Part IIc. OH MASERs

Cosmic MASERs: From Protostars to Blackholes
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OH masers in oxygen-rich late-type stars

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Abstract. We present here some noteworthy results of two related studies on oxygen-rich late type stars. The aim of this work was to study the OH circumstellar shell properties in terms of evolution. These studies are based on an OH monitoring programme carried out with the Nançay Radio Telescope. The first study concerns seven Miras distributed along the colour-colour diagram. They were observed at two or three different epochs covering one to seven cycles over a period from 1980 to 1995 at 1612, 1667 and 1665 MHz in both circular polarizations. The second study concerns thirty objects covering a wide range of mass loss rate from Miras to OH/IR stars. They were observed in 1994 at 1665 & 1667 MHz in both circular polarizations.

1. Long-term variability in Miras

The OH variability programme we undertook for the Miras gives the first overview of the long-term temporal behaviour of such objects (Etoka & Le Squeren, 2000). Figure 1 shows the repartition of the Miras of the study in the colour-colour diagram. We observed that emission has a very similar temporal behaviour both at 1667 and 1665 MHz, different from that at 1612 MHz. In particular, the 1612 MHz components can survive twenty years while mainline components usually vanish in less than ten years. The components at 1612 MHz are less numerous and narrower than the components in the mainlines which is expected for a 1612 MHz emission zone further from the star than that of the mainlines. The amplitude of variations between consecutive minimum and maximum (i.e., $I_{min-max}$) for the integrated flux at 1612 MHz is about 30-35% while for the mainlines $I_{min-max}$ is always greater than 30%, reaching values as high as 95%. Figure 2 gives an illustration of the temporal behaviour of components. We also found that OH variability curves undergo long term changes which span several cycles (cf. Figure 2 left panel). Long-term changes have also been noted in the structure of the H_2O masers and in the dust formation process. These long-term changes may be connected with those we observe in OH.

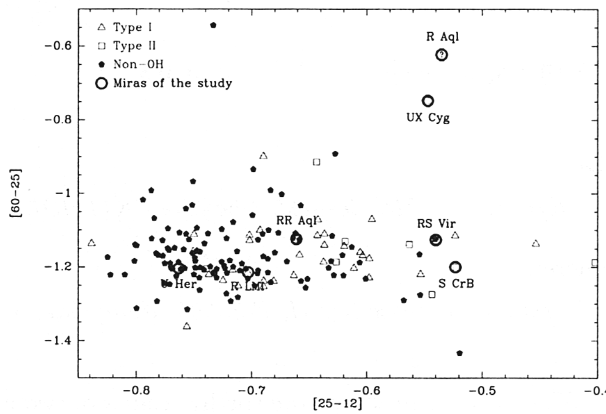

Figure 1. Repartition of the 7 Miras of the study in the colour-colour diagram of Miras distant of less than 1 kpc from the Sun.

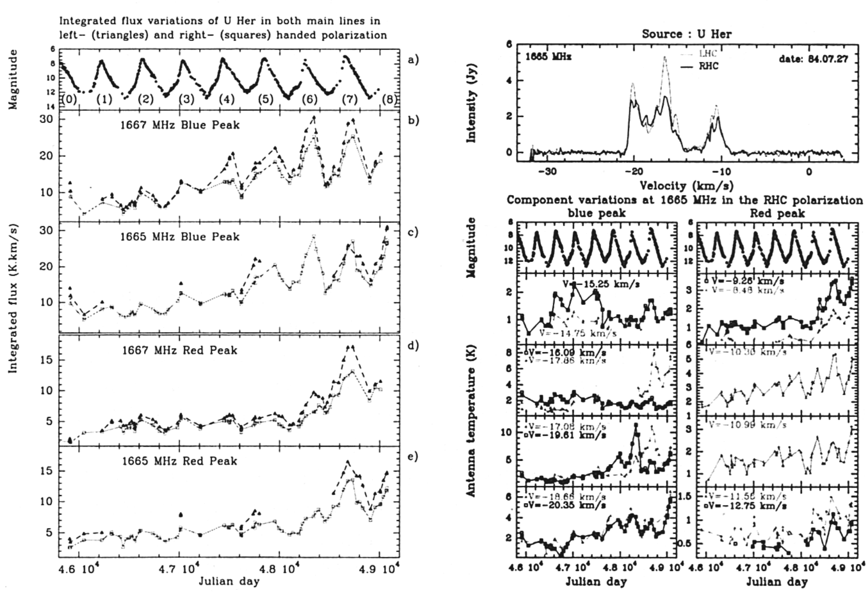

Figure 2. Left panel : integrated variations of U Her in both mainlines. Right top panel : 1665 MHz spectra of U Her. Right bottom panel : temporal behaviour of the components with the greatest longevity at 1665 MHz for U Her.

