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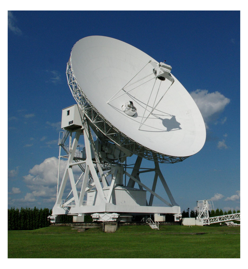
Faculty of Physics, Astronomy and Informatics



Methanol and excited OH masers in HMYSOs at milliarcsecond scales

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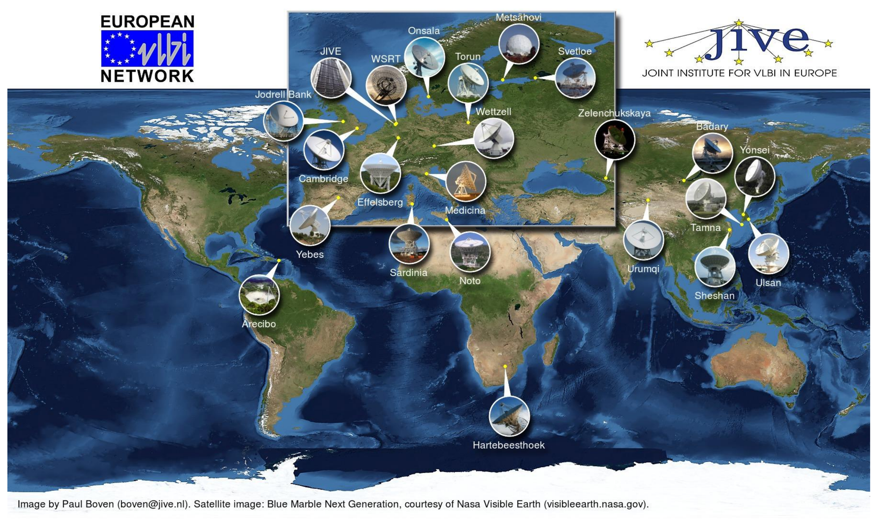
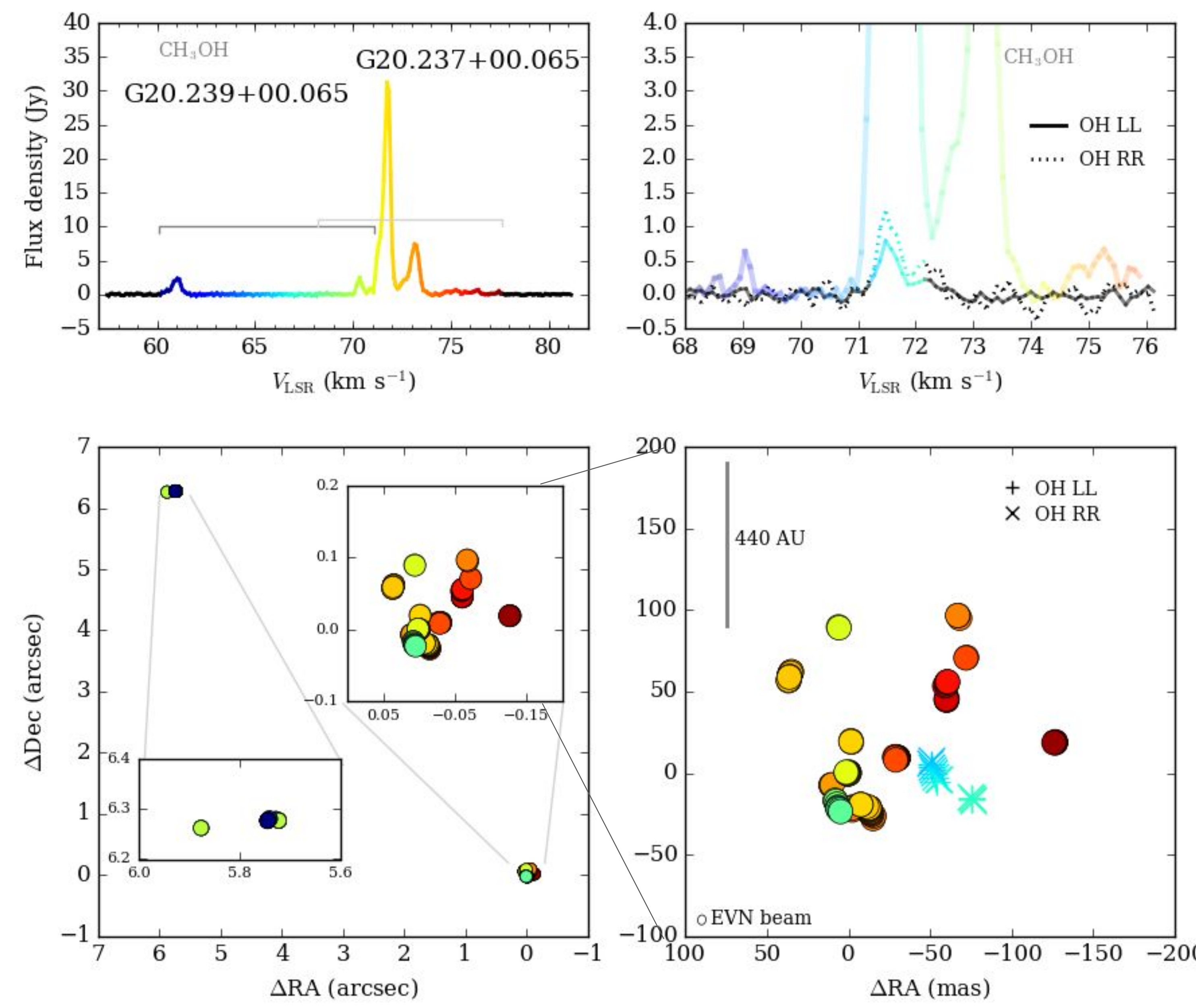
Project: Using **the European VLBI Network**, we have imaged the excited OH maser line at 6.035 GHz in four targets known as high-mass young stellar