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Discrete survey of 5-cm OH emission from planetary and proto-planetary nebulae

J.-F. Desmurs[1], A. Baudry[2], P. Sivagnanam[3], C. Henkel[4] and A. M. S. Richards[5]

[1]Observatorio Astronómico Nacional, Madrid, Spain
email: desmurs@oan.es

[2]LAB - Observatoire Aquitain des Sciences de l'Univers, Floirac, France

[3]Observatoire de Paris, France

[4]MPIfR, Bonn, Germany

[5]Jodrell Bank Observatory, UK

Abstract. We have undertaken a comprehensive search for the first excited state of OH emission (J=5/2, $^2\Pi_{3/2}$) in Planetary and Proto- Planetary Nebulae. With the Effelsberg telescope, we confirm the detection of Vy 2–2 and we present one new detection in the pPN K3−35. This detection has been confirmed by subsequent observations made at 6035 MHz with the MERLIN interferometer. This is the first detection of 6 GHz OH maser emission from a post-AGB star.

Keywords. Maser, stars: AGB and post-AGB, radio lines: stars

1. Introduction

PNe evolve from the envelopes of AGB stars, through the very short ($\sim$ 1000 yr) phase of protoplanetary nebula (pPN). During this phase, the nebular morphology and kinematics are dramatically altered: the spherical, slowly expanding AGB envelope becomes a PN with, usually, axial symmetry and high axial velocities. Sensitive observations of Planetary Nebulae in the 5 cm lines of OH are motivated by several reasons. The 6 GHz observations probe highly excited inner layers and provide important information; excitation models are complex and still uncertain, and predictions on the main pumping routes leading to OH inversion of the ground state will be constrained by observations of the $J = 5/2$ state.

2. Results and discussion

With the 100m MPIfR radiotelescope at Effelsberg, we have undertaken a complete discrete source survey for the first excited state of OH emission (J =5/2, $^2\Pi_{3/2}$) in 31 PN and pPN above a declination of –20 degrees. It is based on previous 18 cm OH surveys in which we have selected all sources exhibiting both 1612 and/or 1665/1667 MHz emission. We reached an average noise value of about $3\sigma \sim$30 mJy for a spectral resolution of 0.29 km/s. We confirm the detection of Vy 2−2 (see Desmurs *et al.* 2002) and we detected one new source, the young PN K 3−35, as a single 1 km/s-wide component around 21 km/s LSR velocity. This is the first detection of 6 GHz OH maser emission from a post-AGB star.

To confirm the 6035 MHz maser emission detected with Effelsberg in K 3−35, we made new observations using the MERLIN interferometer in the ground state ($^2\Pi_{3/2}$, $J = 3/2$) and the first excited level ($^2\Pi_{3/2}$, $J = 5/2$). Figure 1 presents our map of the 6035 MHz

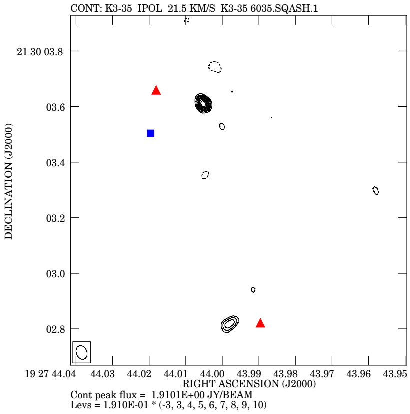

Figure 1. Map of the OH 6035 MHz maser distribution (line contours) compared to the 1612 (blue square) and 1720 MHz (red triangle) maser emission centers.

maser emission (see line contours). The 18-cm positions (position uncertainty is about 40 mas) derived from our interferometric observations are shown for the 1720MHz (red triangle) and the 1612 MHz (blue square). Other 18-cm OH components detected with the Nançay radio telescope around 9 and 18 km/s did not show any 6 GHz counterpart or 18-cm compact emission in the MERLIN data.

K 3−35, is considered to be a very young PN (see OH maser observations by Zijlstra *et al.* 1989) situated in the constellation Vulpecula. VLA observations by Miranda *et al.* (2001) at 22 GHz reveal the shape of a bipolar structure typical of Proto Planetary Nebulae and allow the authors to conclude that this object has just begun its transformation into a planetary nebula. K 3−35 has been detected at 18 cm in the 1612, 1667, and 1720 MHz OH lines (Engels *et al.* 1985, te Linkel Hekkert 1990, Gómez *et al.* 2006). Our interferometric observations of K 3−35, show the quasi spatial coincidence of the 18 cm and 5 cm maser emissions.

The absence of detectable excited emission at 5 cm in pPNe (except in Vy 2−2 and K 3−35) tends to argue in favour of a pumping scheme based on the absorption of 35 and 53 μm photons. In the case of Vy 2−2 the ionisation shell from where the maser emission seems to originate, may present physical conditions (shock, higher temperature and density) similar to those prevailing in HII regions. We note that 1720 MHz masers are exceptionally rare around evolved stars (but have been observed in many star forming regions). A hybrid pumping model applying to both OH/IR stars and HII regions or even a pumping scheme similar to OH maser emission in massive star forming regions may be successful.

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