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Trigonometric parallax of the protoplanetary nebula OH 231.8+4.2

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Abstract. We report trigonometric parallx measurements for H_2O masers around the protoplanetary nebula OH 231.8+4.2 carried out with the Very Long Baseline Array. Based on astrometric monitoring for 1 year, we measured a trigonometric parallax of 0.89 ± 0.04 mas, corresponding to a distance of $1.12\ ^{+0.05}_{-0.05}$ kpc. This is the most accurate distance to OH 231.8+4.2, and the first one based on an annual parallax measurement. The distribution and internal motions of the H_2O masers are consistent with the bipolar outflow suggested in literatures.

Keywords. astrometry, stars: late-type, stars: distances, stars: individual (OH 231.8+4.2)

1. Introduction

Protoplanetary nebula (PPN) is the transition phase from the asymptotic giant branch (AGB) star to the planetary nebula (PN). Since maser emission arises in regions very close to the photosphere of the central object of a PPN that still has AGB star characteristics, maser is an unique tool to study the structure and kinematics of the inner nebula. Measuring trigonometric parallaxes of PPNe is crucial to estimate their fundamental properties - luminosities, mass-loss rate, ages, and initial masses - quantitatively. Thanks to the VLBI technique, distance measurements with trigonometric parallaxes have become possible beyond several kpc.

OH 231.8+4.2 is a well studied PPN, showing SiO, H_2O and OH maser emission. The central source is a binary system, composed of an M9-10 III Mira variable and an A0 main sequence companion (Sanchez *et al.* 2004). It is also known as the *Rotten Egg Nebula* because of relatively large amount of sulfur and the *Calabash Nebula* from its shape.

2. Observations and Results

We have conducted Very Long Baseline Array (VLBA) observations to study the H_2O masers toward the protoplanetary nebula OH 231.8+4.2. In order to measure the trigonometric parallaxes, we used phase-referencing observations by fast switching between the maser target and the extragalactic continuum source, J0746-1555, 1.55 degrees separated from OH 231.8+4.2. The VLBA observations were scheduled under program BC188 at four epochs: 2009 May 01, Oct 19, Nov 09 and 2010 May 01. These dates were optimized to get the maximum and minimum of the parallax signal in right ascension.

Figure 1 shows position measurements of the 41.85 km s^{-1} H_2O maser component relative to background continuum source J0746-1555 for 1 year. Assuming that the movements of the maser features are composed of a linear motion and the annual parallax, we obtain a proper motion and an annual parallax by least-square analyses. We measured the parallax of OH 231.8+4.2 to be 0.89±0.04 mas, corresponding to a distance of 1.12

$^{+0.05}_{-0.05}$ kpc. This is the first distance of OH 231.8+4.2 based on the trigonometric parallax measurements. We also determined the absolute proper motion in right ascension and declination. The results are -3.55±0.18 mas yr^{-1} in right ascension and −4.33±0.80 mas yr^{-1} in declination. After we subtract the average motion of several maser features, internal proper motions of the H_2O masers in OH231.8+4.2 suggest bipolar outflow from the central star (Fig. 2). The origin of internal motions is consistent with the positions of SiO masers in Desmurs *et al.* (2007), which trace the disk of the central star.

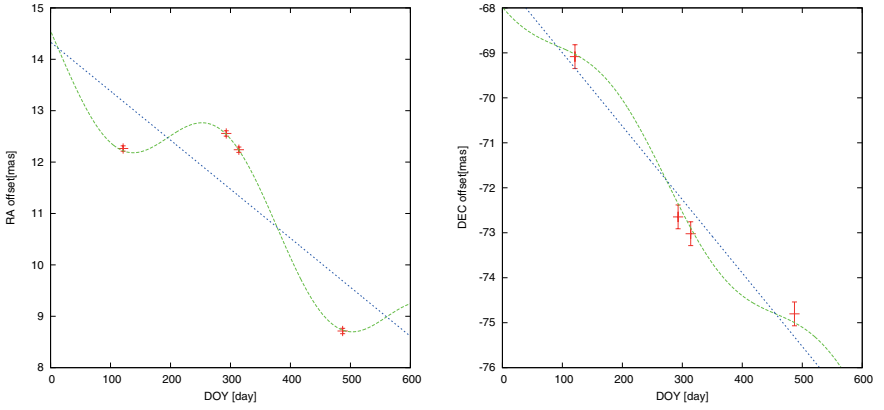

Figure 1. Parallax and proper motion data and fits for OH 231.8+4.2. Red points with error bars are position measurements of the H_2O maser spot at LSR velocity of 41.85 km s^{-1} relative to background quasar J0746-1555. Green lines represent the best-fit model with an annual parallax and linear proper motions. Blue lines represent the linear proper motions. Left panel: the change of position in right ascension as a function of time (day of year). Right panel: the same as the left panel in declination.

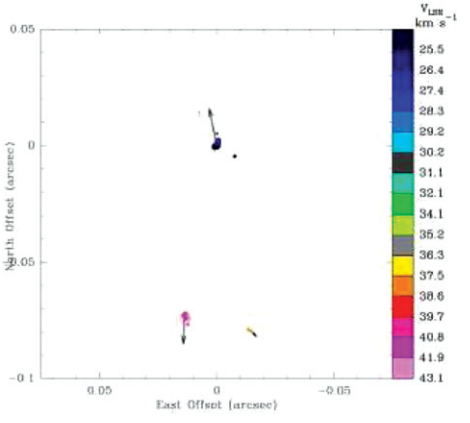

Figure 2. Map of the positions of the H_2O masers in OH 231.8+4.2. Absolute coordinates of the map origin are R.A.(J2000)= 07h 42m 16s.91720 and Dec. (J2000)= -14° 42′ 50″.0795. The arrows show the internal motions of the H_2O maser features in OH 231.8+4.2 after subtracting the absolute proper motion.

References

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