23554 Circumstellar Molecular Maser Emission of AGB and Post-AGB Stars

Georgij Rudnitskij[1], Nuriya Ashimbaeva[1], Pierre Colom[2], Evgeny Lekht[1], Mikhail Pashchenko[1], Alexander Tolmachev[3]

[1]Sternberg Astronomical Institute, Moscow State University, Moscow, Russia

[2]Observatoire de Paris-Meudon, Meudon, France

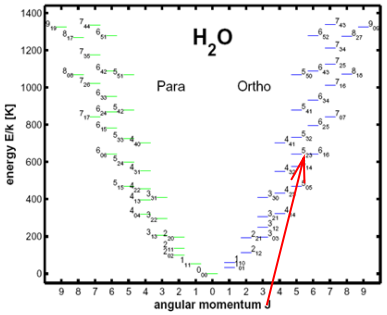
[3]Pushchino Radio Astronomy Observatory, Pushchino, Russia

Results of long-term studies of circumstellar molecular maser emission of late-type giant and supergiant stars are reported. 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, 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 with a time delay of 0.3-0.4 stellar period. 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, U Her, and RS Vir. Especially spectacular flares were demonstrated by the semiregular star W Hya, when its H_2O peak flux density reached several thousand janskys, while on the average it did not exceed 50-100 Jy. The same sample of AGB stars 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). 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 discuss the data of 2007-2018 on the OH emission of the unique symbiotic star V627 Cas (AS 501, AFGL 2999) displaying maser emission in three ground-sate OH lines 1612, 1665, and 1667 MHz, with remarkable redistribution with time of their relative intensities, as well the new data on the OH and H_2O emission of the post-AGB star AI CMi.

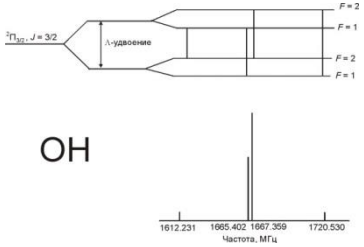
Instruments

RT-22
Pushchino, Russia
22-metre dish,
monitoring in the
H_2O line at 1.35 cm
since 1980,
sensitivity 12 Jy/K,
spectral resolution
0.082 km/s

NRT
Nançay, France
two-mirror,
monitoring in the
OH lines at 18 cm,
sensitivity 1.4 Jy/K,
spectral resolution
0.137 or 0.068 km/s



