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Detection of optical emission in the area of G127.1+0.5

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Abstract. Diffuse optical emission has been detected around the area of the galactic supernova remnant G127.1+0.5 for the first time. Deep Hα CCD images have been used to identify the nebulosity that correlates with both the infrared emission evident on the *IRAS* maps and the radio contours of the galactic remnant G127.1+0.5. The optical filaments of the known nearby remnant G126.2+1.6 have also been observed in order to evaluate the detection ability of our instrumental set-up. The intensity of the optical emission from the nebulosity, has been determined by comparison with the standard star BD +28° 4211. The detection of the diffuse optical emission is established beyond doubt. The structure of the surrounding area is discussed and an attempt is made to identify the origin of the detected emission by studying this area at other wavelengths.

Key words: supernova remnant – interstellar medium

1. Introduction

G127.1+0.5 is a well studied object at radio wavelengths, both for its emission properties and the difficulty in estimating its distance in a firm way. It has been identified as a galactic supernova remnant (SNR) (Caswell 1977; Pauls 1977) and it has been thoroughly studied at radio wavelengths (see references in Green 1988; Joncas et al. 1989) since then. It is considered as a relatively young remnant (18000 yr, Milne 1988) located at a distance of about 6 kpc if it is associated with the observed hole in the HI distribution towards its direction (Fürst et al. 1984). Recently, the infrared (IR) images from the *IRAS* survey of the area became available (Arendt 1989) which show a *bow* shaped emission structure very close to the most intense radio contours of G127.1+0.5. Such a structure is not evident in the existing Hα images of this region (Parker et al. 1979) or the POSS red plate (Pauls 1977). The attempt by Blair et al. (1980) to identify optical emission of the same area, using an [OIII] narrow-band filter and an image tube at the f/7.5 focus of the McGrawHill 1.3m telescope, did not reveal any such emission at those wavelengths.

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We have used the 30cm Schmidt-Cassegrain f/3.2 telescope of the Skinakas Observatory coupled with a cryogenically cooled CCD camera to investigate the region around the radio remnant G127.1+0.5 with an Hα+[N II] interference filter.

The region that we have studied is fairly complex in all wavelengths and it is very close to the galactic plane. Apart from the radio remnant which extends almost perfectly circularly in a diameter of 45 arcmin, an open cluster (NGC 559), slightly displaced off the center of the remnant radio contours, occupies an area of 4.4 arcmin in diameter. The age of the cluster is estimated to be 1.3×10^9y and its distance is about 900 pc. From the photometric study of this cluster it is suggested that there is very little ionized gas left. The HII region DU 65, located to the north-northeast of the radio contours, is present in both the optical images of the area (Dubout-Crillon 1976) and the radio maps (Fürst et al. 1990). The small molecular cloud L 1325 with an extend of 6.7 x 4.5 arcmin^2 (Clemens & Barvainis 1988) is also present near the center of the remnant radio contours.

2. Observations and reduction

The images of the area around G127.1+0.5 were taken using an Hα + [NII] interference filter centered at 6570 Å with a band pass of 75 Å (FWHM). A CCD detector (TI 4892) was placed at the secondary focus of the 30cm Schmidt-Cassegrain f/3.2 telescope which is located on Mount Skinakas on the island of Crete. The advantage of such a configuration is the excellent combination of fast optics and large field of view (32 × 48 arcmin^2) with a CCD imaging camera. The Hα observations were carried out in two different observing sessions, on August 12, 1991 and October 10, 1991. Four partly overlapping images were taken which cover the area of the radio remnant contours. The displacement served both for covering as large an area as possible around the radio remnant contours and also to identify systematic errors due to reflections along the optical path. The nebulosity that is shown in Fig. 1 is the result of the mosaic combination of these 4 images using the available *IRAF* routines. The common part of the three northern exposures which correspond to the brightest features present in Fig. 1 has a total exposure time of 105 min while the remaining parts of the

