Discovery of the Zeeman Effect in the 44 GHz Class I Methanol Maser Line with the EVLA

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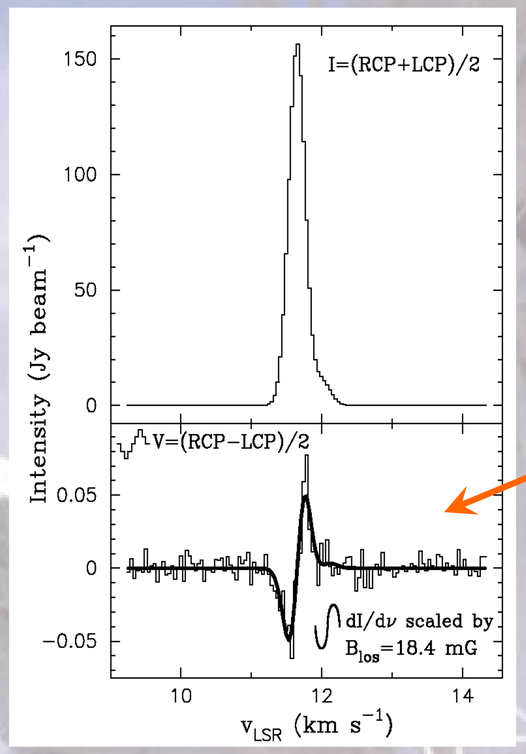
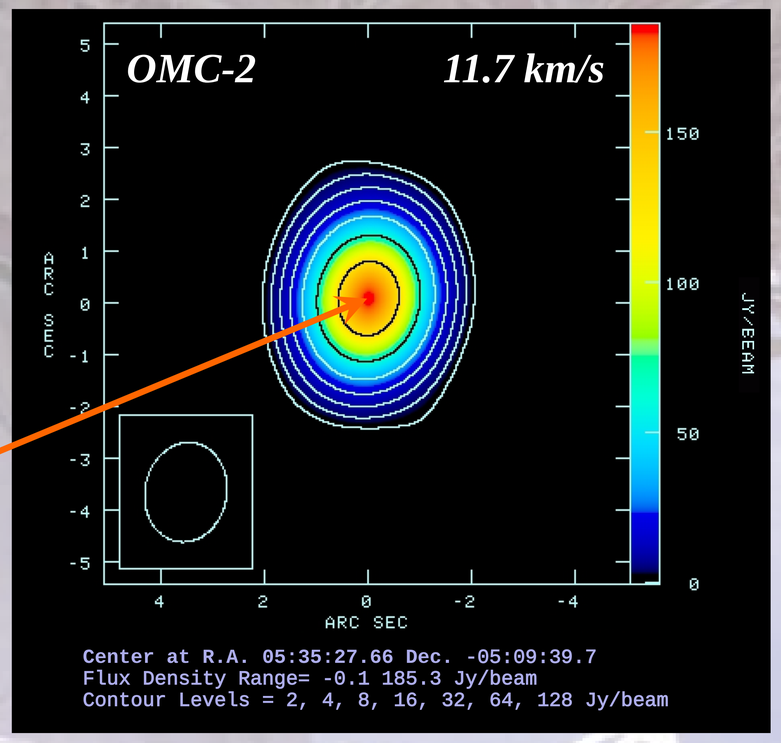
Abstract

We report the first detection of the Zeeman effect in the 44 GHz Class I methanol maser line. The observations were carried out with 22 antennas of the Expanded Very Large Array (EVLA) toward the star-forming region OMC-2. The detected line of sight magnetic field value is 18.4±1.1 mG toward the peak of the maser line. The detected field is not significantly different from the magnetic fields discovered in the 36 GHz Class I methanol maser line in the massive star forming region M8E (Sarma & Momjian 2009), or from those measured in the 6.7 GHz Class II methanol maser line (Vlemmings 2008). This indicates that these masers may trace the large scale magnetic field, or that the magnetic field remains unchanged during the early evolution of star forming regions.





The Expanded Very Large Array (EVLA)

- Full frequency coverage from 1 to 50 GHz.
  - Provided by 8 frequency bands with cryogenic receivers.
- Up to 8 GHz instantaneous bandwidth
  - Provided by two independent dual-polarization frequency pairs, each of up to 4 GHz bandwidth per polarization.
  - All digital design to maximize instrumental stability and repeatability.
- New correlator with 8 GHz/polarization capability
  - Designed, funded, and constructed by HIA/DRAO.
  - Unprecedented flexibility in matching resources to attain science goals.
- <1 μJy (1σ, 12hr) point-source continuum sensitivity at most bands
- Noise-limited, full-field imaging in all Stokes parameters for most observational fields.

Band (GHz)	Band Code	T_{sys}/ε (K) (best weather)
1-2	L	60
2-4	S	55 – 70
4-8	C	45 – 60
8-12	X	45*
12-18	Ku	50*
18-26.5	K	70 – 80
26.5-40	Ka	90 – 130
40-50	Q	160 – 360

*Anticipated

General Notes

- The Zeeman effect is the most direct method for measuring magnetic field strengths.
- Magnetic fields likely play an important role in the star formation process, but the exact nature of their role is still not understood; this is primarily due to the scarcity of observational data.
- The Zeeman effect is usually measured by fitting the Stokes V (the difference of the right and left circular polarizations) profile to the derivative of the Stokes I (total intensity) profile.
- Both Class I and Class II methanol masers trace an early stage of star formation. Class I masers in star forming regions are believed to be associated with regions shocked by outflows from the protostar.
- The measured magnetic field values in this 44 GHz methanol maser in OMC-2 is comparable to those detected in the 36 GHz Class I methanol maser in M8E (Sarma & Momjian 2009) and in the 6.7 GHz Class II methanol masers in other star forming regions (Vlemmings 2008).
- The above indicates that both classes of methanol masers may be tracing the large scale magnetic field, or that the magnetic field remains unchanged during the early evolution of star forming regions.