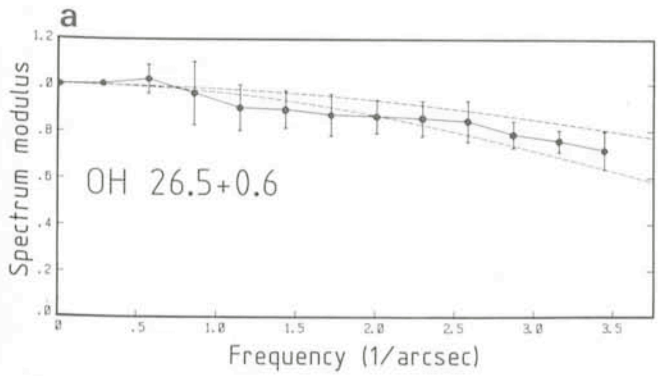

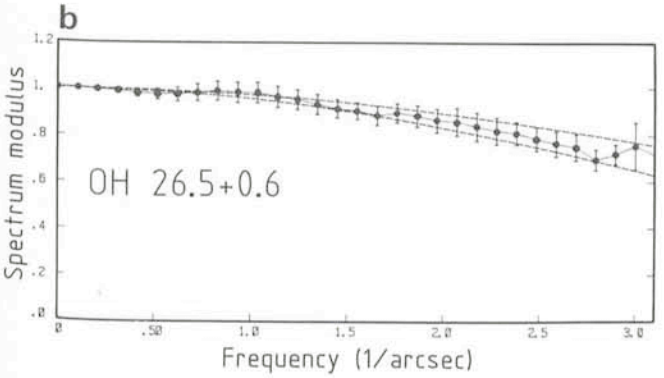

Fig. 4: *Visibilities of OH/IR 26.5+0.6 at 4.64 μm. The scanning direction is east-west.*
a – *June 1981, the large errors at ~ 0.8 $arcsec^{-1}$ come from seeing effects.*
b – *April 1982 (near maximum light). The improved step in frequency comes from a wider scan amplitude. Note also the smaller range of errors due to improved performance.*

26.5+0.6 appears to have a fairly complex gas shell structure at the arcsecond scale with an internal component elongated east-west like a disk seen edge-on as proposed by Baud (1981, *Astrophysical Journal* **250,** L79). Thus it is of prime importance to confirm the expected asymmetry of the emitting dust structure whose kinematics can no longer be interpreted as a simple spherical expansion. Our study aims now to obtain the size in at least two scanning directions.

In our programme, some other OH masers are included, but they belong to both types, depending on which – the main (Type I) or the satellite (Type II; like OH 26.5 + 0.6) – emission line is actually dominant. OH 308.9+0.1, observed in June 1981, is very small at H (d_{fd} < 0.1 arcsec) and has IR characteristics which, in addition to its type I OH maser spectrum, relate it to protostellar objects (Epchtein et al., 1981, *Astronomy and Astrophysics* **97,** 1). Thus the classification "OH/IR" covers very dissimilar mechanisms.

Conclusion

Other types of source were present in our programme. Much is still to be reduced or interpreted but worth mentioning are the observations of the Seyfert galaxy NGC 1068 in four directions in filter L. The visibility at a PA of 45° gives the highest size with an equivalent d_{fd} of 0.40 arcsec whereas other PA yield 0.20–0.25 arcsec. This actually corresponds to the direction of the radio-jet (Pedlar et al., 1983 *Monthly Notices of the Royal Astronomical Society* **202,** 647). This result clearly illustrates the widely spread application field of IR speckle interferometry.

We anticipate to use soon a more efficient instrument which should make it possible to extend the list of accessible objects as well as to provide visibilities of bright objects with smaller statistical errors. This progress comes at a time when released IRAS data may offer new interesting sources and the CERGA long base line two-telescope interferometer may complement speckle results with a higher resolution.

The work presented here was done in collaboration with A. Chelli and P. Léna who promoted it and are largely involved in all the aspects. D. Engels and R. Foy are participating in the evolved object programme. Most of the computer work was supported by ESO La Silla and Munich. I wish to thank M. Maugis and J. Roucher (La Silla) for their permanent and essential support.