1.35-cm line



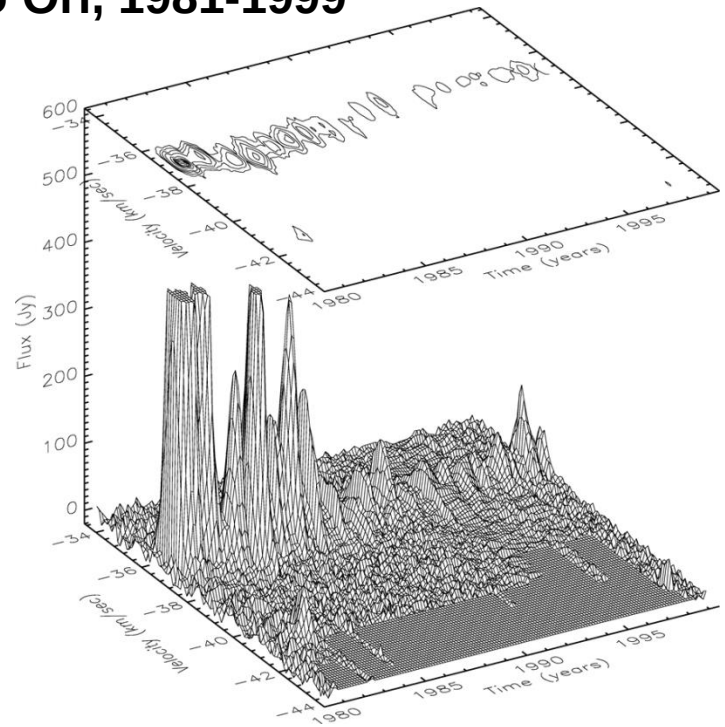
Objects

SR Supergiants
S Per, VY CMa,
VX Sgr, PZ Cas,…

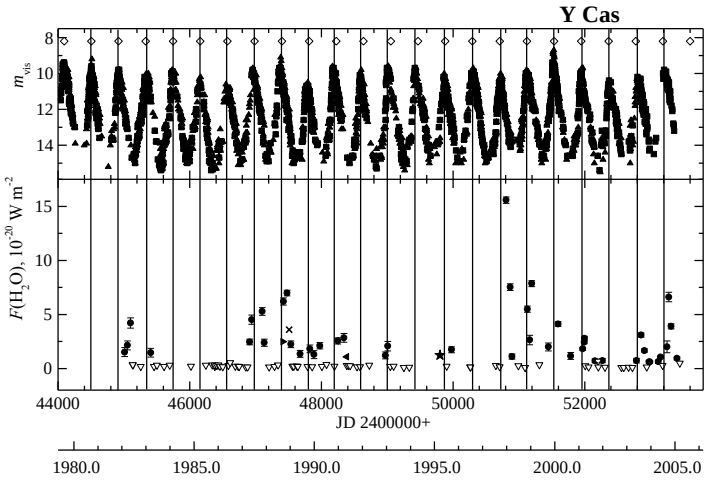
Miras:
Y Cas, WX Psc, T Lep,
U Ori, Z Pup, HU Pup,
R Cnc, R LMi, V Ant,
RS Vir, S CrB, WX Ser,
U Her, R Aql, RR Aql,
R Cas,…

Semiregulars:
R Crt, S Crt, RT Vir,
W Hya, RX Boo,…

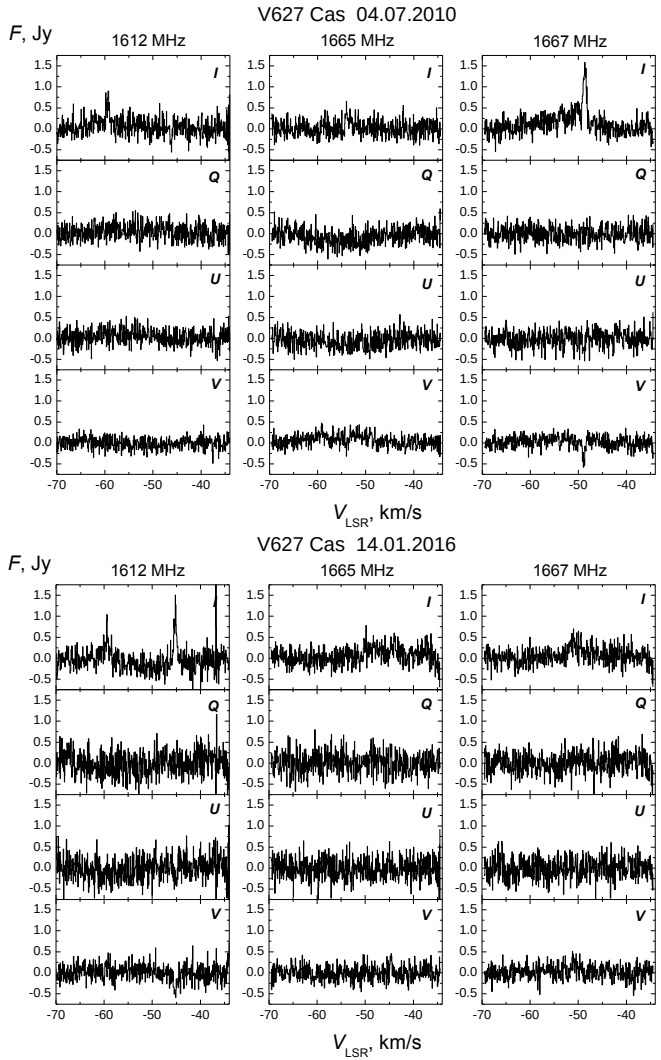
Examples of earlier H_2O data
U Ori, 1981-1999



