OH Infrared Stars – Very Long Period Variables with Enormous Mass Loss

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Since 1975 infrared photometers attached to the ESO 1 m telescope have been used to investigate OH/IR stars. Monitoring them over five years, G. V. Schultz and W. A. Sherwood from the Max-Planck-Institut für Radioastronomie in Bonn and the author proved that OH/IR stars are long period variables, which in extreme cases have periods longer than four years.

In 1973 the first radio survey for OH maser emission at 1612 MHz in the galactic plane was completed by Anders Winnberg and his colleagues. They discovered more than 30 OH sources, showing the double peaked velocity pattern (Fig. 1) characteristic of the OH emission observed in Mira variables and M supergiants. Because of this and because no optical counterparts were found, they were thought to be associated with very red stars and hence called OH/IR sources or OH/IR stars, even before an infrared counterpart was detected. The individual objects were named by their galactic coordinates (for example OH/IR 26.5 + 0.6). The association with infrared stars was strongly implicated in 1975 by the first identifications of infrared counterparts at ESO by Schultz, Kreysa and Sherwood (THE MESSENGER, No. 6 and No. 11). To confirm the identifications, Georg Schultz, Bill Sherwood and myself monitored the infrared stars during the following five years, to show that they were indeed variable (in phase with the OH variability) and to determine their periods and the colour temperatures of the dust shells.

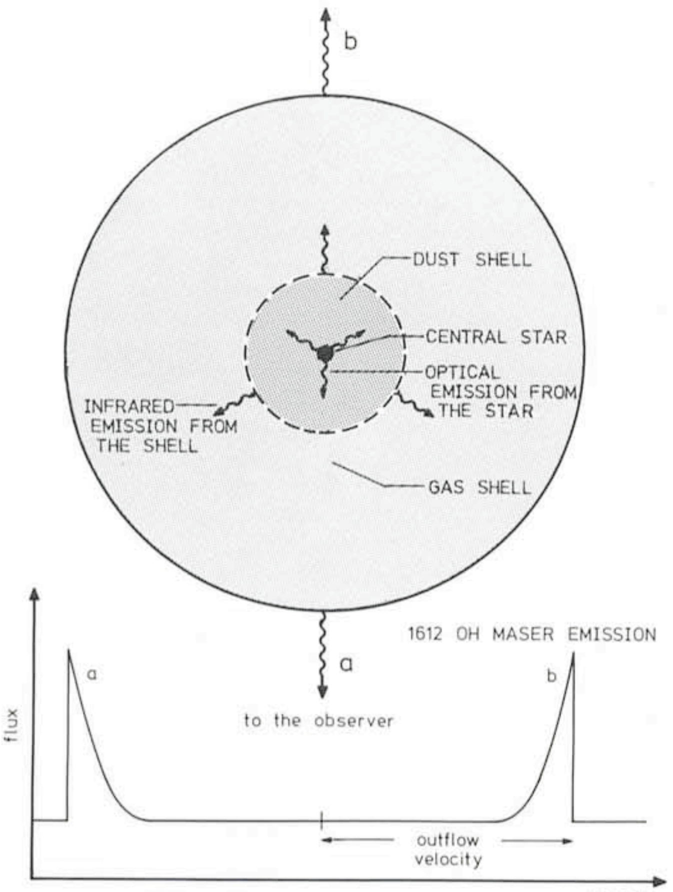

Fig. 1: *Schematic picture of an OH/IR star (above). The central star is surrounded by an expanding circumstellar dust and gas shell, which absorbs the optical emission from the star and reemits the energy in the infrared. The OH masers are located in the outer parts of the shell. At earth the OH maser emission is observed in two velocity groups (below). The low velocity component (a) comes from the front whereas the high velocity feature (b) comes from the back side of the shell.*

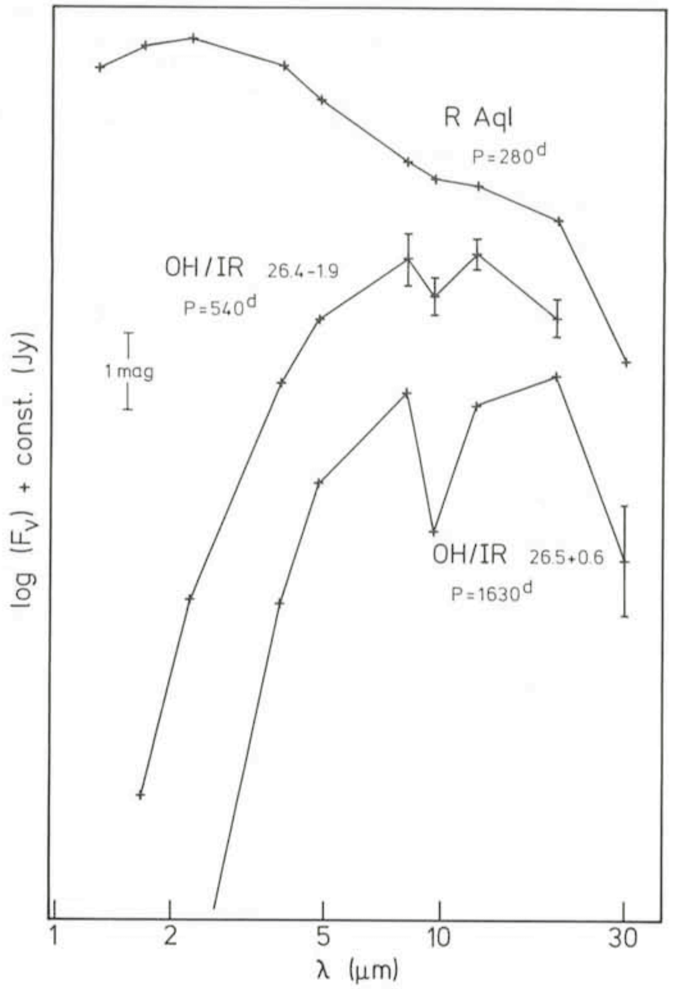

Fig. 2: *Infrared energy distribution measured in July 1980 at the 1 m telescope of two OH/IR stars in comparison to the Mira variable RAql.*

Observations

The observations were made with the ESO 1 m telescope using an InSb Photometer cooled with liquid nitrogen in the near infrared ($\lambda \lesssim 5\ \mu m$) and a helium cooled bolometer in the middle infrared ($5\ \mu m \lesssim \lambda \lesssim 30\ \mu m$).

