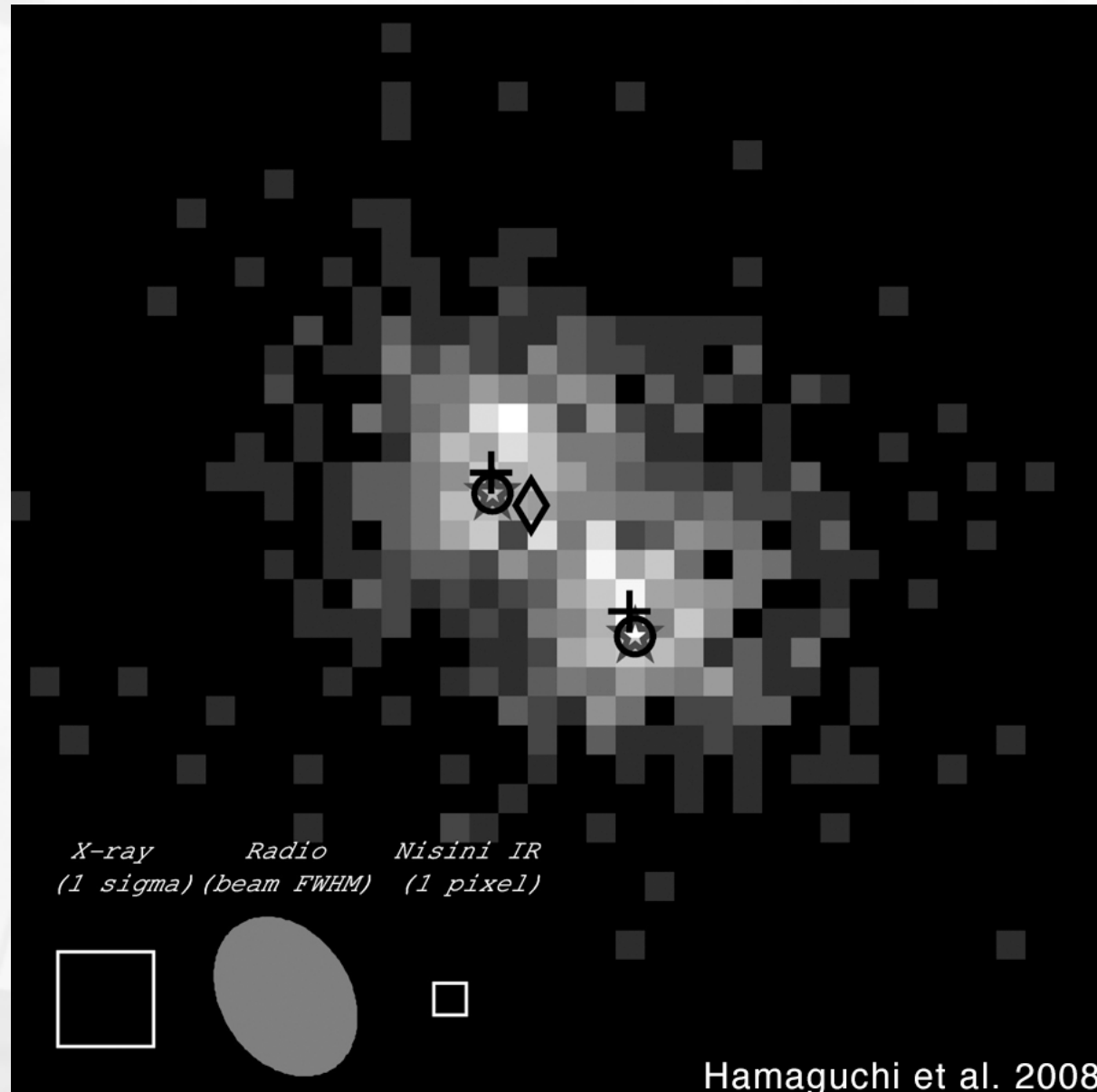
- Interstellar magnetic fields are important in cloud support and core contraction processes.
- Peristellar magnetic fields play a crucial role in the dynamics of circumstellar material.
 - Magnetosphere connects the stellar interior to the circumstellar structure.
 - Magnetospheric accretion
 - Mass ejection by magnetocentrifugal mechanism
 - Disk viscosity by magnetorotational instability
 - Truncation of inner disk
 - Magnetic braking
 - etc.
- Magnetic activities of YSOs
 - T Tauri stars and other PMS stars have magnetospheres and show magnetic activities.
 - Younger objects show higher activities (Preibisch & Feigelson 2005).
 - Some class I protostars show flares, but they are usually detected by chance.
 - R CrA IRS 5
 - Do class 0 protostars have magnetospheres?
 - Probably, but they are hidden by opaque layers of gas.
 - Partially ionized winds of protostars are opaque (free-free absorption) to centimeter waves (Andre 1996).