objects (HMYSOs) associated with the 6.7 GHz methanol masers (Bartkiewicz et al. 2009, 2016). The excited OH emission was found in a survey of methanol maser sources carried out since 2018 with **the Torun 32-m telescope** (Szymczak et al. 2020). Radial velocities of spectral features of methanol and excited OH overlapped in the majority of sources, suggesting that both lines arose in the same volume of gas. We verify this hypothesis with the EVN data. Since the excited OH spectra are highly circularly polarized, we search Zeeman pairs to estimate the strength of the magnetic field.

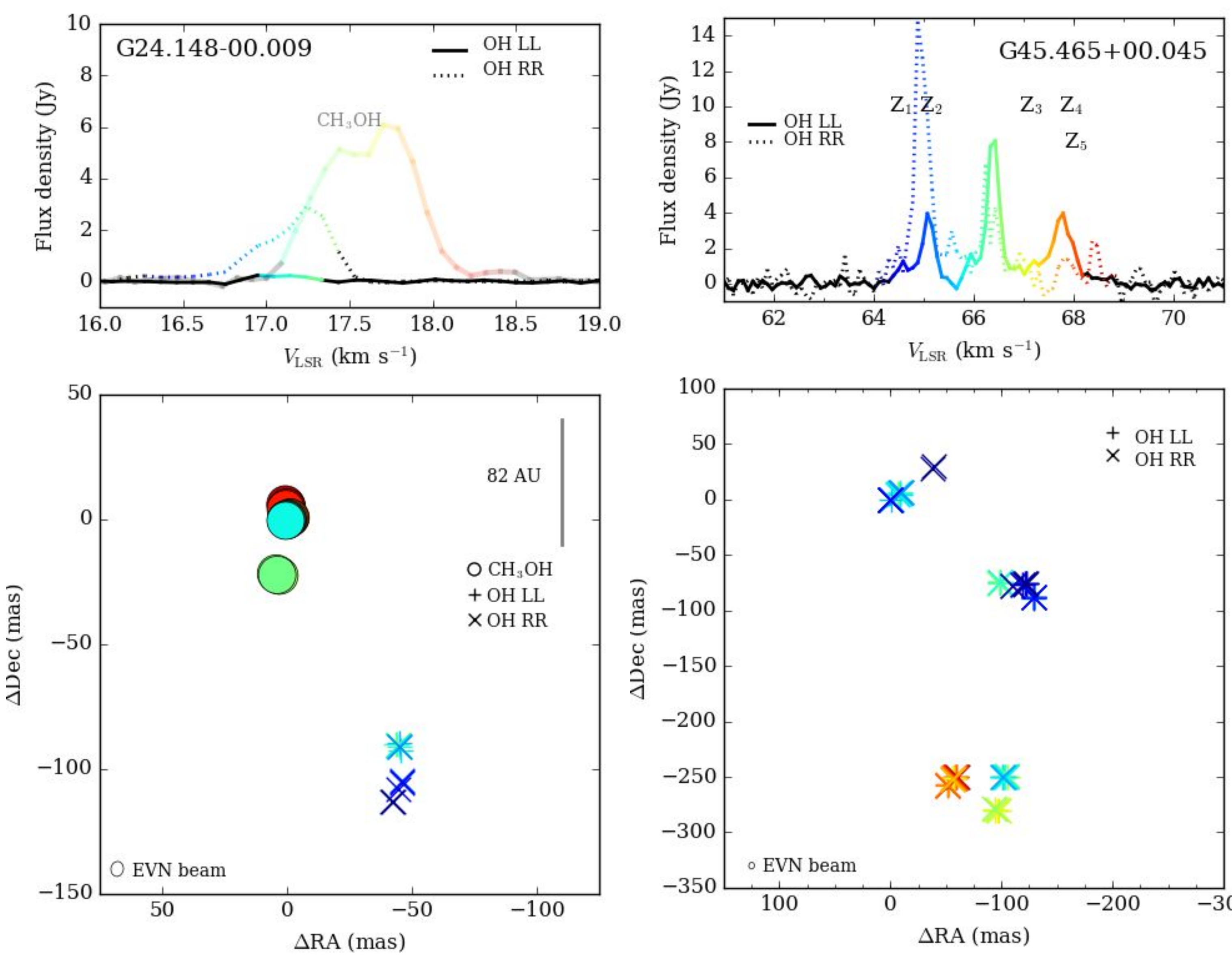


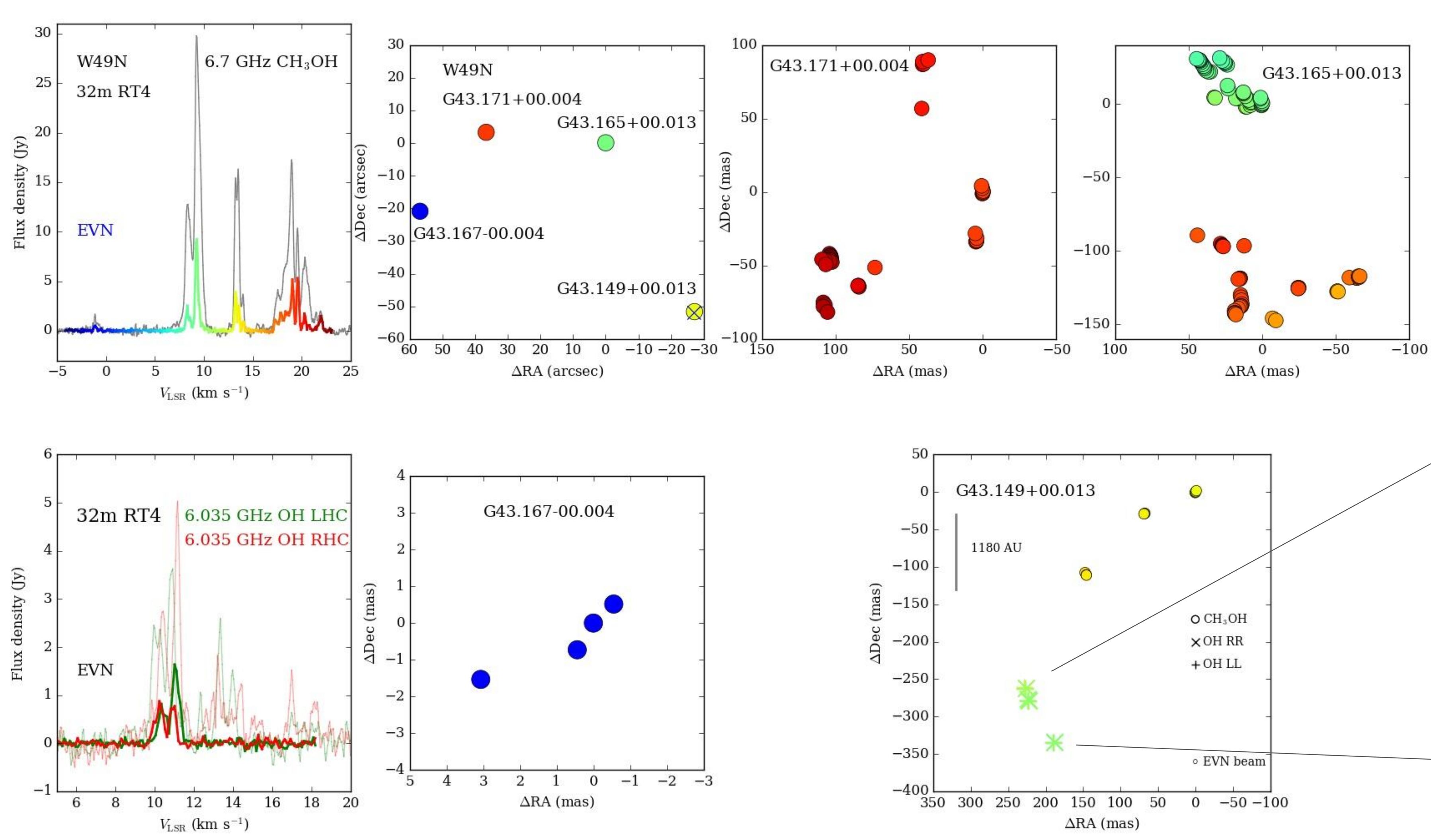
Results: We present first images of excited OH (ex-OH hereafter) masers in four targets. The (0,0) points in the figures for all sources except G45.465+00.045, correspond to the coordinates of the brightest spots of the 6.7 GHz methanol masers as in Bartkiewicz (2009, 2016).

Observations: We observed the following targets: **G20.237+00.065**,**G24.148-00.009**, **G43.149+00.013** (W49N), and **G45.465+00.045** (the names correspond to the Galactic coordinates) under two EVN projects: EB073 and EB079 on 2019 June 3 and 2020 Oct 16, respectively at the 6.035 GHz OH transition in the phase-referencing mode. The rms and synthesized beams on the final images in two circular polarizations (RHC, LHC) were 8 mJy and ~0.015”x0.005” with a position angle of -5°, respectively. The spectral resolution was 0.097 km s^{-1}.

