A New Peculiar Be Object MWC 657

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Article:

MWC 657 was distinguished as a star of B spectral type with $m_V = 12^m$ and H_α in emission (Merill & Burwell 1943). Dong & Hu (1991) identified it with an IRAS source 22407 + 6008 by coincidence of the optical and infrared (IR) positions (R.A. $22^h40^m47^s.6$, *Dec.* + 60°08′ 17″, 1950.0). There is an object of $V = 12^m.5$ at this position in the Guide Star Catalog (GSC 4265.0873). No optical and near-IR photoelectric observations or detailed spectroscopy have been reported previously for the object. IR—fluxes from the object measured by the IRAS and obtained by us using the ADDSCAN procedure are 5.93, 4.22, and 0.40 J_y at 12, 25, and 60 μm respectively. This means that MWC 657 has an extremely red spectral energy distribution (SED) similar to those of the objects surrounded by circumstellar dusty envelopes.

We obtained photoelectric UBVRIK observations of MWC 657 in the Johnson system at a 1—meter telescope of the Tien—Shan Observatory (Kazakhstan) equipped with a two channel photometerpolarimeter of the Pulkovo Observatory (Bergner et al. 1988) in September and December 1996 (Table 1). Typical errors are $0^m.05$ in the U—band, $0^m.03$ in the BVRI—bands, and $0^m.15$ in the *K*—band. HD 214764 (F0) was used as a comparison star and HD 211589 as a check star (Kornilov et al. 1991). Brightness of the latter was found to be constant with respect to the comparison star with an accuracy of $0^m.01$.

The photometric results lead us to the following qualitative conclusions:

1. The star is heavily reddened. Its *U* — B and B — V colors locate at a reddening line for early—B stars.
2. A local peak in the SED corresponding to the R—band (see Fig.1) points out on a strong emission in *H*α which is consistent with the Merrill & Burwell's (1943) description.
3. Brightness in the K—band and the IRAS colors imply presence of the infrared excess which can be explained by circumstellar dust radiation. A steep decrease of the observed flux towards longer wavelengths shows that the dusty envelope should be optically thin in the optical region and have quite a small radial extension.

Table 1: Photometry of MWC 657

JD2450000+	V	$U-B$	$B-V$	$V-R$	$V-I$	K
349.25	12.85	−0.2:	1.35	1.75	2.73	
353.29	12.57	0.01	1.32	1.51	2.47	
417.11	12.70	−0.27	1.40	1.50	2.43	
420.08	12.62	0.00	1.39	1.55	2.42	
422.06	12.57	0.03	1.49	1.55	2.46	6.67
424.10	12.63	−0.11	1.48	1.49	2.47	
427.09	12.67	−0.12	1.49	1.53	2.47	6.31
429.09	12.68	0.02	1.39	1.55	2.31	
433.11	12.62	−0.05	1.44	1.52	2.41	
439.13	12.63	−0.36	1.80	1.50	2.25	