Y Cas, 1982-2005

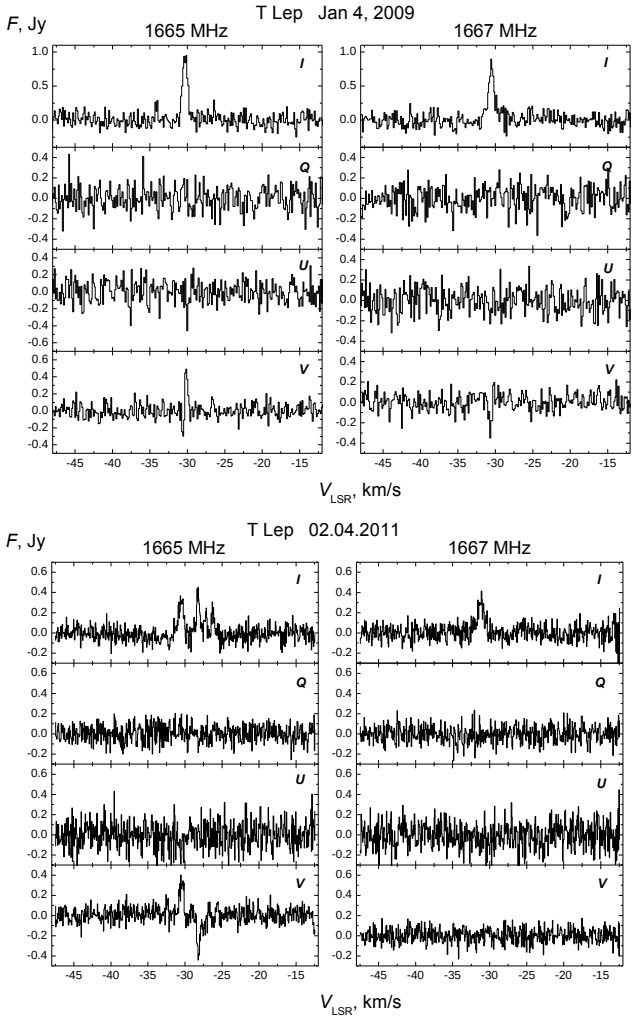


Symbiotic star V627 Cas (AS 501)
OH 18-cm lines



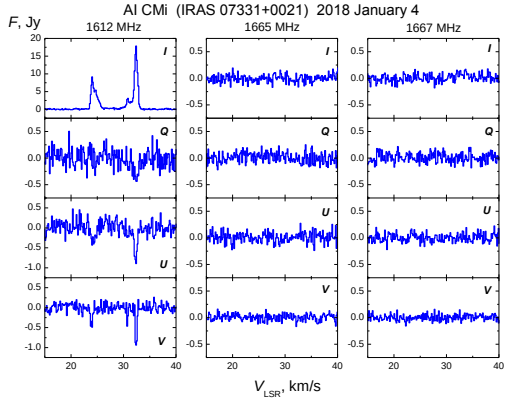
Redistribution of the emission between lines
Asimbaeva et al., 2017, Astron. Reports 61, 16

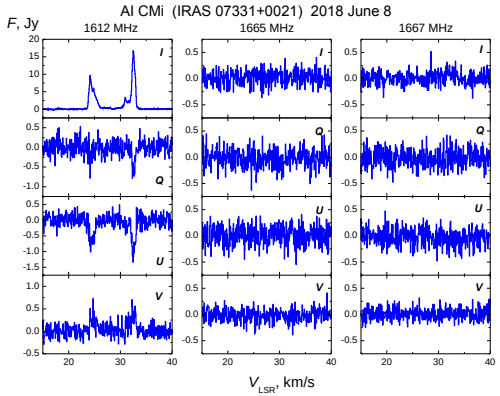
Mira-type star T Leporis, $P = 368^d$
OH 18-cm lines



