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CIRCUMSTELLAR ABSORPTION AND EMISSION IN THE POST-AGB STARS HR4049 AND HD213985

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Abstract. The evolved C-rich low-mass stars HR 4049 and HD 213985 present variable circumstellar extinction and emission. Observations of HR 4049 strengthen the link between the far-UV extinction rise and the presence of small C-rich particles. Variability of the UV absorption bump in HD 213985 is reported here for the first time and is discussed.

Key words: Post-AGB stars – circumstellar matter – HR 4049 – HD 213985

1. Introduction

The stars HR4049 and HD213985 are A-type high-galactic-latitude supergiants with an IR excess. Current interpretation is that both objects are low-mass stars in a late (post-AGB?) evolutionary stage. The dust around both stars appears to be carbon-rich: HR4049 displays the UIR features; the high photospheric carbon abundance of HD213985 suggests that the rather featureless IR emission of this star is due to amorphous carbon grains.

The circumstellar grains of both stars cause variable extinction in the optical and the UV. These stars then offer us rather exceptional opportunities to probe cosmic dust at various wavelengths. In this paper we explore what the correlation between UV, optical and IR dust features of these stars teaches us about dust properties and composition.

2. HR 4049

HR 4049 is a 429-day binary with an unseen low-mass companion (Van Winckel and Waelkens, these proceedings). The optical variability of this star can be explained by periodic obscuration by a dust ring that surrounds the system (Waelkens *et al.* 1991) and that is inclined with respect to the observer: at inferior conjunction obscuration is maximal, while the extinction is low, or sometimes vanishing, when the star is at its most distant position and is seen above or below the part of the ring toward the observer.

This model also accounts for the linear component of the UV extinction. We have obtained low-resolution IUE data for HR4049 at five epochs. These data can be expressed as circumstellar extinction curves if the interstellar reddening and the stellar UV flux are known. The interstellar reddening can be accurately estimated at $E(B-V) = 0.15$: this is the value found for some main-sequence stars near the line-of-sight toward HR 4049 and is also consistent with the observed colors at maximum brightness and the typical B-V for a star with the atmospheric parameters of HR 4049. We have estimated the intrinsic UV flux from an extrapolation of a Kurucz model with parameters $T_{eff} = 7500\text{ K}$, $\log g = 1.0$ and $Z = -2.5$ normalized on the dereddened optical fluxes at maximum brightness.

As already pointed out by Waters *et al.* (1988) and Buss *et al.* (1989) the circumstellar UV extinction consists of a linear component and a far-UV rise. The uncertainty on the UV fluxes of the star may induce a systematic quantitative error on the determination of the UV extinction, but the two-component model must be basically correct. A possible interpretation is that the far-UV rise is linked to the small particles that cause the IR PAH-like emission bands. An interesting new result is that the far-UV rise of HR 4049 appears to be variable: it was much higher than average on November 30, 1993. Remarkably, there have been some unpublished claims (Le Bertre, Private Communication; Geballe, Private communication) that also the strength of the UIR bands is variable.

3. HD 213985

The optical photometric behavior of HD213985 is similar to that of HR 4049 (Waelkens *et al.* 1987, Whitelock *et al.* 1989). Combining all our Geneva photometric data obtained with the Swiss Telescope at La Silla, Chile, with the radial-velocity measurements we have obtained with the CES Spectrograph attached at the CAT Telescope at ESO, Chile, we have found that the same inclined-binary model applies to HD 213985. Maximum brightness occurs again at superior conjunction, and minimum brightness when the star is nearest to us and circumsystem obscuration is maximal. Unlike HR 4049, however, HD 213985 describes a circular orbit. Also, the mass function implies that the mass of the secondary is of the order of two solar masses.

Due to the high galactic latitude of HD 213985, the interstellar reddening is low. A fortuitous circumstance is the presence near the line of sight of the early-B supergiant HD 214080, for which the $E(B-V)$ is 0.15. This reddening is again consistent with the spectral type of HD 213985 (A2 Ia) and the colors at maximum brightness. The description of the intrinsic UV flux of HD 213985 with the Kurucz model derived from the optical atmosphere analysis is probably fairly secure, since the chemical composition

of this star differs much less from the solar composition as in the case of HR 4049. Since the optical variations can be explained by extrinsic effects, there is no reason to assume that the intrinsic UV flux of the star is variable.

The resultant UV absorption curves (Figure 1) show three components: a fairly flat ‘linear’ component, indicating that the grains responsible for the optical absorption are rather large, a (probably constant) far-UV rise, and - most interestingly - an absorption bump of variable strength. The central wavelength of the absorption bump falls in the range between 226 and 240 nm, *i.e.* it is redder than the interstellar 220 nm feature but bluer than the circumstellar bump observed for R Coronae Borealis (Hecht 1986). The width of the bump is intermediate between that of the interstellar feature and that of R CrB. We have not found a clear correlation between the strength of the bump and orbital phase. Nevertheless, no definite conclusion on this point can be made from our data, since unfortunately no simultaneous UV and optical data are available, and since the intrinsic scatter in the optical light curve is large.

We finally also report the surprising detection of CH^+ absorption lines in the optical spectrum of HD 213985. These lines are stationary, and show an expansion velocity of 5 km/s with respect to the systemic velocity. It is not clear whether these absorption lines are caused by the torus of matter near the system or by the larger and cooler dust cloud surrounding the system.

4. Discussion

The configurations of HR 4049 and HD 213985 as binary stars are very similar. In addition, the dust around both stars is carbon rich: HR 4049 displays the IR features, and HD 213985 displays CH^+ absorption. Yet, the extinction and emission properties of both stars are qualitatively different. The most striking difference is the absence of any circumstellar absorption bump for HR 4049 and the prominent presence of a variable bump for HD 213985.

Laboratory results (Blanco *et al.* 1993) suggest that a 220 nm absorption bump may be caused by the dehydrogenation of amorphous carbon grains by UV irradiation. The featureless and broad near-IR excess of HD 213985 may indeed be due to amorphous carbon grains. We point out that HD 213985 is significantly hotter than HR 4049.

Could it be that the presence of CH^+ absorption lines is the signature of this dehydrogenation process? For HR 4049, where carbon-rich circumstellar material is also present, no CH^+ absorption is observed. On the other hand, CH^+ emission is observed for the Red-Rectangle star HD 44179 (Balm & Jura 1992), which has a temperature similar to that of HR 4049. The cir-

Fig. 1. The UV circumstellar extinction curves of HD 213985 on 19/10/86; 22/05/87; 11/11/88; 19/05/92; 4/12/92 and 12/05/94.

cumstellar bump, if any, for HD 44179 is extremely weak (Webster 1993), but we remark that it also doesn't show variable circumstellar extinction in the optical.

The variability of the circumstellar absorption and emission of HR 4049 and HD 213985 clearly offers remarkable opportunities for further probing the dust around both stars. The orbits of both objects, which are the natural time scales on which variability may be expected to occur, are shorter than the expected lifetime of ISO. Simultaneous ISO and IUE observations of HR 4049 and HD 213985 may yield several clues to the solution of several problems concerning the carriers of prominent dust features.

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