The calibration of the near infrared measurements was improved substantially by us together with Willem Wamsteker, through the set-up of a standard star system for measurements in the filters JHKLM covering the southern sky (see ESO

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The Circumstellar Shells and Mass Loss

Our measurements reveal that the infrared energy distribution of OH/IR stars is quite different from those of known late-type stars having OH emission (Fig. 2). Most of the energy is radiated between 3 and 20 μm with a steep decrease of the spectrum shortward of 3 μm. An absorption feature ascribed to silicate material in the circumstellar shell is present at 9.7 μm. Thus OH/IR stars appear to have thicker shells than those associated with the optically visible Mira variables and M supergiants. Dust shell temperatures range from ~ 400°K for thick shells to ~ 1 000°K for the thinner shells.

The split of the OH emission into two velocity components can be explained by the location of the observed OH masers on the front and back sides of a symmetrically expanding shell. Thus direct evidence for the outflow of material from the star is present. Estimates of mass loss rates are of the order of 10^{-5} $M_\odot$/yr or more. This is one hundred times higher than the mass loss rates derived for Mira variables. In a steady state picture OH/IR stars are loosing in about 10^5 years one solar mass, implying that the duration of the OH/IR phase when high mass loss rates occur must be short.

The Central Stars of OH/IR Sources

We have determined periods for the central stars betwen 500 and 1 700 days (Fig. 3) (cf. Proceed. Workshop Phys. Proc. in Red Giants, 1981, in press). These periods are the longest yet found in the galaxy for long period variable stars. The OH/IR stars we have monitored have been shown to be regular variable stars, with amplitudes up to two magnitudes at 2.2 μm.

To get an idea of the evolutionary phase of the OH/IR sources, the nature of the central stars must be determined. It is still a question whether they are M supergiants or M giants (Mira variables) or whether both types are present among them. The large amplitude variations are in contrast to the behaviour of the galactic M supergiants showing OH maser emission; which generally display small amplitude variations

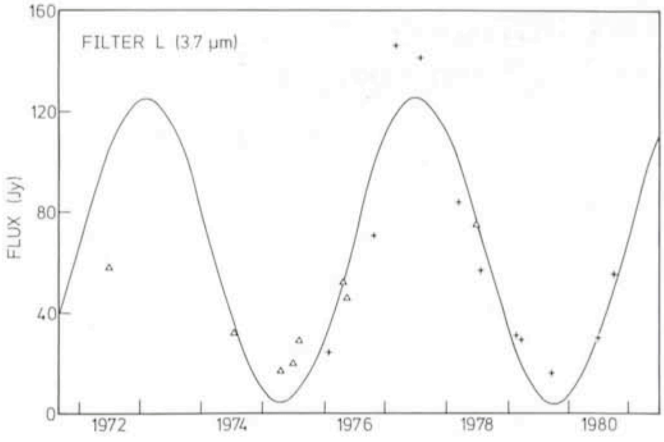

Fig. 3: *Variation of the infrared emission at 3.7 μm of OH/IR 26.5 + 0.6. The period is 1630 days. Crosses are measured at ESO and triangles are taken from the literature.*

and are semiregular. On the other hand the periods have only little overlap with the usual Miras and extend a factor of at least 2 or 3 beyond the longest periods known for Mira stars.

We suggest that OH/IR stars are a rarer, more massive class of Mira variables, which, when they evolve upwards the asymptotic giant branch, begin to pulsate with longer periods and at higher luminosities than the optically visible Mira stars. Indeed we have found that the luminosities do increase with period in a way similar to that for Mira variables. This long period pulsation is connected with increased mass loss leading to the formation of the thick circumstellar shells responsible for the strong infrared and OH maser emission.

What is the fate of these OH/IR stars? With such a high mass loss rate the stars must soon lose their evelopes exposing their hot cores. These cores could then ionize the circumstellar material. Maybe OH/IR stars evolve to planetary nebulae.

Acknowledgement

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Observation of Titan at La Silla during a Total Eclipse

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The edge-on presentation of Saturn's rings and satellites system has provided a rare opportunity to observe total eclipses of Titan in the shadow of Saturn. This event, which comes back every 16 years, occurred during the first semester of 1980, and eclipses of several hours were observable every 16 days from November 1979 to July 1980.

Information upon thermal properties of Titan's atmosphere may be expected to be obtained from the observation of Titan during and immediately after its emersion from the Saturnian shadow. It should be pointed out that, in spite of the remarkable results obtained on Titan by Voyager 1, its atmospheric structure is still poorly understood, especially concerning the aerosols.

Titan's emersions were marginally observable from Europe at large zenith distances; more favourable observing conditions occurred in Chile, but emersions occurred close to the time of local sunset.

Observations

We decided to monitor the temperatures of the upper atmosphere and the lower atmosphere (as close as possible to the surface temperature) during and following Titan's emersion. We used a short integration time in order to be able to describe properly a time-evolving situation. The temperature