Monitoring OH/IR Stars at the 1-m Telescope

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Variability in stars is very common. It makes observations more difficult and their interpretation more complex, but it can be useful as a mean of probing stellar properties. In particular, it can be used to derive information on stellar interiors. When a star is surrounded by circumstellar matter, variability can also be used to probe the latter.

OH/IR stars are among the most spectacular variable sources. They are primarily characterized by the coincidence of a hydroxyle (OH) maser emission with an infrared (IR) source. These stars are enshrouded in circumstellar envelopes. Dust in the shell absorbs light from the central source and re-radiates it in the IR range; OH radicals are formed by photo-dissociation of water molecules in the outer Part of the envelope, and, excited probably by 35-μm photons, produce a maser emission in the satellite line at 1612 MHz. The central stars appear to be in the late stages of stellar evolution, generally as extreme Miras, at the top of the asymptotic giant branch (AGB), or as red supergiants (1); sometimes they may be still more evolved and on their way to the planetary nebula stage (2). In this latter case, pulsations are damped out and strong variability is not observed (3).

Most OH/IR stars known in the southern hemisphere have first been discovered as OH emitters during systematic surveys made with the parkes antenna. Many have been recovered in the IR at the ESO 1-m telescope (4). Time-spread measurements have shown that these sources are variable and a systematic monitoring of a few of them was started in late 1984 with the same 1-m telescope. As OH/IR stars have periods in the range 500–2,000 days, this is a long-term programme from which only preliminary results can be given now. The monitoring is made in the J (1.25 μm), H (1.65 μm), K (2.2 μm), L (3.8 μm) and M (4.6 μm) photometric bands. Depending on circumstellar dust shell optical depth, some objects are very red and cannot be measured at short wavelengths with the 1-m. During nighttime, through a 15″ diaphragm, limiting magnitudes (S/N = 1, in 1 minute integration) are typically 14–15 in the near infrared (J, H, K); due to telescope thermal emission, they degrade at longer wavelengths, and one reaches a limit of ~ 9.5 in L and, depending on weather conditions, 7-8 in M. Thanks to the good pointing and tracking of the telescope, daytime observing is also possible. However, performances are reduced in the near infrared due to sky background; in these conditions one loses typically 3 magnitudes. Also, images are normally worse during daytime (especially in the afternoon), and one may have to use a larger diaphragm which induces, at all wavelengths, a further lowering of performances. Nevertheless, daytime observations are necessary to get a continuous coverage of the lightcurves. Except for a few cases, stars have been selected so that they could be easily measured with the 1-m anytime, at least in K, L and M.

In this sample of OH/IR sources, two objects have been studied especially in detail: OH/IR 285.05+0.07 and OH/IR 286.50+0.06. They have been selected for several reasons. Although their energy distributions (4) are similar, very early, their periods appeared to differ by a factor greater than 2. Furthermore, they are close to each other on the sky, facilitating a comparative study, and their southern position ($\delta \sim -60°$) keeps them away from the Sun all the year round, allowing, in principle, a perfectly continuous monitoring. Finally, both are bright enough so that they can almost always be measured easily in the five photometric bands. In Figure 1, the K lightcurves of both sources are presented. The coverage is almost continuous between Julian Dates (JD) 2446000 and 2447100; there is an interruption of 150 days around JD 2447000 due to the explosion of SN 1987A which obliged us to stop the programme for a while and to observe preferentially that unforeseen event.

OH/IR 286.50+0.06, with a period of ~ 550 days, appears to be an extreme member of the Mira class at the top of the AGB. Its broad-band spectrum indicates that its average total luminosity is