A Bright and Extreme W UMa-type Binary: ε Cr A

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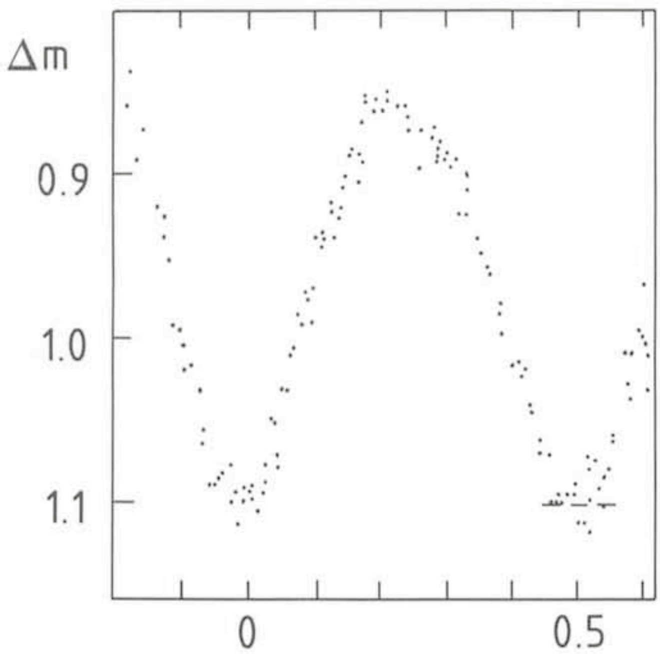
The W UMa Systems, a Mystery of Stellar Evolution

The light curves of close (eclipsing) binaries are not flat between eclipse intervals, due to proximity effects (tidal distortion, light reflection on facing hemispheres). The separation of the two components is so small in W UMa systems that continuous variations are observed in the light curves. Minima are nearly equal (see fig. 1) which means similar colours and effective temperatures for both components (spectral types A to K). They are also spectroscopic binaries. Individual masses and radii of the components can be derived in the most favourable cases. Apparently, they prove to be dwarf stars not too far from the main sequence.

Further advances in the analysis reveal astonishing features. The luminosity ratio between components is roughly proportional to the mass ratio, instead of the fourth power of the mass ratio as usual for dwarfs (for instance, the luminosity ratio is nearly 2 : 1 for a 2 : 1 mass ratio instead of 16 : 1). As a consequence, the spectra of secondaries (less massive stars) can be observed and the amplitudes of light curves do not exceed one magnitude. Recent modeling of light curves on computers shows that the surfaces of the elongated components are actually in contact. As a basic feature, recent theories include the transfer of energy from the primary to the secondary, through a common envelope which could explain the anomalous luminosity ratio. We would be observing rotating "dumb-bell configurations". This interpretation is however confronted with considerable difficulties when the internal structure of the components is investigated and no satisfactory model is yet available.

The contact systems of periods less than one day outnumber other binaries by a factor of (at least) ten. This is an additional difficulty since computations suggest that such configurations should represent a short-lived phase of stellar evolution. Fast evolution is also indicated by period variations (see section 4) but the subject is a matter of controversy. Finally, we have to



An infrared (K) light curve of ε CrA (see text for details).

explain why candidates for progenitors or descendants are so rare.

The Light Curves

Before the 1950s, most light curves were obtained from photographic observations. They always showed curved minima which were interpreted in terms of partial eclipses. Since then, however, intervals of constant light have been observed in the minima of more than 15 out of about 60 systems which have accurate light curves secured through photoelectric photometry. Those systems exhibit total eclipses.

The primary (more massive star) is easily identified with the larger, more luminous component since temperatures (and spectral types) are similar for both components. Binnendijk (1970) classified W UMa systems according to A-type (the primary star is eclipsed at the primary – deeper – minimum) and W-type (the primary star is eclipsed at the secondary – shallower – minimum). Total eclipses (occultation) are eventually observed at the secondary minimum of A-type systems and primary minimum of W-type systems, respectively. Complicated by the limb-darkening and gravity-darkening effects, the interpretation of minima depths in terms of temperature differences between components is a tricky job. According to the present state of the art, it seems that most A-type systems do have thick common envelopes. The A-type systems could be, in some sense, more extreme or more evolved, as suggested by other pieces of evidence.

