Cosmic Masers: Proper Motion toward the Next-Generation Large Projects
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H_2O masers and host environments of FU Orionis and EX Lupi type low-mass eruptive YSOs

Zsófia Marianna Szabó[1,2,3,4], Yan Gong[1], Wenjin Yang[1], Karl M. Menten[1], Olga S. Bayandina[5], Claudia J. Cyganowski[2], Ágnes Kóspál[3,4,6,7], Péter Ábrahám[3,4,6], Arnaud Belloche[1] and Friedrich Wyrowski[1]

[1]Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany.
email: zszabo@mpifr-bonn.mpg.de

[2]Scottish Universities Physics Alliance (SUPA), School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews, KY16 9SS, UK

[3]Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Eötvös Loránd Research Network (ELKH), Konkoly-Thege Miklós út 15-17, 1121 Budapest, Hungary

[4]CSFK, MTA Centre of Excellence, Budapest, Konkoly Thege Miklós út 15-17., H-1121, Hungary

[5]INAF - Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125 Firenze, Italy

[6]ELTE Eötvös Loránd University, Institute of Physics, Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary

[7]Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany

Abstract. The FU Orionis (FUor) and EX Lupi (EXor) type objects are rare pre-main sequence low-mass stars undergoing accretion outbursts. Maser emission is widespread and is a powerful probe of mass accretion and ejection on small scales in star forming region. However, very little is known about the overall prevalence of water masers towards FUors/Exors. We present results from our survey using the Effelsberg 100-m telescope to observe the largest sample of FUors and EXors, plus additional Gaia alerted sources (with the potential nature of being eruptive stars), a total of 51 targets, observing the 22.2 GHz H_2O maser, while simultaneously covering the NH_3 23 GHz.

Keywords. Stars: pre-main sequence, Stars: low-mass, Masers

1. Introduction

Low-mass young stellar objects in their early stellar evolution can undergo accretion-driven episodic outbursts. By studying this phenomena we are able to gather crucial information on the formation and the evolution of Sun-like stars. The member of both FUor and EXor classes experience major increase in their brightness observed in the optical and near-infrared wavelengths. FUors can brighten up to 5-6 magnitudes in the optical and stay in a high-accretion state for decades, but likely centuries (e.g., Fischer *et al.* 2022, and references therein), while EXors brighten between 1-5 magnitudes and remain in a bright state for months or years, and the outbursts are recurring (e.g., Audard *et al.* 2014; Cruz-Sáenz de Miera *et al.* 2022). Masers have been substantially used to probe low- and high-mass star formation regions (e.g., Abraham *et al.* 1981; Omodaka *et al.* 1999;

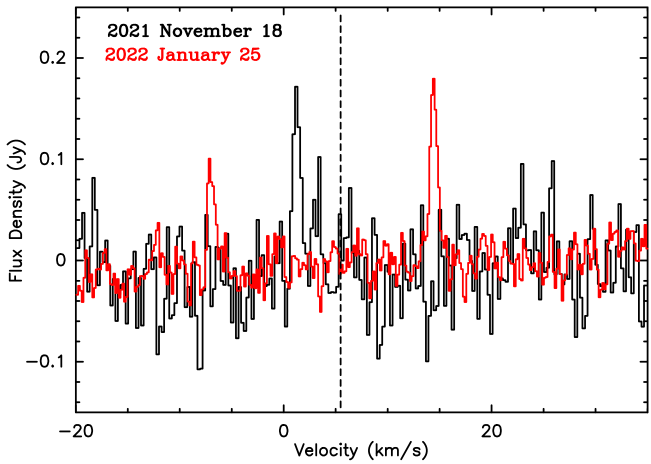

Figure 1. Detected H_2O masers towards HH 354 IRS.

Hirota *et al.* 2011; Furuya *et al.* 2003, 2001), currently still little information exists on masers in FUors/EXors.

2. Results

2.1. *H_2O masers associated with eruptive stars*

We detected H_2O masers towards 5 sources, but only 3 of the detections are likely associated with FUors/EXors, which include one EXor: V512 Per (Class I source) commonly known as SVS 13A, and two FUors: HH 354 IRS (Class 0/I) and Z CMa (Class I). The maser towards HH 354 IRS is the first to be reported. The maser component in Z CMa detected in our survey is a new component yet to be reported (see Fig. 1, Szabó *et al.* 2023b).

2.2. *Serendipitous detections towards Class 0 protostars*

Towards V512 Per (SVS 13A), multiple variable maser features were detected arising from a nearby source H_2O(B) (Class 0 object, known for H_2O masers, Haschick *et al.* 1980), which is within the beam. The source was in an active flare, contaminating the spectra of V512 Per. The peak of the emission was found to be associated with H_2O(B), but one maser feature at $>11\,\mathrm{km\,s^{-1}}$ is likely to be associated with V512 Per (see Fig. 2). Water masers were also detected towards the FUor binary RNO 1B/1C, but they are most likely arising from the molecular outflow of IRAS 00338+6312, located $4''$ from the FUors (see e.g., Fiebig 1995; Fiebig *et al.* 1996).

2.3. *Discussion and conclusions*

The detection rate of our survey of FUors/Exors is only 6%, surprising in light of the close connections between H_2O maser emission and mass accretion. Possible explanations include:

1. Evolutionary effect: H_2O maser detection rate generally decreases from Class 0 to Class II sources (e.g., Furuya *et al.* 2003).
2. Low luminosities in low-mass star formation regions: low bolometric luminosities result in lower flux densities (e.g., Urquhart *et al.* 2011).
3. Rapid time variation: time variability is known and evident from our study, however masers can be in quiescence for ~5 years (Claussen *et al.* 1996). Many of our targets

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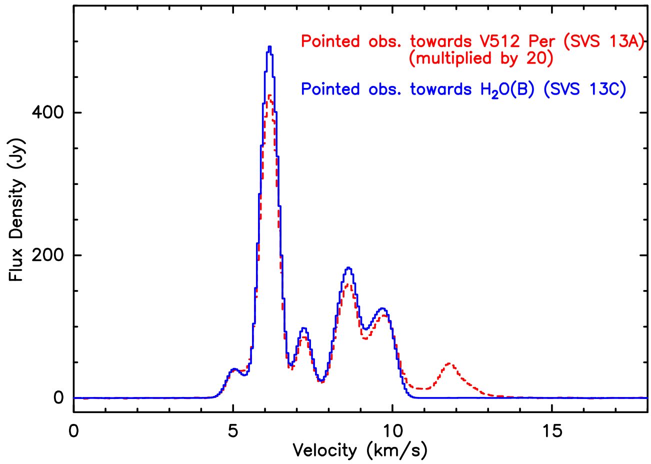

Figure 2. Pointed H_2O spectra towards V512 Per and H_2O(B) observed in 2022 February.

during the survey might have been inactive, despite showing maser emission in the past (see also Szabó *et al.* 2023b).

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