THE SHARPLESS 187 GAS COMPLEX : A STUDY OF THE MOLECULAR, ATOMIC, IONIZED AND DUST COMPONENTS

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1. Introduction

Star forming regions are one of the active components of the interstellar medium and as such play an important role in the galactic "ecosystem". When massive young stars are borned they have a strong impact on their environment through their radiation flux and stellar wind. We are then facing complicated interplays between gas in different states (ionized, atomic and molecular), dust particles and the young stars. The understanding of these interplays can only be done using multifrequency observations. Such an endaveour is already in progress (see Joncas et al. 1988 and Kömpe et al. 1989). We will describe here the young star forming region S187 (Sharpless 1959). This gas complex is nearby (≈1 kpc) thus permitting high spatial resolution with medium size instruments. It contains a faint optically visible HII region ionized by an unidentified B0 or B0.5 star. The associated molecular cloud, discovered by Blair et al. (1975), contains a molecular outflow (Bally and Lada 1983) to which an H_2O maser is associated (Henkel et al. 1986).

2. Observations

The following is a summary, the instruments and data handling will be described in more details elsewhere (Joncas et al. 1989b).

Ionized gas. Three Hα interferograms were obtained with the Université Laval Fabry-Pérot camera. The instrument was installed on the Observatoire Astronomique du mont Mégantic 1.6 m telescope. The detector was the observatory's RCA CCD chip. The scanning Fabry-Pérot interferometer (FP) has a resolution (FWHM) of 0.024 nm. Each interferogram results from the summation of five 2000 sec exposures.

Ionized and atomic gas. The radio centimetric observations were secured with the aperture synthesis radio telescope of the Dominion Radio Astrophysical Observatory (DRAO). It is designed to make HI spectral line observations simultaneously with the observation of 21 cm and 74 cm continuum emission. The inner portion of the uv planes were filled using single dish observations. The resolution (FWHM) was 1'0 EW x 1'.1 NS x 1.32 km s^{-1} at 21 cm. The 74 cm observations were discussed in Joncas et al. (1989a).

https://doi.org/10.1017/S0252921100023538 Published online by Cambridge University Press

Molecular gas. The molecular cloud was observed with the Observatoire de Bordeaux 2.5 m millimeter antenna in the ^{13}CO J=1-0 line. The HPBW of the telescope is 4'.4 and the spectrometer channel width we used was 0.27 km s^{-1}. The spectra have a noise level (1σ) of ≈0.2 K. We surveyed ≈900 square arcminutes but the molecular cloud is not entirely mapped yet.

Dust particles. We used the survey data obtained by the Infra-Red Astronomical Satellite (IRAS). In order to gain higher spatial resolution and sensitivity, the survey scans were reprocessed with a technique called two-dimensional survey coaddition available at the Infrared Processing and Analysis Center (IPAC). The final product are maps with pixel size of 15", 15", 30" and 1' at 12, 25, 60 and 100 μm.

3. Results

3.1 The HII region

Because of the limited size and faintness of the nebula and the large amount of stars which contaminated the FP rings, only a small number of velocity points were confidently measured. From a total of 27 Hα radial velocity points, we obtained a mean LSR velocity of -18.6 km s^{-1} (1σ=4.5 km s^{-1}). Unfortunately there are to few data points to check for the presence of velocity gradients across the nebula.

Figure 1 is a superimposition of our 21 cm continuum emission map from a 1° square field containing S187 on a reproduction of an E plate of the POSS. At the 3σ level (the first contour) the nebula is 7' in diameter and roughly circular. The dented contour at the southern edge comes from the subtraction of a strong extragalactic radio source. The lack of agreement between the optical and radio pictures shows that the HII region suffers from a large amount of absorption. Actually, from Fig. 1, we see this absorption to be present across a good portion of the field. Note also that some diffuse optical emission has no radio counterpart. The measured radio flux is 1.15 ± 0.12 Jy. Assuming the nebula to be spherical (see Fig. 1) we derived from this flux and from an electron temperature of 6200 K (Rossano 1978), an r.m.s. density of 47 cm^{-3}, a mass (H + He) of 8.2 $M_{\odot}$ and an excitation parameter of 13.1 cm^{-2} pc (B0-B0.5 star, Panagia 1973).

3.2 The atomic gas

Although the DRAO synthesis telescope has a 2° field of view at 21 cm, we will concentrate here on the HI line emission in the S187 area. Inspection of the 128 HI maps produced from the observations reveals the presence of HI emission probably related with our object. Figure 2 is a map of integrated HI emission in a 1° square field around S187 with overlaid continuum contours of S187. Apparent is an HI feature taking the form of a shell partially surrounding the nebula over the