The choice of ε Cr A

Strong perturbations (> 0.03 mag) have been ascertained in the light curves of various systems, which are tentatively interpreted as stellar spots or currents of ejected matter. In the northern hemisphere, we have frequently observed 44 i Bootis in various colours from the ultraviolet to the infrared. Infrared light curves proved valuable due to a low coefficient of (terrestrial) atmospheric extinction: typically 0.1 mag per unit air mass. A high accuracy being needed, ε Cr A is a good candidate since it is the brightest system, at least in the southern hemisphere. 44 i Bootis is a triple system and the light of a third, non eclipsing component is added. Moreover, 44 i Bootis is a typical late W-type system with its 2 : 1 mass ratio, while ε Cr A is an early A-type system with an extreme mass ratio of nearly 10 : 1 between components. It is quite interesting to compare their stability and light curve perturbations.

Period Variations

Observed periods range from one quarter of a day to one day. As a general trend, systems with shorter periods have later spectral types. Any observed change in the period of those variables is quite interesting. The observers plot a value which represents the difference between the epoch of observed minimum and the epoch of computed minimum, that is (O–C), against time in either Julian days, years, or number of cycles. The computed epoch is a value predicted from the previously determined period. Several possibilities appear. If the points are distributed on a horizontal line, it means that the period of the system is constant. If they define two straight lines of different slope, a sudden change of period is indicated. Sometimes, there are erratic variations. A smooth curve means that the period has changed continuously: this is the case for the system VW Cep whose (O–C) and period are slowly decreasing. Period changes can be attributed to different causes. Among them, mass loss or mass exchange are most plausible. According to Huang (1956), the period decreases when a component loses mass to its companion. The period increases when mass is lost to the system.

Different types of period variations are observed and it is interesting to monitor times of minimum light. The systems which undergo total eclipses lead to more accurate determinations of orbital elements than systems with partial eclipses. If a light curve is not well-defined, it is difficult to distinguish which minimum is the primary.

By definition, a typical light curve of a W UMa system has very curved maxima and minima nearly equal in depth. The light varies continuously and complete observations are interesting. Light curves do not repeat faithfully from cycle to cycle and it is valuable to observe the complete period during the same night whenever possible.

The Observations of ε Cr A

ε Cr A was discovered as an eclipsing binary in 1950 by Cousins and Cox who gave a period near $0^{d}.8406$ and a range of magnitude variation of 0.26. Cousins (1964) published a photographic light curve of ε Cr A and reported a small variation of period; blue and yellow filter observations were made by Knipe (1963–64) who used a 9 inch refractor and a photoelectric photometer. Other observations were reported in 1965 by Binnendijk.

Since that time, Tapia (1969) and Hernandez (1972) have published photoelectric U B V R and I observations obtained in 1967 at the Cerro Tololo Inter-American Observatory. Their observations are well represented by the following equation:

$$\text{HJD mini} = 2439707^{d}.6619 + 0^{d}.5914264\ E$$

where E is the number of cycles elapsed since the minimum whose epoch is given by the first term. Tapia's conclusion was that the period remained constant for 17 years.

Dinescu and Dumitrescu (1970) have determined orbital elements of ε Cr A from Tapia's observations. They have noted a large difference between the radii of the two components, an annular eclipse for the primary minimum and a complete eclipse for the secondary minimum. The first component is a star of spectral class F5 and the second component, cooler, has a spectral class G0. As mentioned above, this W UMa system is an A-type one.

We have observed ε Cr A at the ESO 1 m telescope during the nights of July 2/3 and 3/4, 1982. The period of the system is 14ʰ.1942336 and we have a large part of a complete cycle (a 12 hours run centred on the meridian transit). The In Sb photometer was used with a K-band filter (2.2 μm) and γ Cr A was used as a comparison star. The light curve obtained during the first night (of better photometric quality than the second one) is shown in fig. 1, where 140 individual observations are reported. The observed minimum is later than the computed one (O–C = 0.07) when Tapia's elements are used. Since his observations, about 9,200 cycles have elapsed. The derived (O–C) could also be explained by a slight difference (0ˢ.7) on the period:

$$P = 0^d.5914345 \text{ instead of } 0^d.5914264.$$

A light curve was obtained during the second night but it is very difficult, from two observed minima, to determine a precise value of the period. We don't observe a complete eclipse at the secondary minimum, but this fact could be explained by a sky transparency fluctuation which unfortunately occurred during the secondary minimum (the expected minimum is shown in figure 1 as a dashed line).