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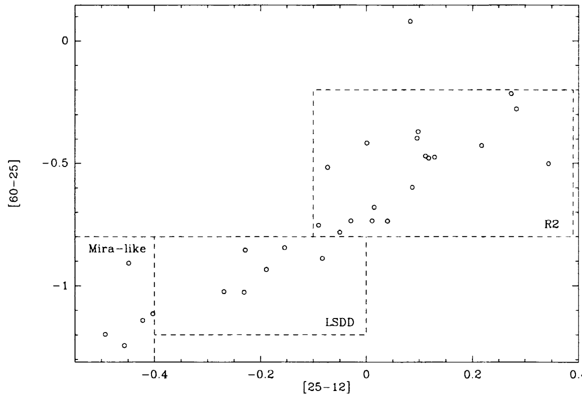

Figure 3. Repartition of the sources of the study in the colour-colour diagram.

2. OH spectral evolution of O-rich late type stars

The repartition of the thirty objects of this study in the colour-colour diagram is given Figure 3. They are distributed as follow :

• 5 objects belong to the box labelled 'Mira-Like' by Sivagnanam et al. (1990);

• 6 OH/IR stars belong to the box labelled 'LSDD' by David et al. (1993);

• 19 OH/IR stars are located in the box labelled 'R2' by David et al. (1993);

These areas of the colour-colour diagram are covered by the so-called regions IIIa, IIIb and IV of van der Veen & Habing (1988) and van der Veen & Rugers (1989). In these regions are found the variable stars with evolved O-rich circumstellar shells with an increasing thickness from IIIa to IV. We observe a linear increase of the 1667/1665 MHz intensity ratio with the [25 – 12] colour index (cf. Figure 4). This means that when the shell becomes thicker the 1667 MHz emission is favoured in comparison with the 1665 MHz emission. The sources are faintly polarized except for one Mira and one OH/IR star. These two objects show very similar spectral characteristics in both mainlines, which are, quite different from the rest of the group to which they belong. The spectra of these two sources are displayed in Figure 5. The location of these sources in the colour-colour diagram and their spectral characteristics suggest that these objects may be respectively at the beginning and at the end of the transition phase Miras→OH/IR stars.

2.1. Conclusion

We studied the OH spectral profile behaviour of Miras and OH/IR stars as a function of the shell thickness. We observe a linear increase of the 1667/1665 MHz intensity ratio with the [25-12] color index suggesting that the 1667 MHz emission is favoured in comparison with the 1665 MHz emission when the thickness shell increases. We also found that one Mira and one OH/IR star show spectral characteristics in both mainlines very similar, quite differents from the group to which they belong. The location of these objects in the colour-colour diagram

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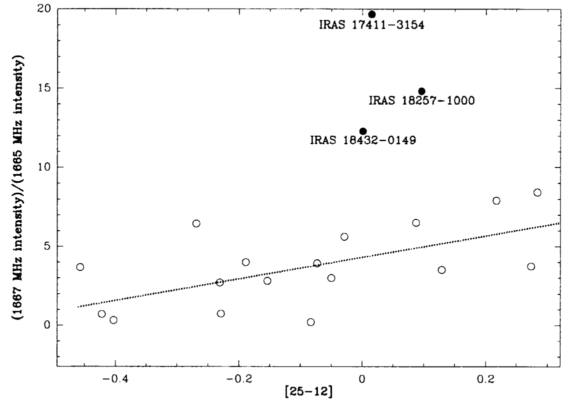

Figure 4. 1667/1665 MHz intensity ratio versus [25 – 12] colour index. The three sources in filled symbols were excluded from the linear regression calculation. These 3 sources belong to the left part of the R_2 box.

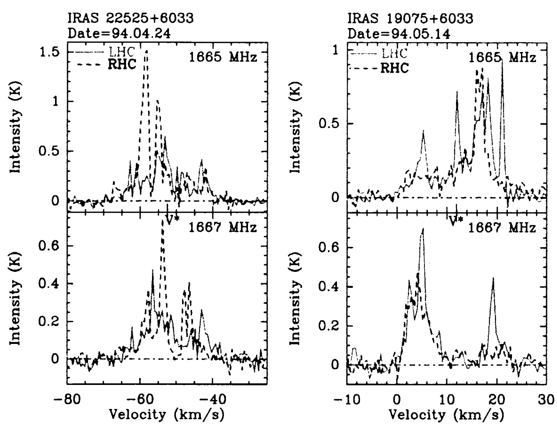

Figure 5. Left panel : Specta of the Mira star. Right panel : Spectra of the OH/IR star.

and their spectral characteristics suggest that they may be respectively at the beginning and at the end of the transition phase Miras→OH/IR stars.

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