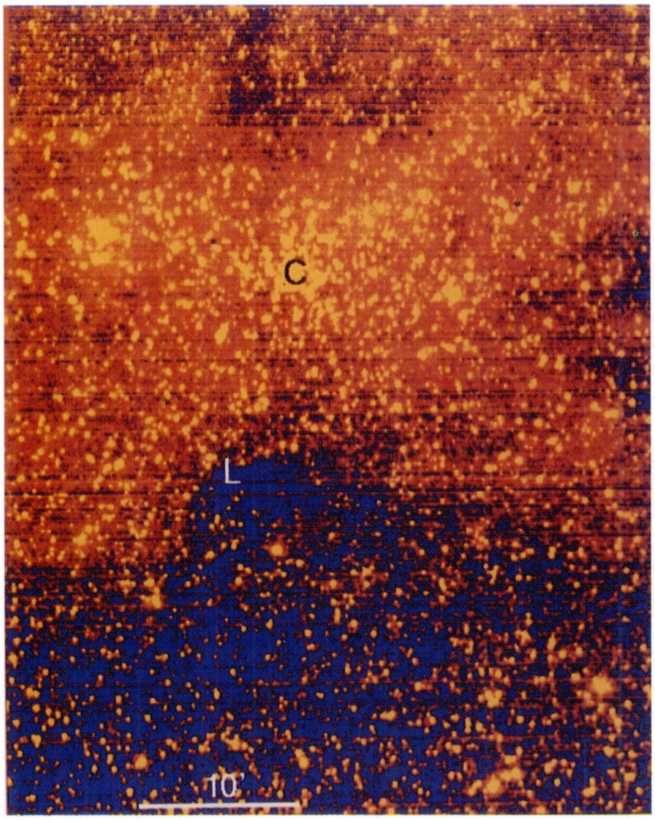
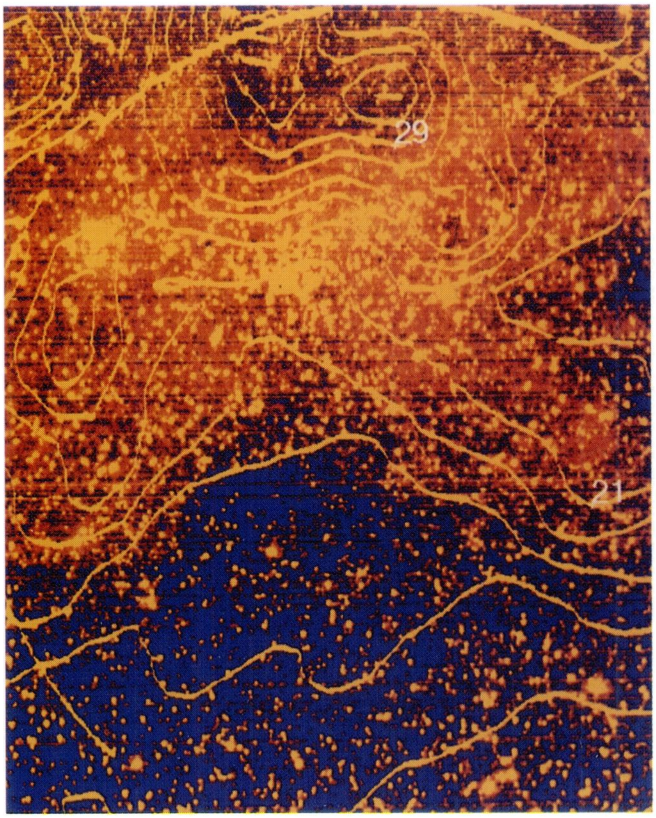


Fig. 1. False colour representation of the mosaic CCD Hα+[N II] image of the area centered at the galactic remnant G127.1+0.5. The four partly overlapping individual images have (from north to south) exposures of 45, 30, 30 and 45 minutes.



