Exploring the radio continuum in megamaser galaxies with the EVN

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Introduction

The origin of the nuclear radio continuum emission in radio quiet AGN, differently from their radio loud counterpart, may be due to multiple physical mechanisms (for a review see Panessa et al. 2019). Indeed, in addition to synchrotron emission from relativistic (or sub-relativistic) particles in low-power jets, it might be produced by accretion disk winds and/or coronae, as well as by nuclear star formation. The study of the radio emission in radio quiet AGN, although they constitute the great majority of the AGN population, is challenging due to their intrinsic weakness. Being preferentially found in radio quiet objects (e.g., Seyfert or LINER galaxies), water megamasers offer a powerful complementary way to shed light on the origin of the radio continuum emission in these AGN. In fact, beside accretion disks, H_2O masers may also trace nuclear ejecta in the form of jets or winds providing estimates of the shock speeds and densities of the outflowing material, and improving our understanding of its interaction with the ISM (for a review see Tarchi 2012).

Here, we present multi-frequency VLBI radio continuum observations of two Seyfert galaxies hosting luminous water maser emission presently under thorough investigation by our group: **IRAS 15480-0344 (hereafter IRAS15480)** and **IC485**.

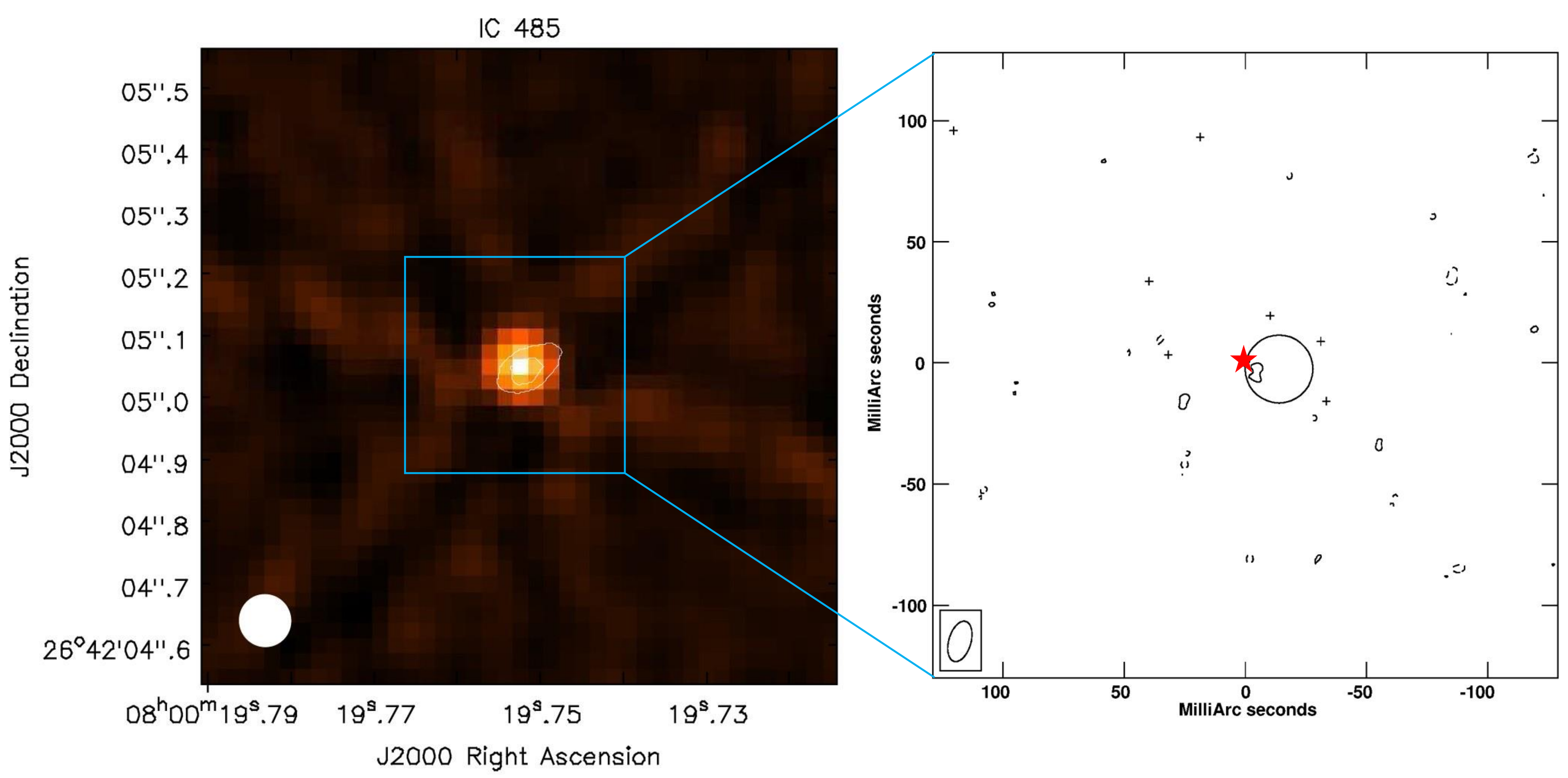

Fig. 2: IC485 integrated water maser (image) and 20 GHz radio continuum (contours) maps from Darling (2017) *(left panel)*; L-band EVN radio continuum map of the nuclear region of IC485, contour levels are -3, 3, 4, 5 x 18 microJy/beam. The position of the main maser line is indicated by the red star, while the black crosses pinpoint the tentative (?) radio continuum sources detected at K-band (Ladu et al. in prep.). The black circle represents the position of the VLA continuum source detected by Darling (2017).

