SPECTROPHOTOMETRIC OBSERVATIONS OF R CrB DURING 1972, 74 MINIMA

N. Kameswara Rao., R. Vasundhara and B.N. Ashoka
Indian Institute of Astrophysics
Bangalore 560034, INDIA

ABSTRACT: The spectrophotometric observations obtained in the wavelength range 3400A to 8000A during 1974, 1972 minima of R CrB have been fitted with Mie scattering calculations assuming sperical graphite particles and various size distributions. Power law type distributions fit the observations fairly well, and indicate that there is decrease in mean particle size as the star comes out of minimum.

1. INTRODUCTION

It was suggested by Loreta (1934) and O'Keefe (1934) that the minima of R CrB are caused due to extinction by carbon particles ejected by the star (see Feast 1985 for a review). Since the particles are supposed to have been formed near the star, a growth in particle size may be expected during the light minimum. Because the extinction properties as a function of wavelength depend upon the size and chemical composition of the particles, the change in the particle size can be inferred from the change in the energy distribution of the star during the light minimum assuming the chemical composition. With this in view we obtained scanner energy distributions during 1972 and 1974 light minima of R CrB using 36 inch Crossley reflector in the wavelength range of 3400A to 8000A with band passes of 16 and 20A (shortward and longward of 5200A respectively). The 1972 minimum observations are displayed in Fig.1.

One of the main problems in the study of energy distribution for estimating the differential extinction is the contamination due to chromospheric emission lines. We have selected regions with least contamination with emission lines except for few wavelengths 4290A, 4395A, etc. in which the emission line behaviour was monitored. The chromospheric emission seems to decay with a time constant ~ 20 days similar to that seen in RY Sgr (Alexander et al. 1972). To study the differential extinction curve we selected the observations obtained in the recovery branch of the light curve (3,12 June and 10 July, 1972) corresponding to 3, 2 and 1.5 mag below maximum) in which the emission line contribution is assumed not to be there. The

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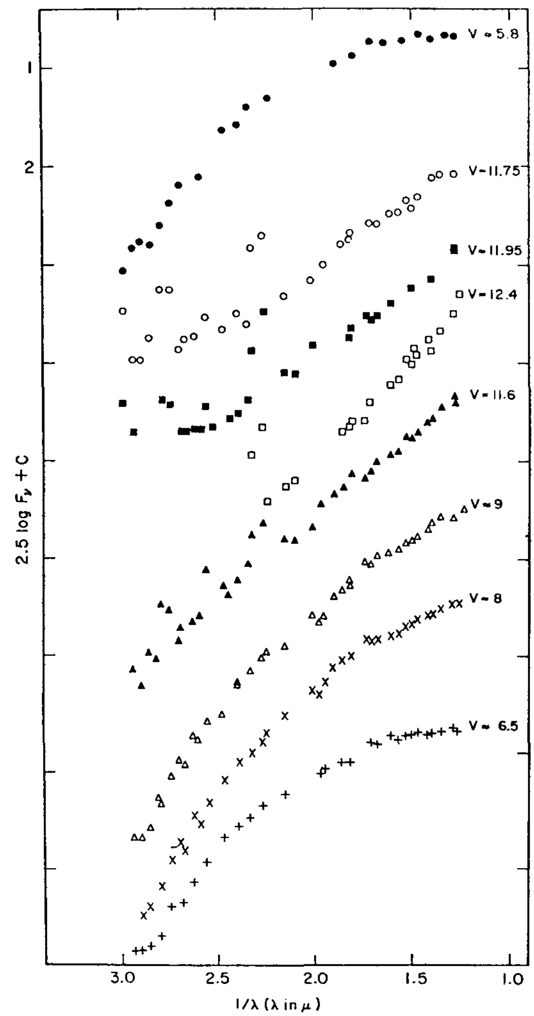

Fig. 1. 1972 minimum observations of R CrB using 36 inch crossley reflector. Pass band: 16A shortward of 5200A and 20A longward of 5200A.

1 February 1974 scan was obtained at an earlier phase (V ~ 10.8) and corrections for the presence of emission lines have been made using coude spectrograms obtained during 1962 minimum by Herbig, assuming that the emission line intensities are roughly the same at a given V magnitude. These observations are differenced with the normal light maximum observation (obtained June 10, 1973) and normalised at 7760 A These are displayed in Fig.2. Since the pulsation period and amplitude of R CrB are quite uncertain no pulsation phase matching has been done.