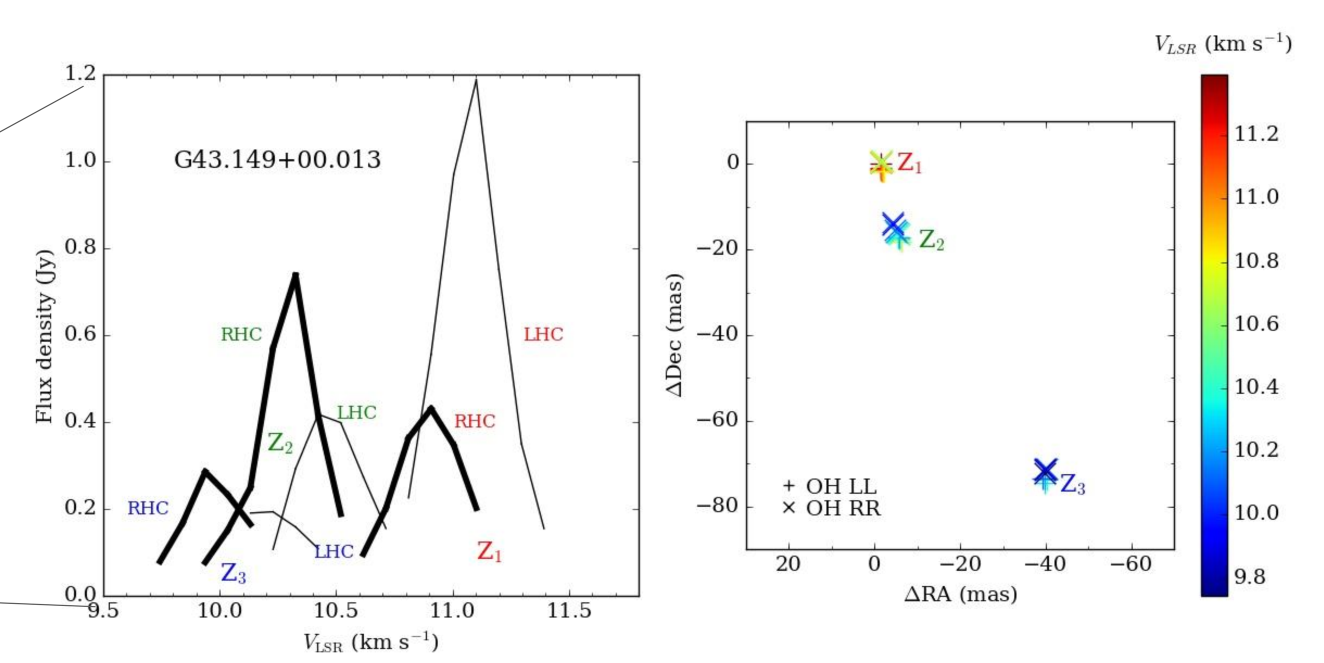
G20.237+00.065: Two ex-OH maser groups appeared in close surroundings of the 6.7 GHz methanol masers. However, a shift of 86 AU (20 mas) is significant even considering 10 year difference between observations and a motion of masing spots of 10 km s^{-1}. Moreover, there is also a displacement in the velocity domain of 4 km s^{-1}.
G24.148-00.009: The ex-OH maser emission is blue-shifted relatively to the methanol masers and clearly displaced.
G45.465+00.045: The ex-OH maser emission is 22” in RA, 17” in Dec away from the methanol maser G45.467+ 00.053. Five Zeeman pairs are confirmed implying the magnetic field strength (B) of ~4mG oriented towards us.
G43.149+00.013 (W49N): The displacement of ex-OH and methanol masers is clear: ~200 mas corresponding to 2200 au for a distance of 11.1 kpc (Zhang et al. 2013). No co-existence of both maser transitions indicate the diversity in densities of the maser-emitting regions (Cragg et al. 2002). According to the evolutionary sequence for masers proposed by Breen et al. (2010) this region would be the most evolved in the W49N. Single-dish spectrum implies that the emission is significantly resolved out. We detected three Zeeman pairs with EVN implying the magnetic field strength (B) of ~4mG oriented away from us.







Summary: We have used EVN to study gas properties in the environment of HMYSO using the 6.7 GHz methanol and 6.035 GHz ex-OH masers. The first results indicate the avoidance of both maser lines at the mas scales. We detected Zeeman pairs in two out of four targets. Since the VLBI ex-OH emission is significantly resolved out with EVN, we also use e-MERLIN to image more extended emission (A. Kobak’s talk at this Symposium).



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