Why Galaxies Care About AGB Stars:
A Continuing Challenge through Cosmic Time
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Circumstellar molecular maser emission of AGB and post-AGB stars

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Abstract. Results of long-term studies of circumstellar molecular maser emission of late-type giant and supergiant variable stars are reported. In the 1.35-cm H_2O line, the peak flux density correlates with the optical brightness lagging behind it by 0.3–0.4 P (P is the stellar period). "Superperiods" of 10 to 15 P are visible in several stars, demonstrated as high maxima in the visible light curve and associated flares in the H_2O maser line. In the 18-cm OH lines, full polarization of the maser emission has been measured. Variable Zeeman patterns suggesting a changing magnetic field of a few milligauss have been detected.

Keywords. stars: late-type, stars: winds, outflows, stars: mass loss, stars: magnetic fields, radio lines: stars.

Results of long-term studies of circumstellar molecular maser emission of late-type giant and supergiant stars are reported. The observations have been carried out during several decades in the H_2O line at a wavelength of 1.35 cm (22-meter telescope in Pushchino, Russia) and in the hydroxyl (OH) lines at 18 cm (Nançay radio telescope, France). A sample of ∼70 AGB long-period variable stars has been monitored in the 1.35-cm H_2O line in 1980–2018. It includes Mira-type stars (U Ori, RS Vir, U Her, Y Cas, R Cas, ...) and semiregular variables (R Crt, RT Vir, W Hya, VX Sgr, ...).

We have traced H_2O maser variations and found them to follow the optical brightness variations of the stars with a time delay of 0.3–0.4 P. Some strong H_2O flares were observed, which occur every 10 to 15 periods, probably due to long-term changes in the mass-loss rate; good examples are U Ori (Rudnitskij *et al.* 2000), R Cas (Pashchenko *et al.* 2004), and RS Vir (Lekht *et al.* 2001). In the star W Hya, the H_2O peak flux density reached several thousand janskys, while on the average it did not exceed 50–100 Jy (Rudnitskij *et al.* 1999). We consider the model of the flares with shock excitation of the H_2O maser in combination with stellar radiation pumping.

A sample of 70 AGB stars, mostly overlapping with the H_2O line program, was observed in the 18-cm OH lines. For 53 of them, the emission was detected in at least one of three OH lines (1612, 1665, or 1667 MHz). Appreciable polarization (nonzero Stokes parameters) was present in 41 stars (Rudnitskij *et al.* 2010). Circular and linear polarization of the maser emission was measured, yielding all four Stokes parameters. Features probably due to Zeeman splitting were detected in the OH line profiles of several stars. Estimated magnetic-field strengths in the maser sources are a few milligauss. In particular, we

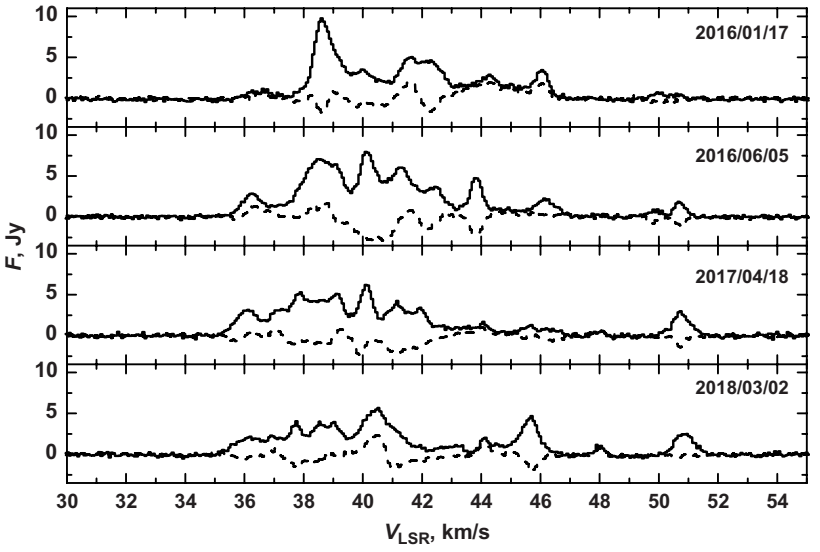

Figure 1. Variation of the semiregular variable star HU Puppis in the 1612-MHz OH line in 2016–2018. Solid curves: total flux density; dashed curves: Stokes parameter V (difference of flux densities in the right- and left-hand circular polarizations).

discuss the data on the 1612-MHz OH emission of the semiregular variable star HU Pup displaying maser emission in three ground-state OH lines 1612, 1665, and 1667 MHz. Figure 1 presents radial-velocity profiles of the 1612-MHz satellite OH line of this star measured on the Nançay radio telescope in 2016–2018. Earlier data on the maser emission of HU Pup were published by Colom *et al.* (2014). The total flux density profile (I) consisting of several peaks spread in velocity between 32 and 52 km/s demonstrates rather small changes, in contrast to the V Stokes parameter shown with dashed curves. Some alternating positive/negative V structures appearing occasionally in the V profile can be interpreted as Zeeman splitting in a few-milligauss magnetic filed in the OH masering region of the circumstellar envelope. The behaviour of the V profile suggests important variations in the pattern of the star's magnetic field producing polarization of the OH emission.

The complete version of this poster in the electronic form can be found at: http://comet.sai.msu.ru/~gmr/IAUS343_23554.pdf

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