On the magnetic field of OH 231.8+4.2

Marcelo L. Leal-Ferreira[1], Wouter H. T. Vlemmings[1,2],
Philip J. Diamond[3], Athol Kemball[4], Nikta Amiri[5,6]
and Jean-François Desmurs[7]

[1] Argelander Institute für Astronomie, Universität Bonn, Germany
email: `ferreira@astro.uni-bonn.de`

[2] OSO (Sweden), [3] JBCA (UK), [4] University of Illinois (USA), [5] JIVE (Netherlands), [6] Leiden
Observatory (Netherlands), [7] OAN (Spain)

Abstract. During the transition from an AGB star to a planetary nebula, a large number of
low/intermediate initial mass stars loses its spherical symmetry. The process responsible for that
change of morphology is, so far, not well understood. The candidates responsible for shaping
these objects are (i) a companion to the star (binary/heavy planet) and its tidal forces, (ii) disk
interaction and (iii) magnetic fields - or a combination of these. In particular a binary induced
magnetic field is a promising option. To study this we observed the polarization of H_2O masers
in the known binary pre-Planetary Nebula (pPN) OH231.8+4.2. Our results show a magnetic
field $B_{||}$ of ∼45 mG is present in the H_2O maser region of this pPN.

Keywords. magnetic fields, masers, polarization, stars: AGB and post-AGB, stars: individual
(OH231.8+4.2)

1. Introduction

The loss of spherical symmetry of evolved stars is still a matter of debate. Simulations
shows that, if present, magnetic field can affect the morphology of these objects, but
observations of the fields are still rare. We aim to investigate the polarization of the H_2O
maser emission, at 22 GHz, of the pPN OH231.8+4.2 (Rotten Egg Nebula), and infer the
properties of its magnetic field. To achive that we used data from the NRAO[†] VLBA.

2. Results and discussion

We detected 30 maser features, 20 of them located in the Northern Region (NReg)
and the other 10 in the Southern Region (SReg). In Fig. 1, the 30 features are scaled
by their fluxes (size of the triangles), and colored according their line-of-sight velocities.
The black lines, scaled in size by the amount of linear polarization, show its direction
(EVPA). The origin (0,0) of the plots is centered on the brightest feature we detected.

Assuming that the masers we observed correspond to roughly the same features detected by Desmurs *et al.* (2007), we can estimate their proper motion between the observations. We selected an area in NReg and another in SReg where the density of masers is
higher and calculated how much the center point of the features have moved. The offsets
we found give a velocity of the separation of 14.8 km/s (with $d = 1100$ pc and $i = 36°$;
Choi *et al.* 2011; Kastner *et al.* 1992; Shure *et al.* 1995). Furthermore, the masers seem
to be dragged on the direction of the nebula jet (Leal-Ferreira et al., in prep.). This effect
can indicate that the masers arise in a turbulent material that is entrained by the jet.

Linear polarization was found for 3 of the 11 maser features in the SReg (see Fig. 1). A
high scatter is present in the EVPA of these features and we can point out two different
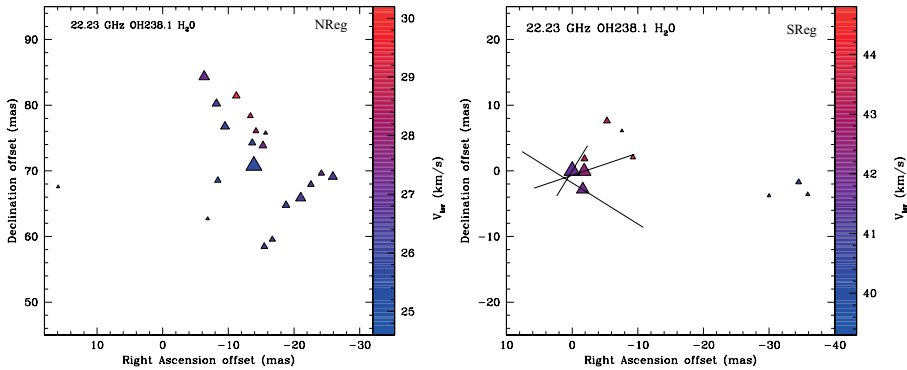
Figure 1. H_2O maser features of OH231.8. The triangles are scaled in size by the maser fluxes, and in color by their velocities. The lines show the EVPA and intensity of the linear polarization.
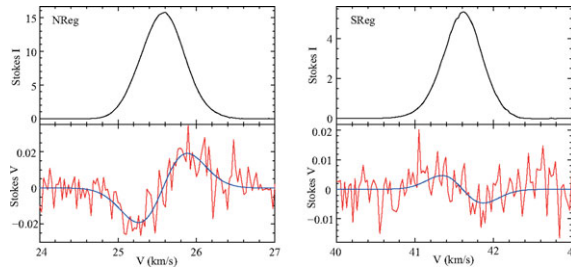

Figure 2. Spectra of the Stokes I and V. The blue lines show the model fits.

scenarios to interpret it: (i) The scatter could be caused by turbulence, or (ii) in case of a toroidal magnetic field, the masers could be located on its tangent points.

We also detected circular polarization on the 2 strongest maser features we observed. Figure 2 shows the spectra of Stokes I and V. Overplotted to the V spectrum (red), we show the model curve that fits the spectrum (blue). From this fit, we found that the strength of the magnetic field is $B_{||}(\text{NReg}) = 44 \pm 7$ mG and $B_{||}(\text{SReg}) = -29 \pm 21$ mG.

The magnetic field morphology is still not defined, as different shapes can fit our polarization results. However, assuming a toroidal field ($B \propto 1/r$) and a distance of ~ 40 AU between the central star and each maser region, it is possible to project the field strength on the stellar surface (taken to be ~ 1 AU). We then found ~ 1.5 G $< B_{\text{surface}} < \sim 2$ G, similar to that estimated for the pPN W43A (Vlemmings *et al.* 2006).

These results, allied with the ones from Etoka *et al.* (2009), make OH231.8 the first evolved star, known to be a binary, in which the presence of a magnetic field is confirmed.

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