WHY GALAXIES CARE ABOUT AGB STARS II:
SHINING EXAMPLES AND COMMON INHABITANTS
ASP Conference Series, Vol. 445
Kerschbaum, Lebzelter, and Wing, eds.

Water Vapour Masers in the Mira Variable U Herculis

A. Winnberg,[1] J. Brand,[2] and D. Engels[3]

[1]*Onsala Rymdobservatorium, Onsala, Sweden*

[2]*INAF-Istituto di Radioastronomia, Bologna, Italy*

[3]*Hamburger Sternwarte, Hamburg, Germany*

Abstract. The H_2O maser line at 22 GHz from the Mira variable U Her has been monitored for more than 20 years. Additional interferometric observations were made at four epochs covering a period of 3 years. We found that the maser components have an average lifetime of 0.5 – 1 year and are distributed in a ring with distances from 12 to 25 AU from the star. The strongly varying shape of the single-dish maser spectra is the result of a superposition of many short-lived maser components with randomly varying intensities. The integrated flux is dominated by the random variations but varies also in response to the large-amplitude light variations with a period of 406 days.

To study the long-term properties of the highly variable H_2O maser emission from late-type stars, we have monitored several stars of various types in the 22 GHz line using the 100-m Effelsberg and the 32-m Medicina radio telescopes over a 20-year period. Some of the stars were mapped using the Very Large Array (VLA) aperture synthesis telescope over a period of 3 years. Results from this monitoring program for the OH/IR star OH 39.7+1.5 were presented by Engels et al. (1997) and for the semi-regular variable stars RX Boo and SV Peg by Winnberg et al. (2008). Here we present preliminary results for the Mira variable U Her.

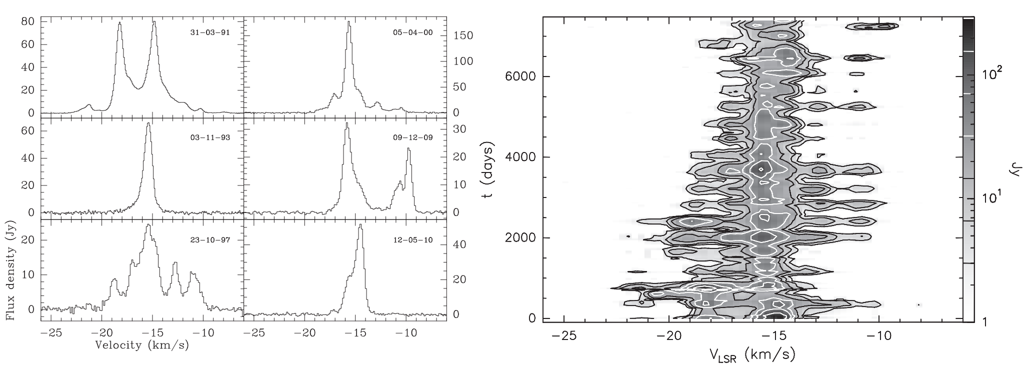

Figure 1. *Left*: Sample spectra from the monitoring program. The spectrum from 1991 is from the Effelsberg 100-m and the other spectra are from the Medicina 32-m telescope. *Right*: Flux density of the H_2O masers of U Her as a function of velocity and time. The time axis covers the period 16 February 1990 – 12 May 2010.

Single-dish observations were made at typical intervals of a few months between 1990 and 2010. Typical sensitivities over the years were 0.1 – 2 Jy (rms). Sample spectra representing the wide variety of line profiles are shown in Fig. 1 (left). The integrated H_2O emission varies with the same 406-day period as the stellar optical emission, but with a delay of about 70 days. Superposed on this are a general decrease of the mean intensity over the last 20 years and random intensity variations of individual maser components (Fig. 1, right). The latter dominate the flux variations of the maser spectra.

U Her was observed at four epochs between February 1990 and December 1992 using the VLA with a typical sensitivity of 20–30 mJy/beam. In the resulting maps typically 9 – 15 maser components could be identified with a relative positional error of $\sim$10 mas. We aligned the maps from the four epochs with the help of maser components which were seen at the same velocity in at least two maps. The resulting distribution of maser components after alignment of the four maps is shown in Fig. 2. Assuming a distance of 266 pc (Vlemmings & van Langevelde 2007), the maser components are distributed in a shell of inner radius 12 – 14 AU and outer radius ~25 AU, presumably concentric with the star. This differs from our results for RX Boo (Winnberg et al. 2008) where the maser components are asymmetrically distributed, occupying only one half of a thick (22 AU) shell of inner radius 15 AU. We do not think that this is a fundamental difference between the two types of stars. The actual distribution of masers is governed by the excitation conditions within the shell, which probably depend on asymmetries in the mass-loss process changing on a time-scale of decades.

The only difference in the maser variability between RX Boo and U Her is the response of the latter to the large amplitude variability in its optical brightness; otherwise random fluctuations of individual maser components dominate in both stars.

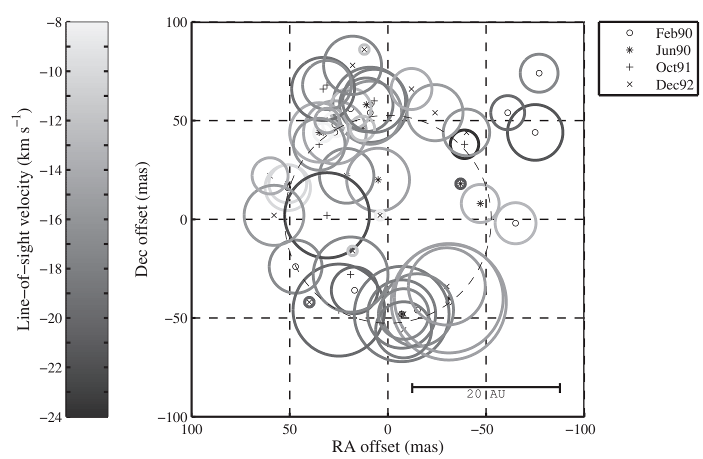

Figure 2. The maser components of U Her identified in the VLA maps. Each component is represented by a symbol and a circle that is grey-coded according to the velocity scale to the left of the map. The radii of the circles are proportional to the flux densities of the components.

References

Engels, D., Winnberg, A., Walmsley, C. M., & Brand, J. 1997, A&A, 322, 291
Vlemmings, W. H. T., & van Langevelde, H. J. 2007, A&A, 472, 547
Winnberg, A., Engels, D., Brand, J., Baldacci, L., & Walmsley, C. M. 2008, A&A, 482, 831