First Detection of the Zeeman Effect in the 36 GHz Class I Methanol Maser Line with the EVLA

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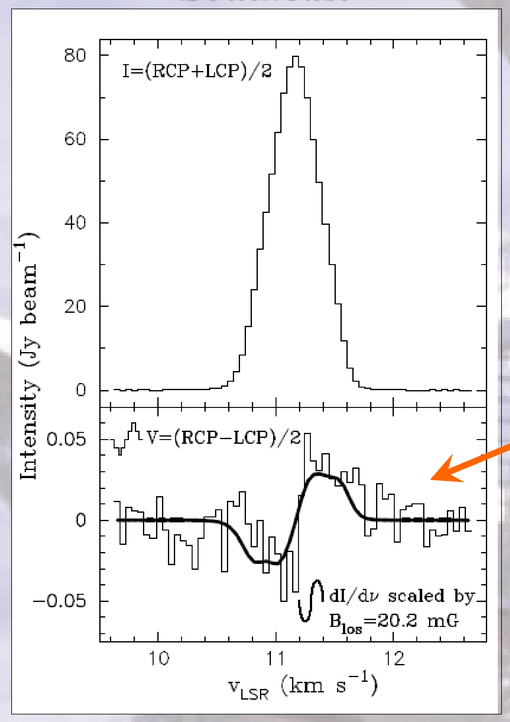
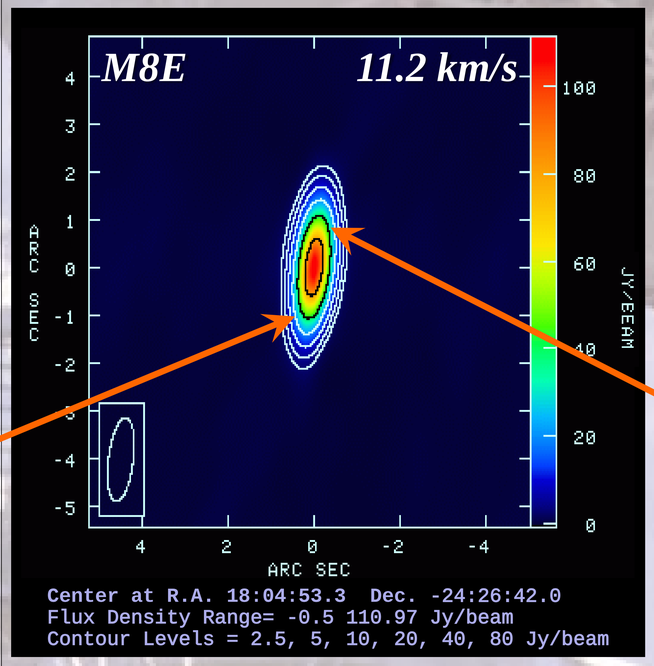
Abstract

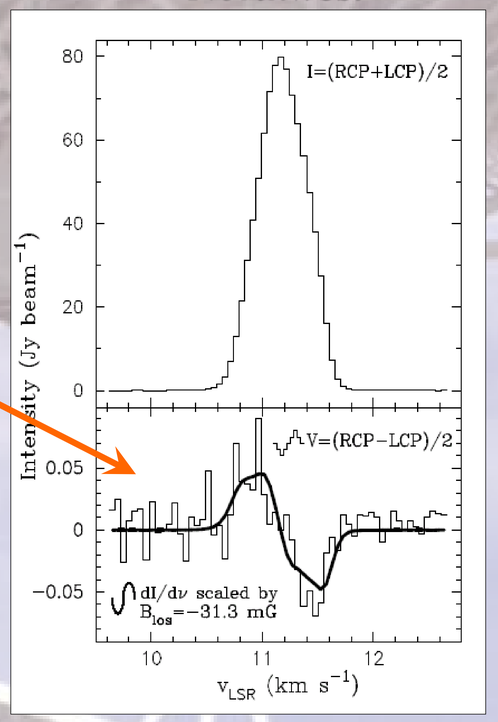
We report the first detection of the Zeeman effect in the 36 GHz Class I methanol maser line. The observations were carried out with 13 antennas of the EVLA equipped with the new 26.5-40 GHz (Ka-Band) receivers, and targeted the high-mass star-forming region M8E. The detected line of sight magnetic field values are -31.3 ± 3.5 mG and 20.2 ± 3.5 mG to the northwest and southeast of the maser line peak, respectively. These magnetic field values have been derived using a Zeeman splitting factor based on laboratory measurements of the 25 GHz methanol line, since no measurements exist for the 36 GHz line. The change in sign of the magnetic field, as revealed in our observations, is over a size scale of 1300 AU in the source M8E (assuming a distance of 1.5 kpc). This may indicate that the masers are tracing two regions with different magnetic fields, or that the same field curves across the regions where the masers are being excited. The detected fields are not significantly different from the magnetic fields detected in the 6.7 GHz Class II methanol maser line, indicating 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. Given what is known about the densities at which 36 GHz methanol masers are excited, we find that the magnetic field is dynamically significant in this star forming region.

Southeast





Northwest



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, but Class II are believed to be closer to the protostellar source.
- The measured magnetic field values in this 36 GHz methanol maser in the source M8E are comparable to those detected in the 6.7 GHz Class II methanol masers in other star forming regions.
- 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.

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