RadioAstron observations of the H_2O maser emission in the star forming region W49N

N. N. Shakhvorostova(1), J. M. Moran(2), A. V. Alakoz(1), H. Imai(3) and A. M. Sobolev(4)
(1) Astro Space Center, Lebedev Physical Institute of RAS, 84/32 Profsoyuznaya st., Moscow, 117997, Russia
(2) Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA
(3) Center for General Education, Kagoshima University, 1-21-30 Korimoto, Kagoshima 890-0065, Japan
(4) Astronomical Observatory, Ural Federal University, 19 Mira street, Ekaterinburg, 620002, Russia

Water vapor masers are commonly used as an important tool for the study of the star formation process as well as scattering in the interstellar medium. Some have compact structure and high flux density, and can be visible on large distances both in our Galaxy and in other galaxies. Extremely high angular resolution is needed for investigation of their angular structure. Linear sizes of Galactic H_2O masers are about $1-100$ AU and, thus, they are unresolved in milli-arcsec angular resolution or finer. Space-VLBI mission *RadioAstron* provided highest angular resolution as fine as 7 μas and permits size estimates of the most compact structures in star forming regions.

We observed H_2O maser emission associated with the massive star formation region W49N with *RadioAstron* and up to six ground stations in five sessions of our maser survey program during 2014-2015 (see [1] and references therein). W49N is an ideal target because of its high brightness and complex structure. It lies at a distance of 11 kpc, at a galactic latitude of less than 0.1°, and interstellar diffractive scattering is known to affect the maser propagation [2]. Because of W49N's high flux density ($\sim$10 kJy) its total spectrum can be accurately measured with the *RadioAstron* data, so that fringe visibilities can be accurately determined from the total power spectra alone, without need of knowledge of SEFDs. Fringes on space baselines were detected with angular resolution as fine as 23 μas, which corresponds to a baseline of 9.6 Earth diameters.

We have measured a smooth, nearly continuous, visibility functions from 100 to 5000 $M\lambda$ for numerous velocity features in W49N from -100 to 100 km/s. There is overlap between some space-ground and ground-ground baselines, which agree very well and shows that there is no problem with the calibration of the *RadioAstron* data. The ground-ground data with baselines less than 1000 $M\lambda$ on a few velocity components are each well modeled by an elliptical component with parameters V(0)=0.88, major axis = 237 μas, minor axis = 183 μas, and PA= 98°. We assume that this represents the scattering kernel due to turbulence in the intervening ISM. This is first measurement of the anisotropy of the scattering in an H_2O maser. The PA is in rough agreement with that determined for the OH masers [3]. Since V(0) = 0.88, there is a large scale component with, at most, 12 percent of the flux density. This missing flux density could be in the form of a halo produced by local scattering in the maser region as suggested by Gwinn [4]. At very long baselines the visibilities plateau and remain approximately constant at about 0.005 for baselines from 1500 to 5000 $M\lambda$ (extending the work of [1]). This phenomenon is probably due to refractive scattering. This is the first detection of refractive scattering in a water vapor maser. A previous upper limit has been determined by [2]. A combination of diffractive and refractive scattering due to the ISM has been observed in the continuum sources 3C273 and SgrA* [5, 6].

We also analysed the distribution of hundreds of the W49N maser components based on the fringe-rate mapping method and compared it with previous results. The principal maser cluster are remain the same, but small temporal structural differences are evident. We can therefore study any variation in scattering properties across the 2" extent of W49N.

References

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