Variable Zeeman pattern in the 1665-MHz OH line

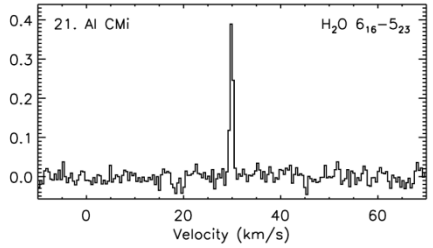
Post-AGB star Al Canis Minoris,
OH lines
(no H_2O emission detected, F < 10 Jy)



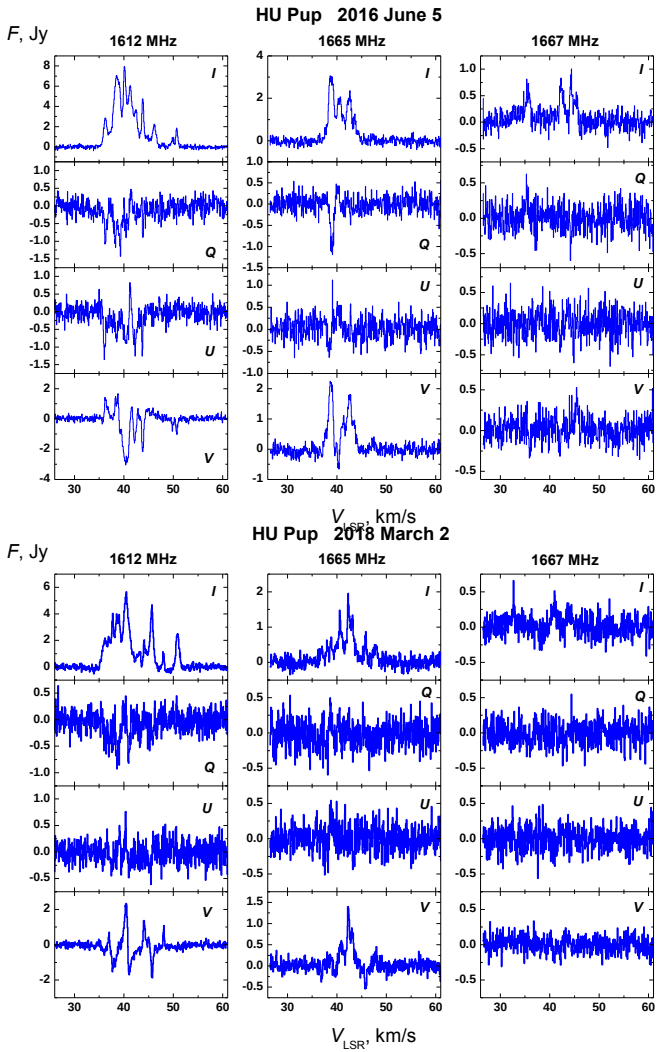


OH lines are good tracers of magnetic fields. Full-polarization measurements of OH lines at Nançay can yield this information

However, Yoon et al. (2014) detected H_2O with F_{peak} = 10 Jy



Semiregular star HU Puppis
OH 18-cm lines



Earlier OH and H_2O data:
Colom et al., 2014, Astron. Lett. 40, 212
+ unpublished results

