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Research Note

SAO 75669: a late type giant behind the molecular cloud MBM 12

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Abstract. Photometric and spectroscopic observations of the star SAO 75669 in the region of the high galactic latitude molecular cloud MBM 12 are presented. The optical, near-infrared and far-infrared IRAS photometric magnitudes together with the observed CCD spectrum and the large degree of polarization are consistent with the star being an M type giant behind the molecular cloud MBM 12 suffering about 1.8 magnitudes visual extinction. The wavelength dependence of polarization indicates that the dust in the cloud is normal.

Key words: stars: SAO 75669 – interstellar medium: molecular clouds

1. Introduction

In a polarimetric study of the high latitude molecular MBM 12, Bhatt & Jain (1992) found that the star SAO 75669 seen projected in the region of the cloud has a very large degree of polarization. In fact, of the 19 stars observed in the area, SAO 75669 shows the highest value of linear polarization (P $\sim$ 3.7%) and is one of the brightest ($\sim$ 8.8 mag). Other stars in the area brighter than $\sim$ 9.5 mag have low values of polarization (P$\leq$0.45%) and were inferred to be foreground stars. Thus the observed degree of polarization of SAO 75669 seems to be anomalously large unless the star is behind the cloud and intrinsically bright. The distance to the cloud MBM 12 has been determined to be $\sim$ 65 pc (Hobbs et al. 1986), but that of the star SAO 75669 is not known. An estimate of the distance to the star could be made if its spectral class and absolute magnitude were known. If SAO 75669 turns out to be a star behind the cloud, then a detailed study of its observed characteristics can also give information on the characteristics of the absorbing material in the cloud MBM 12.

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2. Observations

Observations of SAO 75669 were carried out at the Vainu Bappu Observatory, Kavalur in March 1992. CCD photometry in the B and V bands was done with the 102 cm reflector using Thomson CSF TH 7782 CCD chip coated for enhanced sensitivity to ultraviolet radiation. Magnitudes were obtained by using DAOPHOT aperture programme. We used M67 standards (Schild 1983) for calibration.

Spectrum in the wavelength range $\lambda\lambda \sim$ 4300-6500 Å was obtained with the 234 cm reflector. Astromed GEC P8603 CCD chip coated for enhanced sensitivity to ultraviolet was used as a detector. The Boller & Chivens spectrograph with a 300 lines/mm grating and a 6 inch camera yielded a resolution of 4.8 Å/pixel. Wavelength calibration was done using a Fe-Ar source and HR 4468 was used for flux calibration (Breger 1976).

Photometric measurements in the near-infrared J(1.25μm) and K(2.2μm) bands were made with the 102 cm reflector using a liquid nitrogen cooled InSb photometer.

The following results were obtained

(i) Photometry

(a) Optical: The photometric magnitudes in the Johnson B and V bands are
B = 10.99 $\pm$ 0.06, V = 8.77 $\pm$ 0.05.

(b) Near-infrared: The photometric magnitudes in the Johnson J and K bands are: J = 4.6 $\pm$ 0.1, K = 3.4 $\pm$ 0.1. The visual magnitude V = 8.77 $\pm$ 0.05 measured by us agrees fairly well with that obtained by Craine & Scharlach (1982) who give V = 8.84 $\pm$ 0.02 and I = 5.44 $\pm$ 0.02 for SAO 75669. There are no previous measurements in the near-infrared bands available. In the far-infrared the Infrared Astronomical Satellite detected SAO 75669 and the flux densities in the 12 μm and 25 μm bands are (IRAS Point Source Catalog 1985): 2.33 Jy(12 μm band) and 0.65 Jy(25 μm band). In magnitudes these are equivalent to: [12 μm] = 2.71 and [25 μm] = 2.54. In the discussion to follow in this paper we adopt the following photometric magnitudes for SAO 75669:

B = 10.99, V = 8.84, I = 5.44, J = 4.6, K = 3.4, [12] = 2.71, [25] = 2.54.

(ii) Spectroscopy

Figure 1 shows the optical spectrum of SAO 75669. The flux density rises steeply towards the longer wavelengths. The spectrum clearly shows the presence of TiO absorption bands. The appearance of the TiO bands and their relative strengths indicate that the star is of $\sim$ M0-M1 spectral type. A strong Na D absorption line is also present.

3. Discussion

SAO 75669 is clearly a cool star of a late spectral type. Its observed colour index $(B-V)_o$ = 2.15 is redder than even the coolest M type stars. This indicates that the star is reddened due to wavelength dependent extinction in the interstellar medium. By assuming different spectral types (and luminosity class) for the star (thus fixing the value of the intrinsic colour index $(B-V)_i$) we can determine the required reddening $E(B-V) = (B-V)_o - (B-V)_i$. Then for a standard interstellar extinction law (Savage & Mathis 1979) we can determine the expected values of other reddened colour indices ((V−I), (V−J) and (V−K)) and compare them with the observed values. The best match is obtained for a M1 III spectral type star of unreddened visual magnitude V = 7.0 suffering a normal interstellar extinction with A_V = 1.8, for which the predicted photometric magnitudes B = 10.94, V = 8.80, I = 5.60, J = 4.61, K = 3.30 match fairly well with those observed for SAO 75669 as B = 10.99, V = 8.84, I = 5.44, J = 4.6, K = 3.4. The observed IRAS flux densities $S_{12\mu m}$ and $S_{25\mu m}$ in the 12 μm and 25 μm bands and the colour $S_{25\mu m}/S_{12\mu m}$ = 0.28 for SAO 75669 is also typical of a normal M1 III star (Kenyon & Fernandez-Castro 1988; Kenyon 1988).