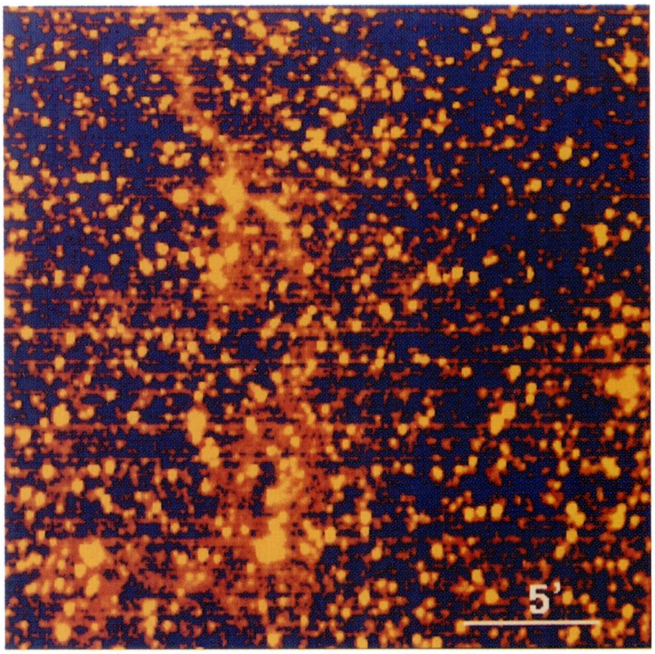


Fig. 2. The northwest part of the known remnant G126.1+1.2 showing filamentary structure is presented here in a 90min total exposure in Hα+[N II]. The field of view here is 26x40 arcmin^2 and the pixel resolution is 4.9 arcsec.

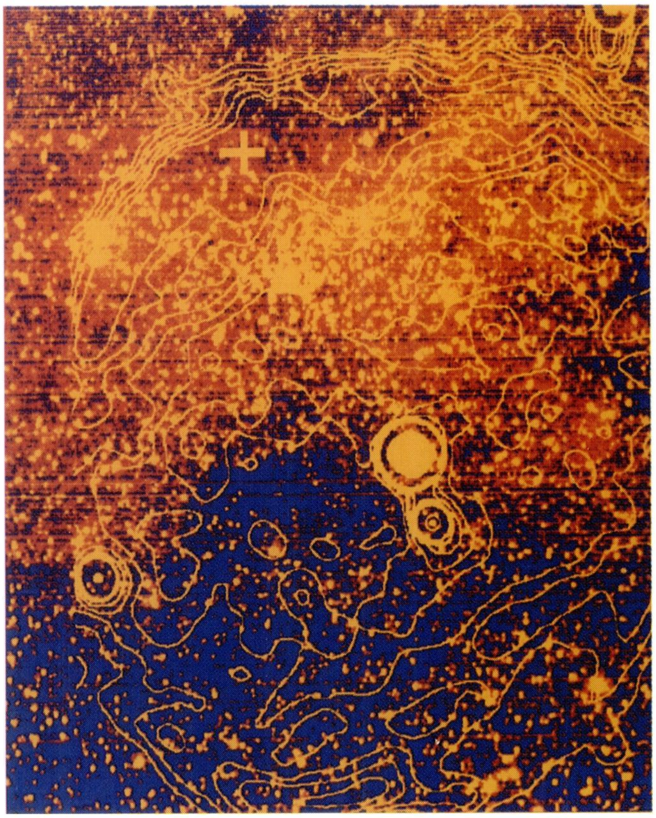


Fig. 4

◀ **Fig. 3.** Overlay of the IR image of the area centered at G127.1+0.5 and the optical CCD image, as in Fig. 1. The IR contour levels are 16, 17, 18, 19, 20, 21, 22, 23, 25, 27, 29, 31, 33, 35 MJy/sr. The background level (15.3 MJy/sr) is indicated by a "+".

combined image are scaled by using the median values of the overlapping regions.

All images were taken when the object was between 50° and 60° in elevation. The reduction was done with the *IRAF* image processing package.

The images were bias subtracted and flat field corrected, using twilight flat field images. In order to calibrate the measured fluxes, we observed the standard star BD +28° 4211 (Massey et al. 1988). The known nearby remnant G126.2+1.6 (Blair et al. 1980) was also observed in order to test the ability of our instrumental set-up.

3. Results and discussion

3.1. The optical emission

The resultant composite image is presented in Fig. 1. It is evident that a diffuse nebulous emission is present in the northern area of the supernova remnant G127.1+0.5. No filamentary structure is evident within our limits of resolution (5 arcsec/pixel). The location of the open cluster NGC 559 is indicated with the letter C on this Figure. Towards the north-northwest of the cluster location there is a more prominent optical emission region along the concentration of bright stars in the shape of a *spear*. This region is also identified by the IR contours (Fig.3) as the area which lies between the 26-29 MJy/sr contours. A less prominent emission appears south of the cluster and resembles a *bow* with its concave side facing south. Close to the center of the remnant the diffuse emission stops and a dark area appears, whose location and extend coincide with that of the small molecular cloud L 1325 (indicated here with the letter L). The southern part of the remnant area does not reveal any optical emission at the level of the northern part.