Supergiant semiregular star S Persei
H_2O data

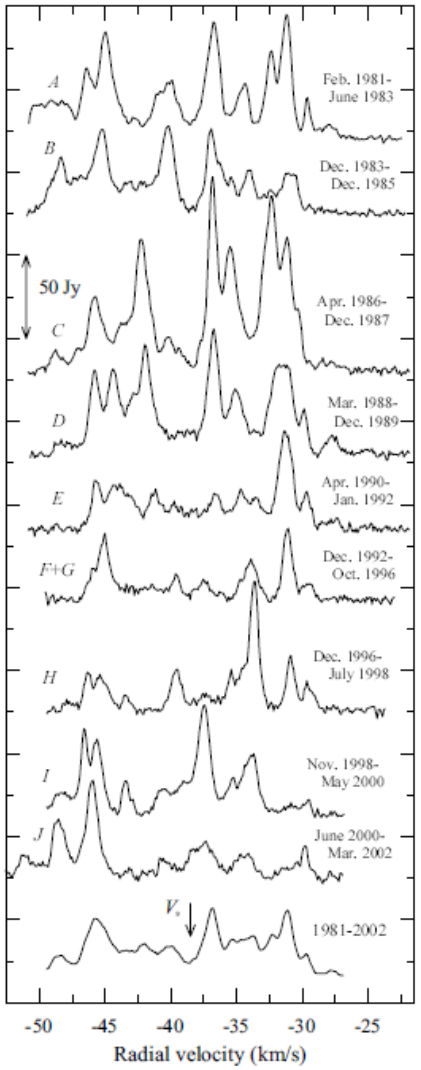


Fig. 6. Average spectra for each time period (A through H). The gr average spectrum is shown in the bottom panel. Intervals F and G joined together due to the small amount of data.

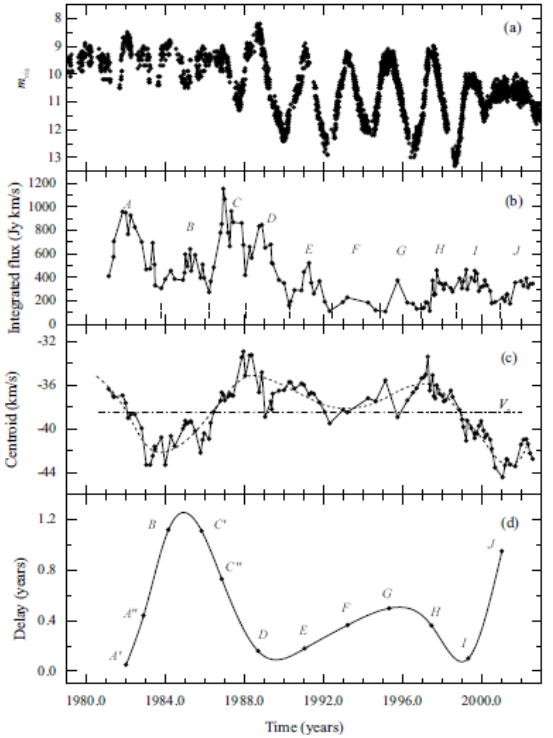


Fig. 2. Visual light curve of S Per, AFOEV data **a**), variations of the total flux **b**), velocity centroid **c**), delay (years) between the H_2O line and visual maxima **d**). Vertical dotted lines divide the entire time interval into activity periods labeled A through J; points A′A″ and C′C″ mark the limits of the integrated-flux events A and C, respectively.

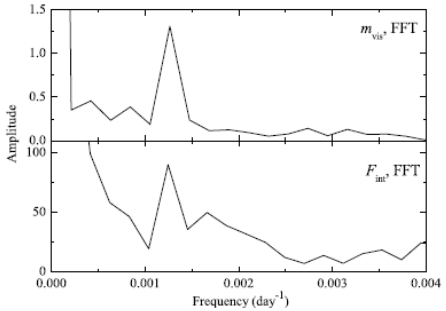


Fig. 3. Fourier spectra of the visual light curve and integrated flux curve (Fig. 2), calculated for the time interval 1987.0–2000.0. Both spectra show a peak at $f \approx 0.0125$ d^{-1}, corresponding to a period of 800^d.

Lekht et al., 2005, A&A 437, 127