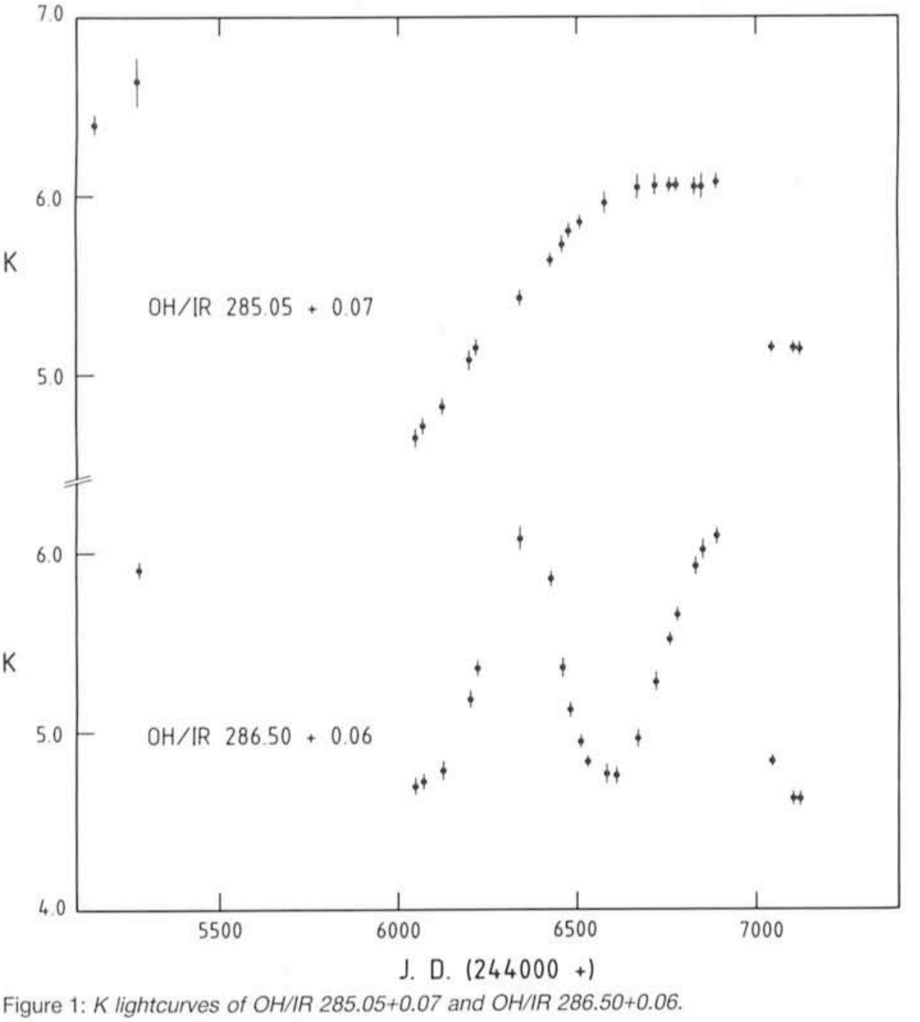

Figure 1: *K lightcurves of OH/IR 285.05+0.07 and OH/IR 286.50+0.06.*

◄ *In the central part of the Gum Nebula, just north of the Vela supernova remnant, we find several relatively unknown nebulae. The northernmost part of the filamentary Vela SNR is seen near the lower right edge of the picture, which was photographically enhanced by C. Madsen from a red plate from the ESO/SERC Atlas of the Southern Sky (IIIa–F + RG630; 120 minutes with the ESO Schmidt telescope). The large nebula to the upper right contains several areas where stars are now being born (the densest is NGC 2626). Many dust lanes are also visible in this negative picture and there are several open stellar clusters, notably NGC 2671, just to the right of the nebula in the lower left part.*

