

## The First VLBI Image of 6 GHz OH Masers Toward PN K 3–35

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K3–35 is a prominent young Planetary Nebula (PN), which is the brighter one of two PNe detected 6 GHz OH masers up to now. Considering the rareness of 6 GHz OH masers in PNe, we proposed a relative motion measurement for such kind of masers toward K3–35 with the European VLBI Network (EVN) in full polarization spectral line mode, to study the morphology and kinematics of the central core where the masers reside, and understand the role of the magnetic field in shaping its circumstellar envelope. Here we just present the preliminary results of the first epoch observations carried out on 16 June, 2014, which showing that the 6 GHz OH masers in PN K3–35 can be detected even at the milli-arcsecond scale.

**Keywords:** VLBI, PNe, K3–35, OH masers.

### 1 PN K3–35 and the 6035 MHz OH maser

Planetary nebulae (PNe) represent the transitory phase in the final stage of evolution for intermediate mass stars ( $\leq 8 M_{\odot}$ ), after they have passed through the asymptotic giant branch (AGB) phase and a brief post-AGB phase or proto-PNe. K3–35 (IRAS 19255+2123) is a prominent young PN, harboring both 18 cm OH emission (main and satellite lines) and the first excited state of OH maser emission at 6035 MHz (Desmurs et al., 2010). It is also the first PN where 22 GHz H<sub>2</sub>O maser was discovered (Miranda et al., 2001). K3–35 exhibits bipolar morphology at radio wavelengths (Aaquist, 1993), and the H<sub>2</sub>O maser emission is arising not only from the central core of the PN in a torus-like structure, but also from the tips of the bipolar lobes (Miranda et al.,

2001). Uscanga et al. (2008) studied the kinematics of the H<sub>2</sub>O masers near the central core of K3–35, by analysing the spatial distribution and line-of-sight velocities of the maser spots from the VLA observations. They identified an expanding and rotating ring, and suggested that the presence of a disc or torus may be relate to the collimation of the outflow.

The first 6035 MHz OH maser map for K3–35 was obtained from the MERLIN observation by Desmurs et al. (2010), which shows that the OH maser spots are very compact. Much higher angular resolution observation with the EVN on the 6035 MHz OH masers would be promising for providing morphologic and kinematic information, combined with the distance of the PN (~ 3.9 kpc, Tafuya et al., 2011), allowing us to obtain the full 3-dimensional motions, which is essential to understand the original of the asymmetry observed in K3–35.

## 2 The EVN observations

In order to study the morphology and kinematics of PN K3–35, and understand the role of the magnetic filed in shaping the envelope of this stellar system, We propose to observe the 6035 MHz OH masers toward K3–35, with full polarization spectral line mode using the EVN at three epochs spanning ~1 yr.

The first exploratory epoch (EVN code: EC044) was carried out on 16 June, 2014, with a recording rate of 256 Mbps and two correlator passes, one pass generates 16 channels for all data and a second pass generates 1024 channels for line sources. The observations were continuing in total of 9 hours, and J1925+2106 was observed as phase-reference calibrator, 3C286 and 3C48 were observed for polarization calibration. the EVN antennae involved were Effels-

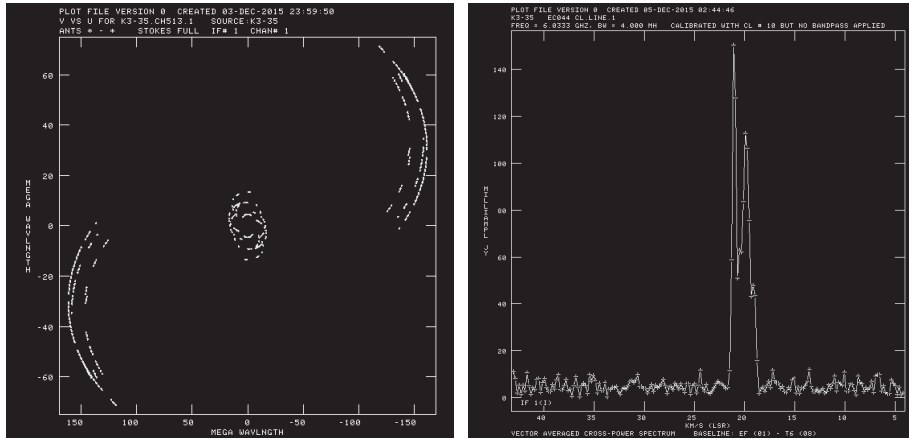


Fig. 1. The uv-coverage (*left*) and cross-power spectrum (*right*)