As can be seen from the image in Fig. 1, the intensity of the optical emission varies with location. The faintest features, like those surrounded by the 21 MJy/sr IR contours (see Fig. 3) southwards of NGC 559, correspond to a 2σ detection above the sky background. Using BD +28° 4211 as a standard star for our calibration, we have converted the measured intensity units into flux units. The flux that corresponds to the 2σ of the nebulosity is 0.6×10^{-16} ergs sec^{-1} cm^{-2} arcsec^{-2} while some brighter areas along the *spear* correspond to a flux of 1.5×10^{-16} ergs sec^{-1} cm^{-2} arcsec^{-2}.

For a further check up of the emission level that our experimental set-up could reach, we have observed in Hα+[NII] the nearby remnant G126.2+1.6 whose radio properties are thought to be very similar to those of G127.1+0.5 (Fürst et al. 1984). This remnant is known to exhibit filamentary structure in both Hα (Rosado 1983) and [OIII] (Blair et al. 1980). The image of the area containing the filaments of G126.2+1.6 is presented in Fig. 2 as the resultant image of the addition of two 45min exposures. Some of the faint areas of the filaments are found to be at the 3σ detection level which corresponds to a flux of 0.9×10^{-16} ergs sec^{-1}cm^{-2}arcsec^{-2}. This value assures us that if there were any filamentary structure of G127.1+0.5 we would have detected it too.

The diffuse nebulosity observed in the area of G127.1+0.5 could in principle be associated with either the projected radio remnant or the open cluster. A third possibility is to originate from the HII region which is located at the north-northeast of the cluster at an angular distance of 1° and extends circularly in a 45arcmin diameter. In order to narrow the possibilities we correlated our results with the existing IR and radio data available for this region.

◂ **Fig. 4.** Overlay of the Hα image of the area centered at G127.1+0.5 and the 21 cm radio contours. The contour level indicated by a "+" represents the area of the most intense radio emission. Higher contour levels appearing on the original map have been removed to avoid crowding.

3.2. The IR emission

The 60 μm IR contours taken from Arendt (1989) were scanned and brought to the same scale as our image. The overlay of these contours and our Hα image is shown in Fig. 3. The location of the optical emission previously identified as *spear* lies between the 26-29 MJy/sr contours. The *bow* shaped optical emission, south-southwest of NGC 559, is enclosed by the 21 MJy/sr contour. Thus, there appears to be remarkably good coincidence between the optical and the IR emission. The southern part of the remnant, where no optical emission was detected, does not show any appreciable emission in all IR bands.

3.3. The radio emission

The overlay of the 21 cm radio continuum contours, scanned from Joncas et al. (1989) and the optical image (Fig. 4) reveals at certain locations such as the *spear*, a fairly good correlation between the optical and the radio emission. Generally the optical emission is more prominent towards the inner part of the northern radio contours but there is no coincidence of the radio rim and the diffuse optical emission.

4. Conclusions

We have used deep Hα CCD images to detect for the first time faint diffuse optical emission which is located at the northern part of the area covered by the G127.1+0.5 radio contours. As it was shown here, the emission detected is well above the sky background. The optical image correlates fairly well in some locations both with the IR and the radio emission. No filamentary structure has been seen in the area covered by the radio remnant contours.

The area that we have studied is fairly complex due to the fact that many objects which could contribute to the optical emission reside there. The very old open cluster NGC 559 occupies a small region at the center of the optical emission. The HII region in the vicinity of the remnant does not seem to be connected with the diffuse optical emission that we have observed here. Therefore, we are led to the conclusion that G127.1+0.5, which is considered a younger remnant than G126.2+1.6 and resides at an uncertain distance between 0.9 and 6.5 kpc, is the source of the optical emission that we have detected. We hope that future spectroscopic observations would verify our conclusion.

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