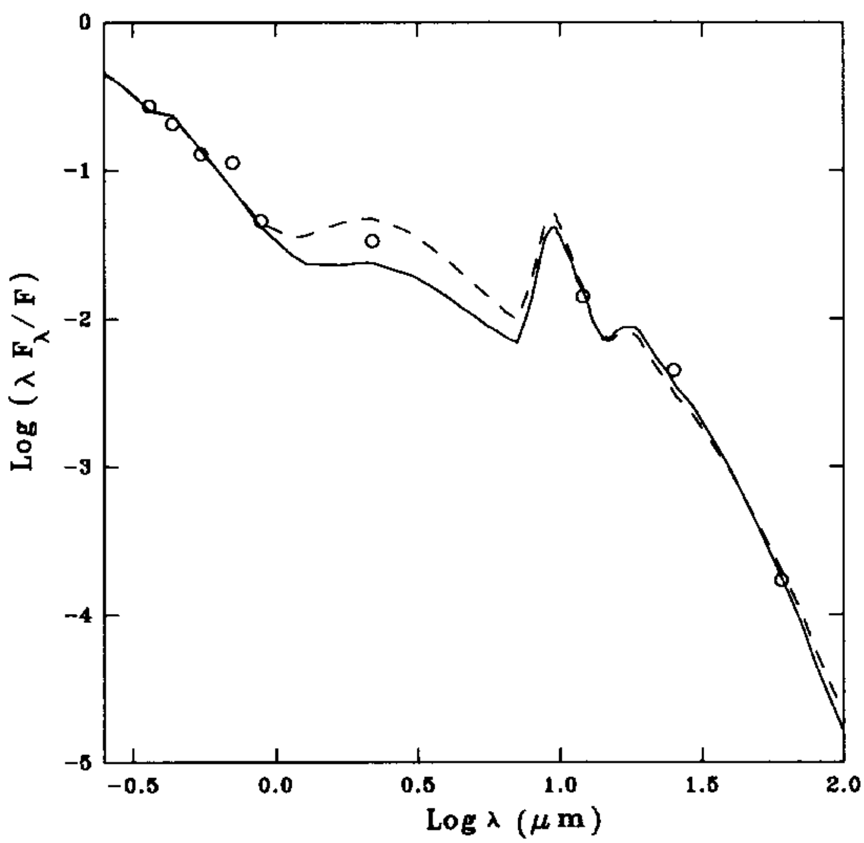

Figure 1. Spectral energy distribution of MWC 657 (circles) and the modeling results. The model with α=1.5 is shown by solid line, with α=2.0 by dashed line. Other parameters are described in text. The SED is expressed in units of the bolometric flux (F).

Taking into consideration these items we tried to model the SED of MWC 657 constructed from averaged photoelectric data and the IRAS photometry using a radiative transfer code DUSTY by Ivezić, Nenkova, & Elitzur (1997) for spherical dusty envelopes. The dust temperature distribution is calculated self–consistently including dust scattering, absoprtion, and emission. We used the Kurucz (1979) models to describe radiation of the central star and optical properties of the interstellar dust (Mathis, Rumpl, & Nordsieck 1977) for the dust particles in the envelope. The dust sublimation temperature was fixed at 1500 K. A grid of models with different stellar temperatures (T_*), the dust density distributions ($\propto r^{-\alpha}$, where r is the distance from the star), the envelope optical depths (τ_V), and ratios of its outer and inner radii (Y_{out}) has been calculated. An additional free parameter of the fitting was interstellar extinction (A_V).

The modeling showed that the SED in the IR region could be fitted well with different parameters of the envelope while T_* and A_V defining the SED in the optical regime remained the same: 20000 K and $4\overset{m}{.}9$ respectively (Fig.1). The best fit was found for α between 1.5 and 2.0. Other envelope parameters are different at these boundaries: τ_V = 0.03, Y_{out} = 100 for α =1.5 and τ_V = 0.05, Y_{out} = 700 for α =2.0. The former density law is expected for free–fall matter while the other one for constant mass loss from the central object.

The bolometric flux calculated (F_{bol}) from the theoretical SED scaled with the dereddened observations is 1.2×10^{-4} Wm^{-2}. Since stellar radiation dominates in the optical region and scattering is negligible, one can estimate the star's angular diameter or ratio of its radius (R_*) to distance (D) towards the object using a formula $F_{bol} = \sigma T_*^4 (\frac{R_*}{D})^2$. This value turned out to be 1.2×10^{-10} which corresponds to $R_* = 5.9 R\odot D_{kpc}$. Interstellar extinction in the object's direction smoothly increases with distance from the Sun up to 3–4^m at D of about 2–3 kpc with almost no further increase beyond this region (Bergner et al. 1986). Thus, even if we take 2 kpc as a distance toward the star it will have a bolometric luminosity $\log \frac{L_{bol}}{L\odot} = 3.67$ and locate above the main sequence.

Some suggestions on the object's evolutionary state can be presented. Usually such optically and geometrically thin envelopes are not observed in pre–main–sequence objects. However, there are several peculiar B–type stars with a similar far–IR brightness decrease which have been suspected as possible Herbig Ae/Be stars (HD 45677, HD 50138). Other interpretations cannot be excluded, i.e. a binary system or a very young planetary nebula, but they require additional observational evidences. It is certainly needed further study of this interesting object. This should include at least optical spectroscopy, near–IR photometry, and optical photometric monitoring.

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