The above results emphasize the need of a more complete and accurate monitoring of this bright and interesting system.

Acknowledgements

It is a pleasure to remind the valuable help from the ESO staff on La Silla, especially from Rolando Vega.

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Search for Wolf-Rayet, Carbon and M Stars in External Galaxies with the GRISM/GRENS Technique

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Introduction

Surveying in extended field objects which are recognizable only by their spectral features would be an almost impossible task without instruments having *simultaneously* a wide field and some spectral discrimination capabilities. Monochromatic imaging with colour or interference filters offers such a means, which has been widely used for searching for H II regions and planetary nebulae in the Galaxy and in external galaxies. An alternative method is to use objective prisms or transmission gratings which supply for each object in the field of the telescope a spectrum, usually recorded on a photographic plate. However, the difficulties involved in manufacturing very large gratings or prisms, limit this method to telescope diameters of about 1 metre, the approximate size of the largest existing Schmidt telescopes. Fortunately, there is a variant of this set-up adapted to larger telescopes, in which a prism, or a grating, or a combination of both is inserted in the converging lightbeam at a short distance of the focal plane. These devices, usually fitted on the prime focus adapter, are called GRISMs or GRENSes. A GRISM combines a transmission grating and a prism with opposed dispersion to compensate the aberrations (coma, astigmatism and field curvature) produced by the grating in the convergent beam, and is associated with a wide-field corrector. A GRENS has a grating grooved on one face of the last lens of a wide field corrector, and also has minimal aberrations. Both are blazed such that most of the light is concentrated in the first order. The GRISM technique has already been widely used to search for quasars through their emission lines, mainly at the Cerro Tololo Inter-American Observatory (Hoag and Smith, 1977, *Astrophysical Journal* **217,** 362; Osmer, 1982, *Astrophys. J.* **253,** 28), and at La Silla for the detection of carbon and M stars in nearby galaxies (Westerlund, *The Messenger* No. 19, December 1979, p. 7).

From a preliminary study of the statistics of Wolf-Rayet (WR) stars, M supergiants and blue massive stars in our Galaxy at different distances from the centre, and in the Magellanic Clouds where systematic WR surveys have been made most recently by Azzopardi and Breysacher (1979, *Astronomy and Astrophysics.* **75,** 120, 243; 1980, *Astron. Astrophys. Suppl.* **39,** 19), Maeder, Lequeux and Azzopardi (1980, *Astron. Astrophys.* **90,** L 17) concluded that the WR/M number ratio decreases very fast with decreasing heavy element abundance, while the ratio (WR + M)/(blue massive stars) remains roughly constant. This can be explained in the following way: amongst the various scenarios which can lead to the formation of WR stars, one seems dominant for stars of initial masses 20–60 $M_\odot$ (Maeder, 1982, *Astron. Astrophys.,* **105,** 149). These stars, after having exhausted hydrogen in their cores, move to the right of the Hertzsprung-Russell diagram and become red supergiants. In the absence of mass loss they would stay there until they explode as supernovae. However, mass loss at the different stages of their evolution may be such that the hydrogen envelope disappears completely at some stage, having a star whose surface is mainly composed of helium, with a lot of ^{14}N produced by the previous CNO cycle: the star has become a Wolf-Rayet of the WN type. Further mass loss may peel of the star still deeper until the carbon fabricated by the 3 $^4He \rightarrow {}^{12}C$ reaction appears at the surface: the star is now a WC. The star may end its life as a supernova at any of these stages (the evolution of the core is independent from what happens to the outer parts of the star). If the mass loss at *any* stage is large, the star has a good chance of reaching the WR stage before exploding and will not stay long as a M supergiant. The most massive stars will even by-pass the M supergiant stage. Since mass loss is likely to increase with metallicity, we expect more WR stars and less M supergiants at high metallicities, just as observed. The ratio (WR + M)/(blue massive stars) is roughly equal to the ratio of the duration of the helium burning phase to that of the hydrogen burning phase and does not depend on mass loss in a first approximation, as observed.

Stimulated by the agreement between theoretical ideas and observations, a collaboration was set up between Marc