References

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IRAS 15480

IRAS15480 is a lenticular (S0) galaxy located at a distance of ~130 Mpc that harbors a Seyfert 2 nucleus (Young et al. 1996). A luminous H_2O maser was detected in IRAS15480 reaching a total single-dish isotropic luminosity of ~200 L_{sun} (Castangia et al. 2016).

In order to shed light on the origin of the maser (jet, outflow, or disk), we observed the radio continuum emission in IRAS 15480-0344 with the European VLBI network (EVN) at 1.7 and 5.0 GHz.

The EVN maps show **two bright sources** (labeled SW and NE, **Fig. 1**) in the nuclear region of IRAS15480, which we interpret as **jet knots** tracing regions where the radio plasma impacts dense molecular clouds (for details see Castangia et al. 2019). The narrow maser feature is approximately at the center of the imaginary line connecting the two continuum sources, likely pinpointing the core, and might be associated with the accretion disk or a nuclear outflow. The location of the broad maser feature, instead, coincides with source NE, suggesting that the maser emission might be produced by a **jet-cloud interaction**, as it was proposed for NGC 1068 (Gallimore et al. 2001) and Mrk 348 (Peck et al. 2003). The combination of our VLBI radio continuum and maser observations unveil the presence of a compact radio jet and of strong interactions of the latter with the dense interstellar medium in the nucleus of a relatively radio quiet galaxy. This highlights the potential of maser studies to shed light on the parsec scale environment around AGN and, possibly, on the role of low power jets on galaxy evolution.

