AG CAR: VARIABILITY, EXTINCTION, DISTANCE AND LUMINOSITY

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I. INTRODUCTION

AG Car is one of the few Luminous Blue Variables (LBV's) in our galaxy. The star is a photometric variable which had a recent outburst in 1981 (Whitelock et al., 1983; Wolf and Stahl, 1982) and is surrounded by a resolved ring nebula (Thackeray, 1950; Paresce, 1989). These properties indicate that AG Car is a typical LBV. However, at its canonical distance of 2-2.5 kpc, derived from its assumed membership of the Car OB1 or OB2 association, AG Car has a bolometric luminosity of $M_{bol} \simeq -8.5$ to -9.0 and is located significantly below the Humphreys-Davidson limit, and also below the upperlimit for red supergiants (RSG). This implies that AG Car might have been a RSG and that the ring might be due to the interaction of the RSG wind and the LBV wind.

In this paper we present new evidence for a larger distance and a higher luminosity of AG Car. The star has not been a RSG and the ring nebula must be due to an LBV outburst.

II. THE EXTINCTION OF AG CAR

We have studied the UV and visual energy distribution of AG Car at nine different epochs when the star varied in brightness between V=6.75 and 8.42. For each epoch the energy distribution was compared with those of a set of standard supergiants ranging in spectral type between O9 Ia and B9.5 Ia. The energy distribution of AG Car, corrected for interstellar extinction with $0 \leq E(B-V) \leq 1\overset{m}{.}0$ in steps of $\Delta E(B-V) \simeq 0\overset{m}{.}05$ was compared with each standard star. This results for each epoch in a best-fit comparison star and a corresponding value of E(B-V) for AG Car. The result is listed in Table 1.

Although the energy distribution of AG Car varied drastically during the observation period, the resulting value of E(B-V) is consistently 0.63±0.02. The observed visual magnitudes were corrected for extinction with E(B-V) = 0.63 and the observed bolometric correction was applied to derive m_{bol} for five epochs. The values of m_{bol} are about constant with a mean value of $m_{bol} = 3.05 \pm 0.06$.

III. THE DISTANCE AND LUMINOSITY OF AG CAR

We derived an estimate of the distance of AG Car from the extinction versus distance relation for 27 normal stars with $9 < V < 14^m$ within 17' from AG Car. The stars were observed with the Walraven photometric system at ESO. The extinction-free colours were used to derive an estimate of T_{eff} (within ~ 1000

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TABLE 1

JD -2440000	V AG Car	Best-fit comparison star HD	Type	E(B-V) AG Car	V_0 AG Car	BC obs	m_{bol}
3848	6.75	41117	B2Ia	0.65±0.05	4.80	1.70	3.10
4358	7.14	2905	B1Ia	0.65±0.05	5.19	2.23	2.96
4552	6.96	140379	B1.5Ia	0.65±0.05	5.01	1.96	3.05
4820	6.23	58350	B5Ia	0.65±0.05	4.28	1.20	3.08
5491	6.94	52138	B3Ia	0.60±0.05			
5846	7.37	190603	B1.5Ia	0.60±0.05			
6268	7.98	150898	B0.5Ia	0.67±0.05			
6384	7.92	150898	B0.5Ia	0.63±0.03	5.97	2.92	3.05
6606	8.04	150898	B0.5Ia	0.65±0.05			
				0.63±0.02			3.05±0.06

K) and of log g (within 0.1 for the brighter stars and within 0.4 for the faintest ones). The temperatures and gravities were compared with the predicted evolutionary tracks of Hejlesen (1980) and Maeder and Meynet (1987) to derive M_V and the distance. The value of E(B-V) was derived from the observed B-V and the one predicted by the Kurucz (1979) model atmospheres. The E(B-V)-d relation for stars near AG Car shows general increase from E(B-V) $\simeq$ 0.15 at d = 0.3 kpc to E(B-V) $\simeq$ 0.57 at d $\geq$ 6 kpc. The extinction of E(B-V) = 0.63 for AG Car indicates that the star is more distant than 5 kpc. This agrees with the kinematic distance of 7.2 kpc derived by Humphreys et al. (1989). It also agrees with the distance of d $\simeq$ 5±1 kpc derived from the empirical relation between the amplitude of the B-variations and the luminosity of LBV's by Wolf (1989). We adopt a distance of d $\simeq$ 6 ± 1 kpc. With this distance, the luminosity of AG Car is log L = 6.2±0.2 and M_{bol} = -10.8±0.4, which is well above the upper limit for red supergiants.

CONCLUSIONS

1. The extinction of AG Car at all phases is E(B-V) = 0.63±0.02 and the apparent bolometric magnitude at all phases is m_{bol} = 3.05±0.06 magn.
2. The distance derived from the E(B-V)-d relation of nearby stars and from the radial velocity of AG Car is 6±1 kpc.
3. The luminosity of AG Car is log L = 6.2±0.2 or M_{bol} = -10.8±0.4.
4. AG Car has not been a red supergiant. The ring must be the remnant of an LBV outburst. The diameter of the ring is 1.0 pc and its kinematic age is 1.10^4 yrs.

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