Radio Observations of YSO Magnetic Activities



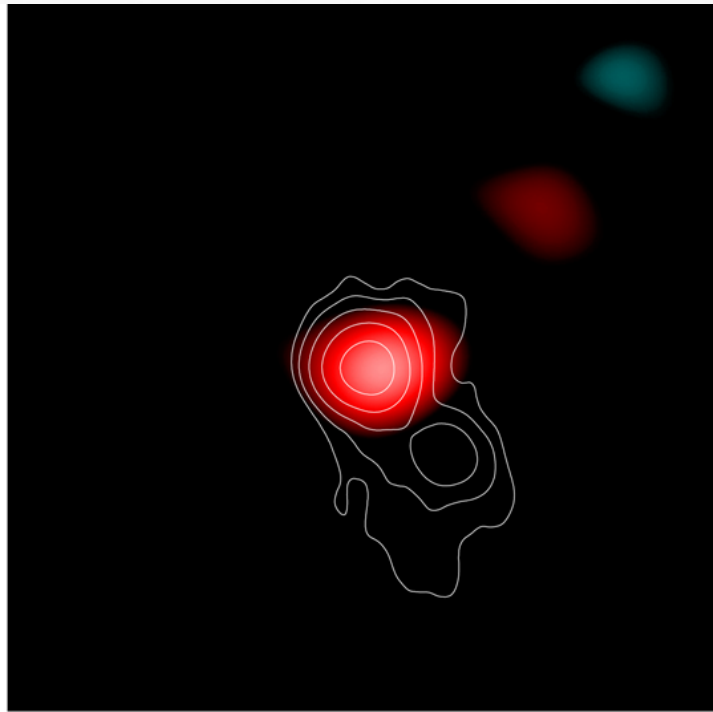
- Key characteristics
 - Variability
 - Flare durations of a few days (hours to weeks)
 - YSO flares are much larger than Solar flares.
 - Circular polarization
 - Gyrosynchrotron radiation from mildly relativistic electrons
 - Negative spectral index
 - Nonthermal emission

R CrA IRS 5

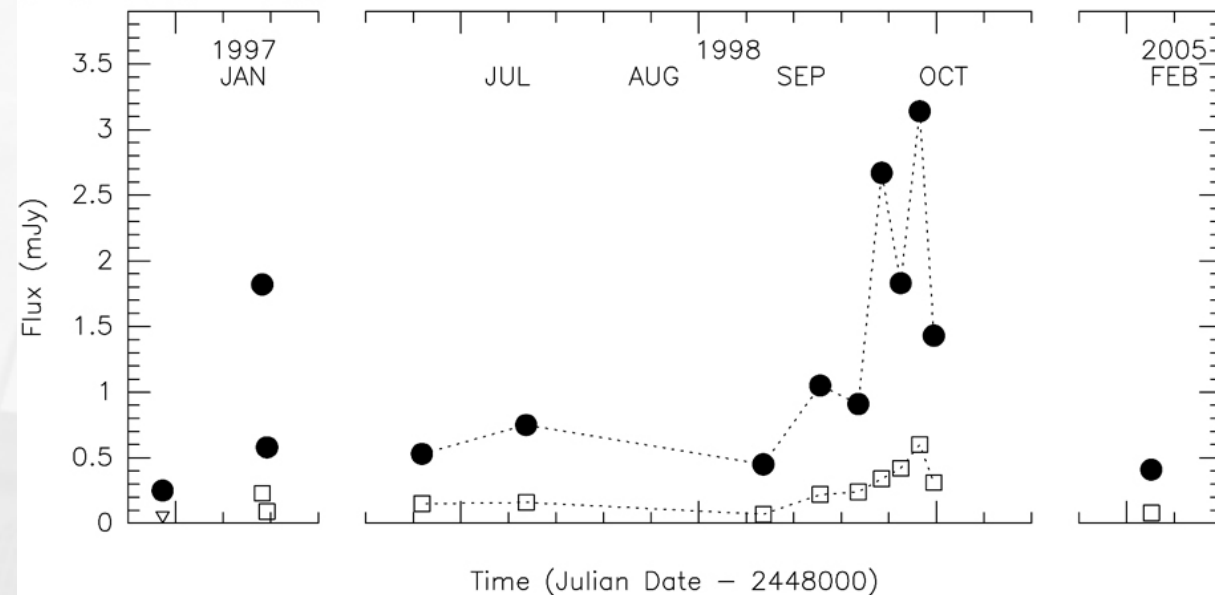


- Class I source
 - Nearby (170 pc) YSO
- Binary system (Nisini et al. 2005)
 - Separation = 0.9" or 160 AU
 - IRS 5a = K5-K7 V star
 - IRS 5b = later?
- Chandra X-ray images
 - Both are X-ray variables.
 - Flare timescale ~ 6 hr
 - Youngest binary system resolved in X-ray (Hamaguchi et al. 2008)
- VLA images
 - A-array observations in 3.5 cm
 - Both are radio variables.
 - IRS 5b is usually brighter.

Magnetic Activities of R CrA IRS 5b



Choi et al. 2009



- Active phase
 - Timescale \sim month (Choi et al. 2008, 2009)
 - The magnetosphere is much larger than the stellar radius.
 - Star-disk flare??
- Circular polarization
 - Always present at $\sim 20\%$ level (Feigelson et al. 1998; Forbrich et al. 2006)
 - Gyrosynchrotron radiation
 - Stokes V always positive
 - Magnetosphere geometry may be stable over many years.
- The only class I protostar showing magnetic activities persistently.
 - Why is IRS 5b special?

Summary

- Some class I protostars such as R CrA IRS 5 show magnetic activities and probably have magnetospheres.
 - Questions
 - Are "luminous" class 0 protostars magnetically active?
 - Do class 0 protostars have magnetospheres?
 - Origin of the magnetic fields?
 - X-ray flares? Effects on the circumstellar material?