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Radio continuum of galaxies with H_2O megamaser disks

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Abstract. In our attempt to investigate the basic active galactic nucleus (AGN) paradigm requiring a centrally located supermassive black hole (SMBH), a close to Keplerian accretion disk and a jet perpendicular to its plane, we have searched for radio continuum in galaxies with H_2O megamasers in their disks. We observed 18 such galaxies with the Very Large Baseline Array in C band (5 GHz, ∼2 mas resolution) and we detected 5 galaxies at $8\,\sigma$ or higher levels. For those sources for which the maser data is available, the positions of masers and those of the 5 GHz radio continuum sources coincide within the uncertainties, and the radio continuum is perpendicular to the maser disk's orientation within the position angle uncertainties.

Keywords. Galaxies: active – Galaxies: jets – Galaxies: nuclei - Galaxies: Seyfert – Radio continuum: galaxies

1. Introduction

Galaxies, where the 22 GHz H_2O maser line (from the H_2O vapor 6_{16} - 5_{23} rotational transition) traces their central accretion disk, provide a unique view into the pc to sub-pc region surrounding the SMBHs (a prototype is NGC 4258, see Herrnstein *et al.*1998). Observing the radio continuum (which traces outflows or jets launched by the central engine) with the same linear resolution as the maser disk, provides an opportunity to study the spatial relationship between the radio jets and megamaser disks in detail.

2. Sample and Observations

We initially observed a sample of 24 active galaxies with the Very Large Array (VLA) mostly in B configuration and in Ka-band (central frequency of 33 GHz, see Kamali *et al.* 2017). From the 21 detected galaxies, we observed 14 sources plus 4 other sources with the Very Large Baseline Array (VLBA) in C band and with 2 mas resolution, to map the radio continuum on the same linear resolution as that of the maser disk. The contour maps of the 5 detected sources are shown in Fig. 1.

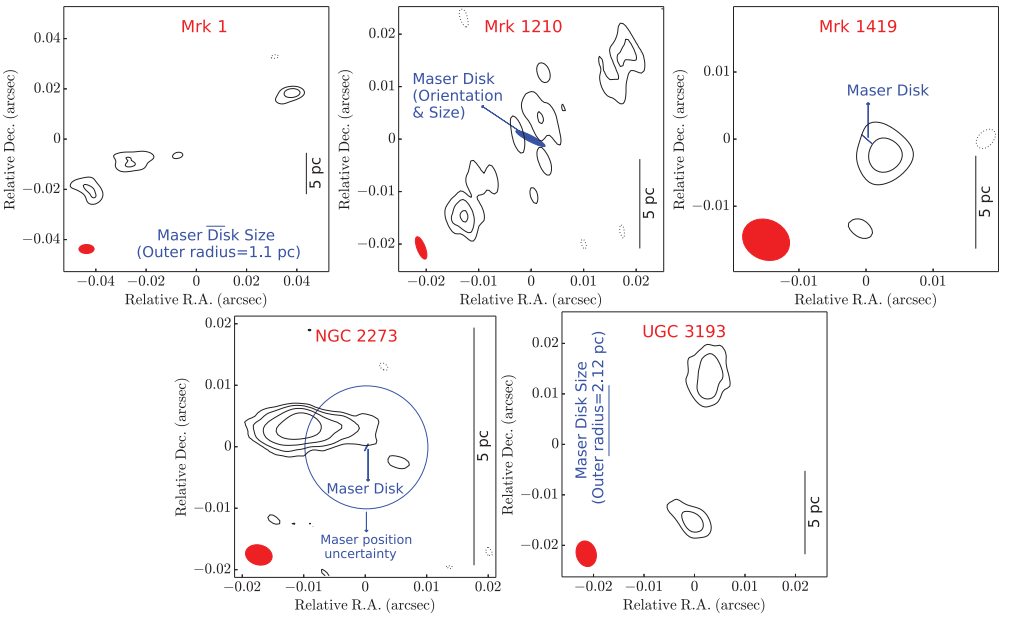

Figure 1. The 5 GHz contour maps for the five H_2O disk maser galaxies detected in the VLBA observations. The contour levels are ±3, ±6, ±12, ±24 times the $1\,\sigma$ rms ($\sim 35\,\mu$Jy/beam). The synthesized beam is shown in the lower left corner of each plot. The H_2O maser disk is also shown (for Mrk 1 and UGC 3193 only the size of the maser disk is available, for Mrk 1210 both size and orientation of the maser disk are known and for Mrk 1419 and NGC 2273 the position of the maser disk is also known). Disk maser data taken from Kuo *et al.* (2011), Braatz *et al.* (2015) and Zhao *et al.* in prep.

3. Results and outline

As seen in Fig. 1, when the maser position is available, it coincides with the 5 GHz radio continuum source within the maser position uncertainties. In addition, for those galaxies for which the maser disk orientation is measured, the maser disk is perpendicular to the extended radio emission within the position angle uncertainties. The low detection rate of radio continuum emission on pc to sub-pc scales in our study ($\sim$27%) could indicate that most of the radio emission observed on the kpc scale (in low luminosity AGNs (LLAGNs)) is due to star formation activity. Re-observations of the detected sources with a higher sensitivity, as well as observations with intermediate resolutions ($\sim$40 mas), are our next steps towards a better understanding of the radio continuum emission from the LLAGNs.

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