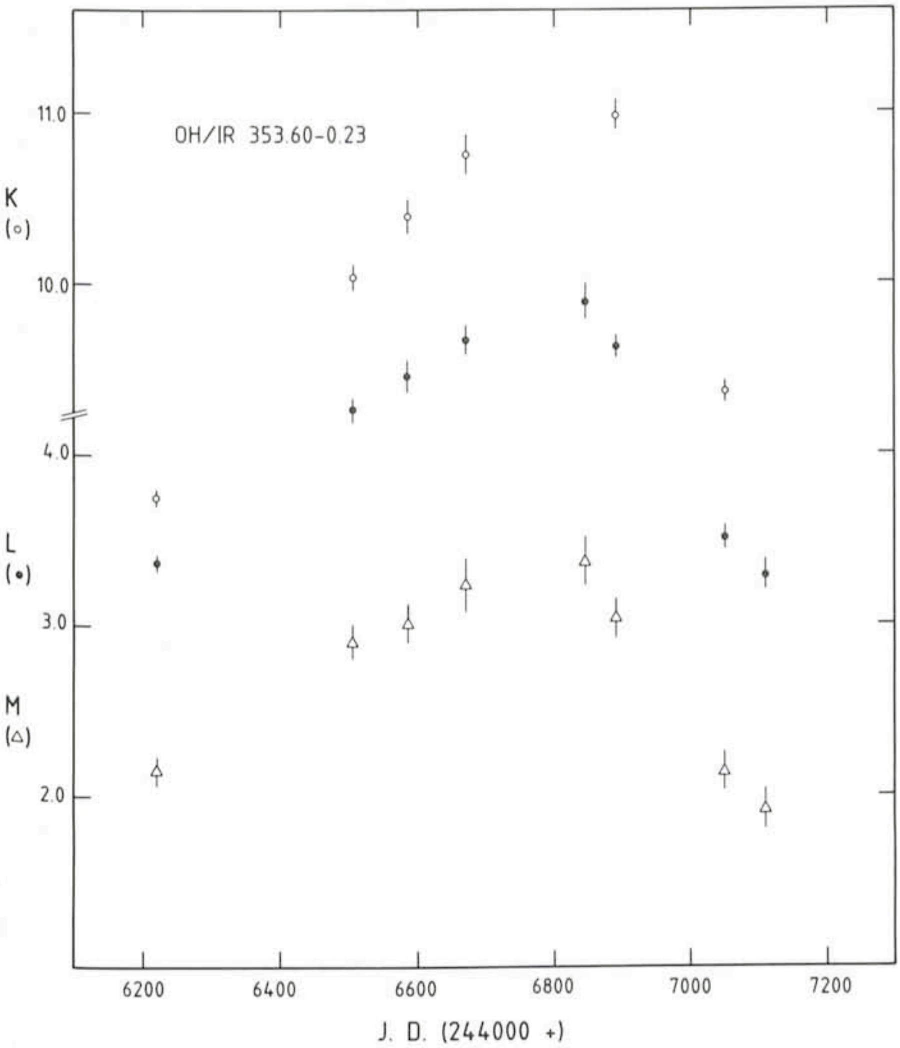

Figure 2: *K, L and M lightcurves of OH/IR 353.60–0.23.*

around 10^5 $L_\odot$, and its mass loss rate, ~ 1.5 10^{-5} $M_\odot.yr^{-1}$ (3). The case of OH/IR 285.05+0.07 is less straightforward. If periodic, its period (defined as the lapse of time between successive extrema of the same type) should be larger than 1,000 days. In fact, comparison of data acquired in this programme with earlier data (e.g. around JD 2445200) shows that the lightcurve presents irregularities. Also, one notes a strong asymmetry in the lightcurve. It exhibits a linear variation for ~ 500 days followed by a plateau lasting at least 250 days. Then, the object passed from minimum to maximum in less than 150 days. Quite surprisingly, the lapses of time corresponding to the linear part and to the plateau are wavelength dependent.

OH/IR 353.60-0.23 is another programme object. The infrared counterpart of the OH maser was also discovered at the ESO 1-m (4). Its energy distribution peaks at 10 μm (5) and is similar to that of the prototypical object, OH/IR 26.5+0.6. This kind of source is very red (K-L ~ 6); in general, they cannot be measured at wavelengths shorter than 2 μm with the 1-m telescope. The K, L and M lightcurves are displayed in Figure 2. As for OH/IR 285.05+0.07, the period is at least 1,000 days. The observed lightcurves consist of two branches in which magnitudes are varying linearly with time. The declining branches last at least 500 days and the rising ones at least 300 days; at minimum, there is no evidence for a plateau of more than 100 days. This broken line lightcurve shape, without plateau, is similar to that of OH/IR 26.5+0.6 (see Figure 5 in 1); however, the latter's lightcurve shape is symmetric, which is not the case for OH/IR 353.60-0.23. Finally, from the available data there is no evidence that the shape of the lightcurve might change with wavelength. On JD ~2446200, i.e. near maximum, an H magnitude of 14.2 ± .2 was measured at the 1-m; obviously, to study the J and H lightcurves would require a more powerful system.

As dust shells are heated by central stars, variations observed in the IR reflect, among other effects, changes in total output luminosity of the central stars. From minimum to maximum (in 150 days or less), the central source of OH/IR 285.05+0.07 is varying from 4 10^4 to 6 10^4 $L_\odot$, the one of OH/IR 286.50+0.06 from 6 10^4 to 15 10^4 $L_\odot$ (in 250 days) and, finally, that of OH/IR 353.60-0.23 from 5 10^4 to 25 10^4 $L_\odot$ (in 300 days). Such intense variations in stellar objects are surpassed only by those of novae or supernovae.

It is generally assumed that OH/IR source lightcurves are quasi-sinusoidal (1); this assumption has never been checked. Although the sample of objects that we monitor is small, it seems that strongly non-sinusoidal lightcurves are, in fact, common. Also, in some cases (e.g. OH/IR 285.05+0.07), the shapes are wavelength dependent. Clear correlations between lightcurve shapes and presence of OH (6) or H_2O (7) maser emission have been found in Mira stars; it is believed that they indicate a relation, between the pulsational properties of central stars and the physical properties of circumstellar matter, originating in the mass-loss phenomenon. Such correlations have not been established in the case of OH/IR stars for lack of data. In fact, as some lightcurve shapes are wavelength dependent, the story might be more complex; however, observations of such wavelength dependency (like observations of time variability) would be useful in providing supplementary constraints on stellar and circumstellar models.

The success of this work would not be conceivable without the efficient and friendly support of all the La Silla infrared staff. Also, I am grateful to the numerous visiting astronomers who are spending, sometimes, a large amount of their precious time in discussions with their support astronomer, and, thus, are making of La Silla a place of scientific exchange.

References

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Visiting Astronomers

(April 1–October 1, 1988)

Observing time has now been allocated for Period 41 (April 1–October 1, 1988). The demand for telescope time was again much greater than the time actually available.

The following list gives the names of the visiting astronomers, by telescope and in chronological order. The complete list, with