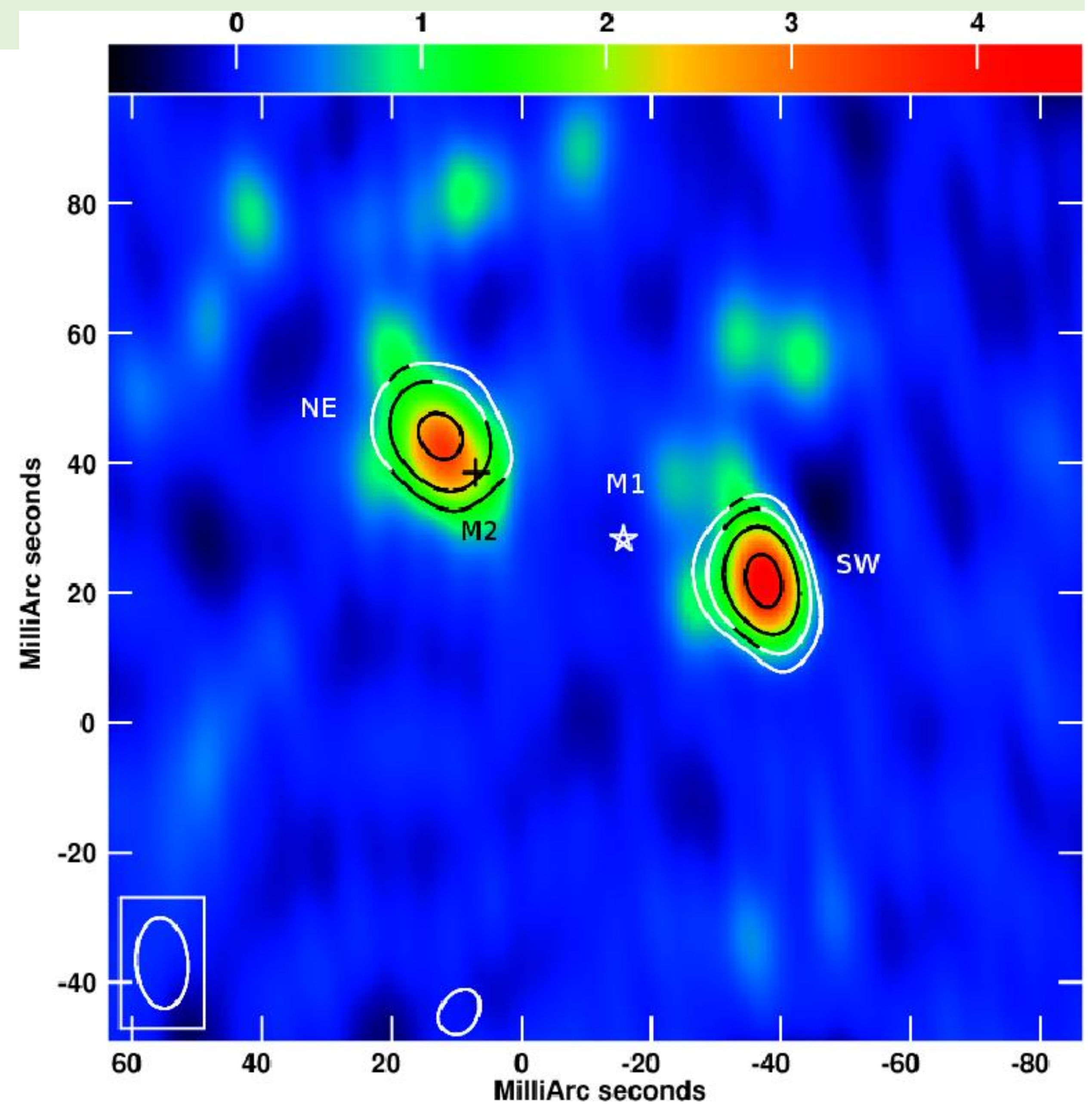

Fig. 1. Radio continuum emission in the nucleus of IRAS 15480 (Castangia et al. 2019). The color scale represents emission at L-band ranging from -0.7 to 4.6 mJy/beam, while the overlaid contours delineate the C-band emission convolved with the L-band beam (contour levels are -1, 1, 2, 4, 8, 16, 32, 64 x 0.45 mJy/beam).

IC485

Located at a distance comparable to that of IRAS15480, IC485 (D=122 Mpc) is a spiral galaxy spectroscopically classified as a Seyfert 2 (Kamali et al. 2017), although an alternative classification as a LINER was reported in Darling (2017). An H_2O megamaser of 900 L_{sun} was detected in this galaxy showing a triple-peak profile (Pesce et al. 2015). The sensitive single-dish spectrum together with the accurate position of the maser spots determined through 22 GHz VLBI observations **(E. Ladu's talk on Thursday)** indicate that the maser emission might by produced in an edge-on **accrection disk**. Unresolved and faint radio continuum emission was detected at VLA scale both at 1.4 GHz (Condon 2002) and 20 GHz (Darling 2017). We observed the radio continuum emission of IC485 with the EVN in May 2018, at 1.4 and 5.0 GHz, for a total of about 1.5 hours on source for each frequency, reaching rms noise levels of 18 and 28 μJy, respectively. No continuum source was detected above the 5σ noise level neither at 1.4 nor at 5.0 GHz in a region of 100 mas radius from the maser position. **A tentative source** is visible in the L band map with a peak flux density of 68 μJy (3.8 σ). This source coincides with the VLA source detected at 20 GHz by Darling (2017) and is very close to the main maser line (see **Fig. 2**). Considering the NVSS peak flux density of 4.4 mJy (Condon 2002), if we assume (as it was case for IRAS15480) that only the 30% of the VLA flux is recovered in VLBI images, we would expect a flux density of about 0.9 mJy in the L band map, well above the 5σ noise level of 90 μJy. The non detection of radio emission at parsec scale, therefore, suggests that the emission at larger scales is mostly resolved out, indicating a diffuse morfology.