berg, Yebes, Torun, Noto, Westerbork, Jodrell Bank, Onsala and Tianma65. Unfortunately, Yebes and Noto did not get useful data because of LO wrong settings. However, the good data getting from the rest six antennae is enough to look into some general properties of the 6 GHz OH masers residing in K3–35.

### 3 Preliminary Results

Here we just present the preliminary results of the EVN observations. The uv-coverage is given in panel left of Fig. 1, and the cross-power spectrum between Effelsberg (EF) and Tianma65 (T6), the longest baseline with the length of  $\sim 8000$  km, is given in panel right, which shows that the 6 GHz OH maser is detected distinctly with the SNR of  $\sim 20$ . In Fig. 2, the 6035 MHz OH maser channel map of K3–35 is presented, with the resolution of milliarcsecond, which is the highest angular resolution for this kind of maser in PNe to date.

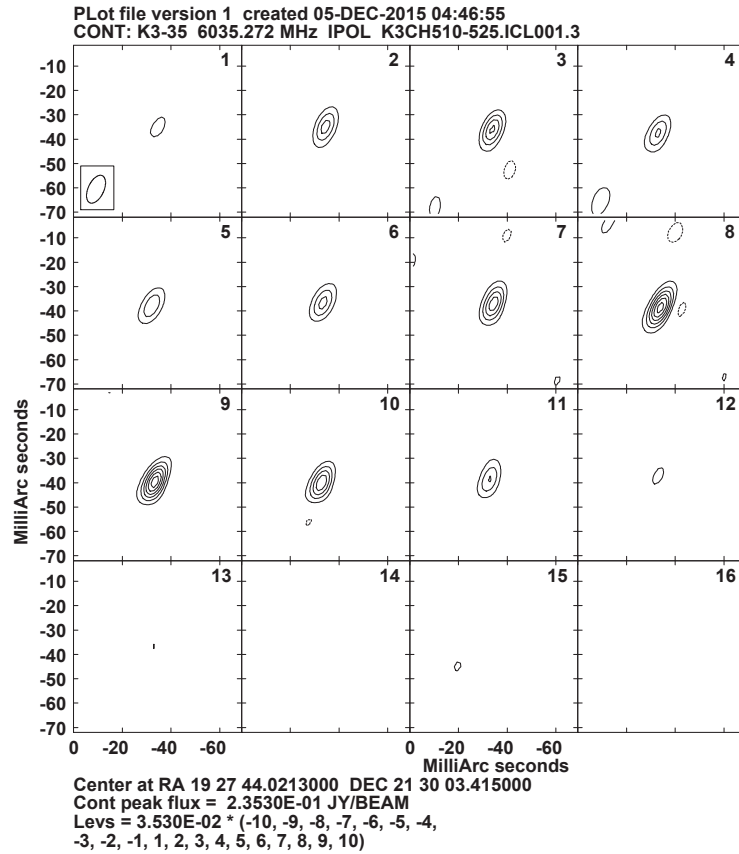


Fig. 2. The 6035 MHz OH maser channel map of K3–35 obtained with the EVN

#### 4 Summary

We carried out an exploratory epoch of the EVN observations on the 6 GHz OH masers toward PN K3–35 on 16 June, 2014. The VLBI image with milliarcsecond resolution of such kind of masers is obtained for the first time, not only for K3–35, but also for all PNe. The image shows that the 6 GHz OH maser spots in K3–35 are detectable and compact enough at mas scale, and suitable for the kinematics study and the determination of magnetic field strength.

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