The source of illumination of the bipolar nebula near NGC 7129

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Summary. Polarization data are presented for a small nebula located in the southern outskirts of the reflection nebula NGC 7129. The nebula is bipolar, illuminated from within by a totally obscured star. The position of the star is RA = 21 41 48.4 ± 0.7, Dec = 65 50 39 ± 4 (1950).

1 Introduction

In a recent survey of bipolar and cometary nebulae Neckel & Staude (1984) describe a small bipolar-like patch of nebulosity situated in the southern outskirts of the reflection nebula NGC 7129. The object is number 20 in their list. They are unable to associate the nebulosity with any visible or IR source and suggest that the nebulosity is not a reflection nebula.

The nebulous object is also listed as RNO 138 by Cohen (1980) in a survey of red and nebulous objects associated with dark clouds and was described as a star with close nebulosity. Cohen & Schwartz (1983) refer to the object RNO 138 as a 'very faint star within an arcuate cometary nebula' and indicate that the star is of T-Tauri type.

The nearest unambiguously visible star to the nebulosity is approximately 15 arcsec to the NE and was found to be a 2-μm source by Strom, Vbra & Strom (1976). This star, number 6 in their listings, is known in the literature as SVS6. Harvey, Wilkings & Marshall (1984) determine the IR colours of SVS6 and raise the possibility of a physical association between this star and the nebula.

Magakyan (1983) refers to the nebula as GM1 − 57 and finds that the spectrum of the object has a faint continuum with traces of Hα emission and that it is distinctly visible in the blue which suggests that it may be a reflection nebula. This author makes no mention of any star in the vicinity of the object other than SVS6.

It is clear that the structure, association with other stars and the source of illumination and excitation of the nebula are uncertain and in order to resolve matters we have mapped the linear polarization of the nebula and its surroundings.

2 Observational details and reduction procedures

Observations were made at the f/13.5 focus of the 1-m telescope of the Wise Observatory, Israel on 1984 June 6 using the Durham Imaging Polarimeter using a CCD detector system
based on the GEC P8600 chip, the properties of which are well detailed by Wright & Mackay (1981). The polarimeter, reduction procedures and method of error determination on the measured polarization parameters are described by Scarrott et al. (1983); no significant changes to the procedures were necessary to accommodate the CCD data. In the results described in the next section the errors on the degree of polarization and position angle are 1–2 per cent and 5–8 degrees respectively for the surface brightness ranges involved. No filter was used so the observations covered the spectral range 450–1000 nm with peak response at 850 nm.

3 Results and discussion

The results are displayed in Fig. 1. The intensity contour map shows the structure of the small nebula SW of the visible star SVS6. The contours show the hour-glass shape typical of bipolar nebulae and the 'waist' can be identified with the central dust lane or torus usually associated with such nebulae. Clearly the lobe to the SE is much brighter than its counterpart suggesting a degree of tilt or differential extinction in the system. North of this area is faint nebulosity.

Figure 1. A contour and linear polarization map of the bipolar nebula south of NGC7129. The contour intervals are 0.25 mag and the intensity range covered is 0.7 to 0.15 sky brightness. The integration bins of the polarization map are 3.6×3.6 arcsec\(^2\) spaced at 2.4 arcsec intervals. The centre of the polarization map is marked with a cross and the brightness maximum in the nebula and the position of the star SVS6 are denoted by M and S respectively. The scales of the axes are relative to the star SVS6 whose accurate position is given by Strom et al. (1976).
representing the extremities of the much larger nebula NGC 7129, the illuminating stars of which are some 2 arcmin north of the centre of the region under investigation. The adjacent polarization map in Fig. 1 shows considerable polarization (up to 20 per cent) in the NGC 7129 component of nebulosity. In the region of the nebulosity of current interest there is an approximately centro-symmetric arrangement of polarization orientations typical of a reflection nebula with an illuminating source within. This is slightly oblate due to the effects of an overlying contribution from NGC 7129.

The centre of the centro-symmetric pattern of polarization vectors is indicated on the contour map. With respect to the position of SVS6 given by Strom et al. (1976) the centre is located at RA = 21 41 48.4 ± 0.7 and Dec = 65 50 39 ± 4 (epoch 1950).

The association of our position with that of a visible star is difficult. Clearly SVS6 is far too remote and plays no role in the illumination and excitation of the nebulosity in question. What about RNO 138, the faint star of Cohen & Schwartz within the nebulosity? The coordinates of this star given by Cohen (1980) are not precise enough (+3 arcmin) to give an identification on the scale of our data. If we associate this star with the brightness peak marked M on the contour map we find the brightness profiles of this region are elongated and distinctly non-stellar compared to those of field stars e.g. SVS6.

However, stars embedded in nebulosity and particularly illuminating stars of bipolar and cometary nebulae (R Mon in NGC 2261 is a classic example) often do not give stellar optical images due to the high obscuration about the star and appear as knots or condensations. RNO 138 could be of the same genre but would require a contrived distribution of obscuration to give the observed brightness profiles. Furthermore our position for the illuminating source is not coincident with the brightness peak, we require a point-like source close to the ‘waist’ in the contour map and there is no obvious stellar image there. We suggest that there is a highly obscured star in this region, so far unseen, and that the brightness peak (M) is just the brightest part of a lobe of reflection nebulosity. If we assume the T-Tauri classification of RNO 138 by Cohen & Schwartz really refers to bright reflection nebulosity then this classification is valid for the illuminating source – our hidden star. Young stars are frequently found in bipolar nebulae and the mass loss and stellar winds from such stars may produce the characteristic form of these objects.

With regard to the levels of polarization in the nebula we note that they range between 2 and 12 per cent which is somewhat less than that found at shorter wavelengths in similar objects (e.g. LkHα 20B has a range of polarization of 2 to 25 per cent: Shirt, Warren-Smith & Scarrott 1983). Furthermore, even in the present data the nebulosity belonging to the reflection nebula NGC 7129 has a level of polarization of typically 20 per cent. The reduced levels of polarization in the present bipolar nebula may indicate that the geometry is unusual or that the nebula is optically thick or a combination of these. The different levels of polarization between the lobes again suggest a tilt to the system.

Clearly further observations in narrower wavebands and higher spatial resolution would improve our understanding of the structure of this object.

4 Conclusion

We believe that the object variously known as Neckel-Staude 20, RNO 138 and GM1 – 57 is a bipolar reflection nebula illuminated from within by a T-Tauri star that is hidden from direct view by a dense circumstellar dust torus that delineates the nebula into the two lobes. The distinct difference in the brightness structure and polarization levels of the lobes suggest that the system is tilted to our line-of-sight. The star SVS6 plays no part in the illumination or excitation of the nebula.
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References