The large value of extinction (A_V = 1.8) and polarization (P = 3.7%) with position angle similar to other faint stars in the region of the molecular cloud MBM 12 (Bhatt & Jain 1992) indicates that SAO 75669 is behind the cloud and suffers extinction and polarization as its light passes through the cloud. The distance to the star therefore must be greater than that of the cloud which is $\sim$ 65 pc. The absolute magnitude M_V of SAO 75669 therefore follows from

$$M_V = V_o + 5 - 5logd - A_V$$

where V_o = 8.84 is the observed visual magnitude, A_V = 1.8 is the derived extinction and d is in pc. With d > 65 pc we obtain

$$M_V < 2.98$$

SAO 75669 cannot therefore be a main sequence star of M spectral type which has $M_V \geq 9$. If the star were a M supergiant ($M_V \leq -5$) its distance (from Eq. (1)) would be $\geq$ 2.56 kpc. For the galactic latitude b = -34^o of SAO 75669 its height above the galactic plane would be > 1.43 kpc, a value too large compared to the scale height of supergiants ($\sim$ 50 pc). We therefore conclude that the star is a red giant of type M1 III. With $M_V = -0.4$ for a M1 III star, Eq. (1) gives the distance of SAO 75669 as d=310 pc and its height above the galactic plane z = 170 pc. Polarization measurements of SAO 75669 were made by Bhatt & Jain (1992). They reported a value for the percentage polarization P in optical unfiltered light as P = 3.67%. This star was also measured in Johnson B(0.44 μm), V(0.55μm) and R(0.70μm) filters. The observed polarization was P_B = 3.35 ± 1.36%, P_V = 3.82 ± 0.15% and P_R = 3.39 ± 0.21%. The wavelength dependence of polarization is consistent with Serkowski's (1973) relation: $ln(P_{max}/P_\lambda) = 1.15ln^2(\lambda_{max}/\lambda)$ for normal interstellar polarization with P_{max} = 3.7% and λ_{max} = 0.56 μm. The normal wavelength dependence of polarization indicates that the dust in the cloud MBM 12 that causes the polarization is similar to the interstellar dust. This is unlike some other dense clouds where λ_{max} values much larger than the mean interstellar value (0.55 μm) are found; for example ρ Ophiuchi (Carrasco et al. 1973) and B5 (Bhatt 1986) for which λ_{max} can reach values as large as $\sim$ 0.8μm.

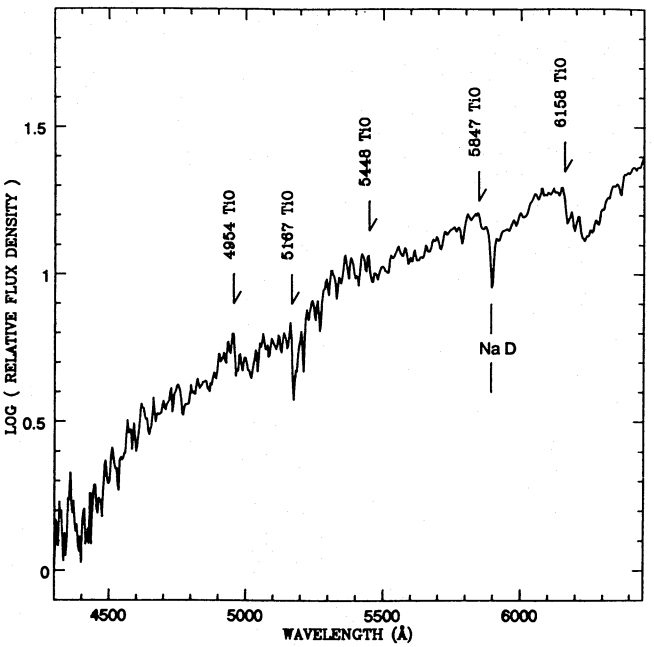

Fig. 1. Optical spectrum of SAO 75669. The prominent TiO bands are marked along with the Na D line

4. Conclusion

We have presented optical CCD photometric, spectroscopic and infrared photometric measurements of SAO 75669, a red star with a large degree of polarization in the region of the high latitude molecular cloud MBM 12. We conclude the following.

(i) The star is a normal red giant of type $\sim$ M1 III behind the cloud MBM 12 at a distance $\sim$ 310 pc.

(ii) The dust in the cloud is similar to the mean interstellar dust and causes an extinction A_V = 1.8 mag and polarization P $\sim$ 3.7% with normal wavelength dependence typical of the interstellar medium.

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