The extinction curves are matched with theoretical curves computed using Mie theory (Shah 1977) assuming various distributions of spherical graphite particles. Even though Hecht et al. (1985) suggested amorphous or glassy carbon from the ultraviolet data, the composition of the particles is assumed to be of graphite for the following reasons. It was shown by Hecht et al. that the fit for the extinction curves to R CrB in the wavelength range 1750 to 3250A is better for graphite of 40 nm size than for glassy carbon. Secondly the extinction bump at 2400-2500A attributed to amophrous carbon was not present in the 1983 decline in light of R CrB (Holm et al. 1985). Further, amorphous carbon (similar to glassy carbon) is expected to show an emission peak at about 6-8 μm (Koike et al. 1980, Borghesi et al. 1985) which is not seen in R CrB infrared spectra. Since no single sized particle could match the observed extinction curves we have assumed power law type size distributions similar to the distribution proposed by Mathis, Rumple and Nordsieck (1977) for interstellar medium. Refractive indices were calculated using the dielectric functions tabulated by Draine (1985). In fitting the theoretical curve with observations, three parameters were allowed to vary: the lower and upper limits of grain size distribution and the power law index q. These fits are shown in Fig.2. There seems to be an increase in the power law index as the star is coming out of the deep minimum indicating steady decrease in the mean size of the particles (such a trend is also seen in the behaviour of R the ratio of total to selective absorption estimated from UBV photometry of the recovery branch of minima). This could result if the larger grains are selectively ejected or the larger grains break up into smaller grains. The efficiency for radiation pressure Q_{PR} for the bigger grains is high with a maximum around 800-900A size, as such they could be ejected selectively. Thus there is production and to an extent dispersal or distruction of grains during a light minimum.

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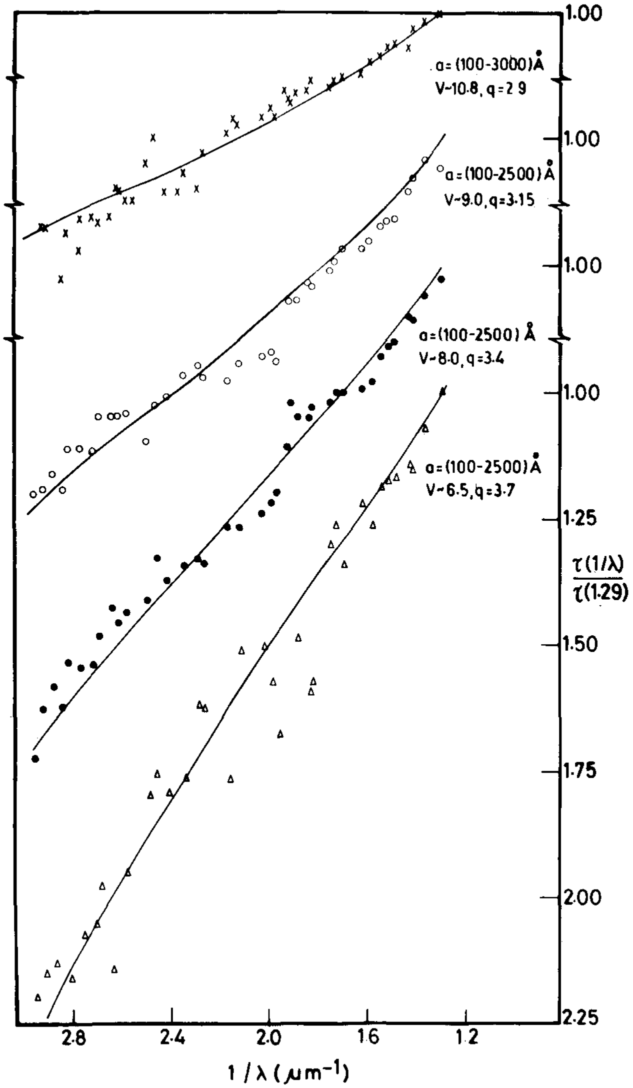

Fig.2. Extinction curves normalised at λ7760 Å compared with theoretical ones computed for MRN size distribution. Crosses: 1 Feb. 1974, open circles; 3 June 1972, filled circles 12 June 1974, and open triangles: 10 July 1972.

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DISCUSSION

FEAST: You could say that the particle size decreases as the star comes out of minimum. I prefer to say that the spectrophotometry does not tell you the size. But whether you can get around this problem of starting off with big particles and ending up with small ones, I don't know. I mean, this model worried me; it seems to be the wrong way round.

N.K. RAO: Maybe what we can really do is to try to look for features at λ2200 or at λ 2470, which can say something about the size. But there one really runs into trouble because of the emission lines. Probably the best thing is to observe in the IR, but apparently it doesn't show any features.

VARDYA: There was a contention in the IRAS meeting as to whether the particle density distribution has gradients of -1 or -2. And here you are getting steeper gradients. I don't know whether it indicates anything or not.

N.K. RAO: Well, maybe we are dealing with smaller particles.

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