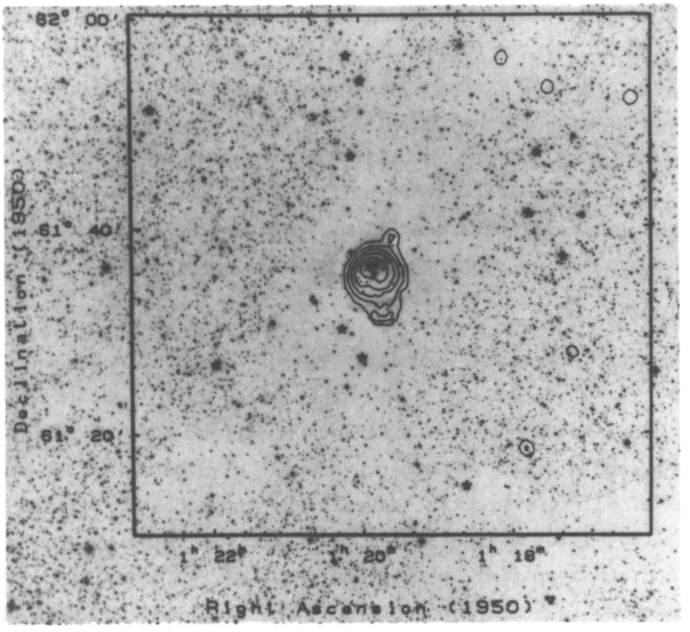

Fig. 1. Superimposition of a reproduction of an E plate of the POSS with a DRAO 21 cm continuum map of the S187 area.

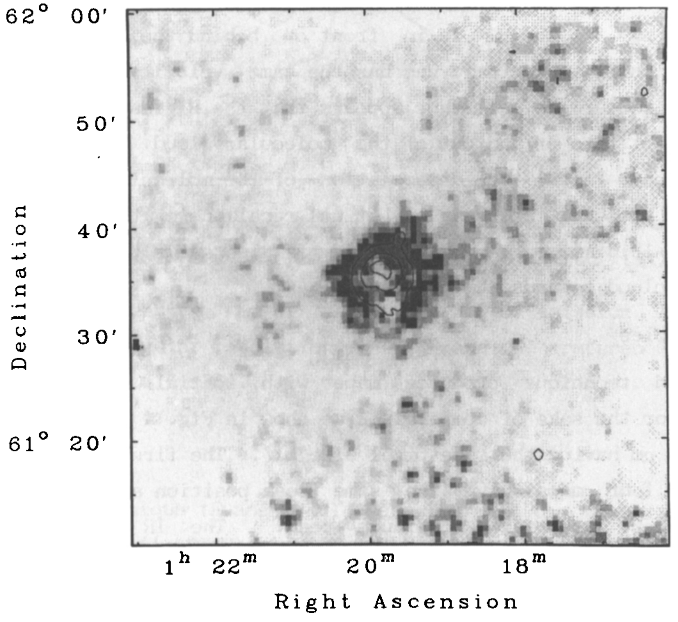

Fig. 2. Map of HI emission in a 1° x 1° field around S187 integrated over the velocity range -10.1 to -22.4 km s^{-1}. Overlaid is the radio continuum contours of S187.

https://doi.org/10.1017/S0252921100023538 Published online by Cambridge University Press

integrated velocity interval (-10.1 to -22.4 km s^{-1}), its diameter is ≈12.5'. Starting at -10.1 km s^{-1} the HI first follows the northwestern contour of the nebula. As the velocity becomes more negative the HI emission migrates to follow the NE and SW contours. At Vlsr ≤ - 18.3 km s^{-1}, the HI is now found at the SE edge and overlaps part of the nebula. The shell is ≈0.7 pc thick on its eastern half and ≈1.6 pc thick on its western half (FWHM). The total mass of the shell is ≈70$M_\odot$ (assuming optically thin conditions). The velocity range of the ionized gas (-10.5 to -27.0 km s^{-1}) is roughly within the limits of the shell's velocity field.

3.3 The molecular cloud

Figure 3 shows the integrated intensity map of our ^{13}CO observations. The LSR velocity range is -7 to -18 km s^{-1}. The molecular cloud is ≈12 pc x ≈6 pc in extent and is elongated along a NW-SE axis. Recall however that the cloud may be somewhat bigger and differ in shape since we have not finished its mapping yet. The summation of all our spectra reveals the presence of 4 velocity components located at -14.5, -13.0, -11.5 and -8.5 km s^{-1}. No velocity gradient is apparent across the cloud at a spatial resolution of 4.4'. The origin of the different velocity components is still conjectured. We calculated the mass of the cloud to be ≈4600$M_\odot$.

Eventhough they have different spatial resolution, we compared the velocity field of the HI shell with the overlapping ^{13}CO spectra. For the area covered by the nebula, the HI gas is blueshifted with respect to the molecular gas. It is impossible to say if the HI is in front or behind the HII region. In the area covered by the shell, the atomic gas has the same velocity or is blueshifted with respect to molecular gas. It thus appears that the HI feature surrounding S187 is expanding in part into or/and out of the molecular cloud. We believe the atomic gas to originate from the dissociation of the molecular gas by the UV photons emanating from the exciting star. Let us recall here the mean velocity of the ionized gas, -18.6 km s^{-1}. The ionized gas also seems to be expanding away from the molecular cloud towards the observer.

4.4 Dust particles

The 2-D coadd technique produces maps with spatial resolution varying with wavelength. For the sake of comparaison we show in Fig. 4 IR continuum maps at 12, 25, 60 and 100 μm having the same pixel size, 1'. The first contour is at the 3σ level. All four maps have the same peak position and it corresponds to the position of the 21 cm radio continuum peak. The IR emission has the same orientation as the ^{13}CO emission and is as extended. We derived the following fluxes 360, 680, 6700, 10000 Jy for the emitting dust. From these the total IR luminosity (8 to 2200μm) was derived to be 2.3 x 10^4 $L_\odot$. Assuming that the IR radiation comes from the absorption of every Ly α photons, a B0 star would supply all the necessary radiation.

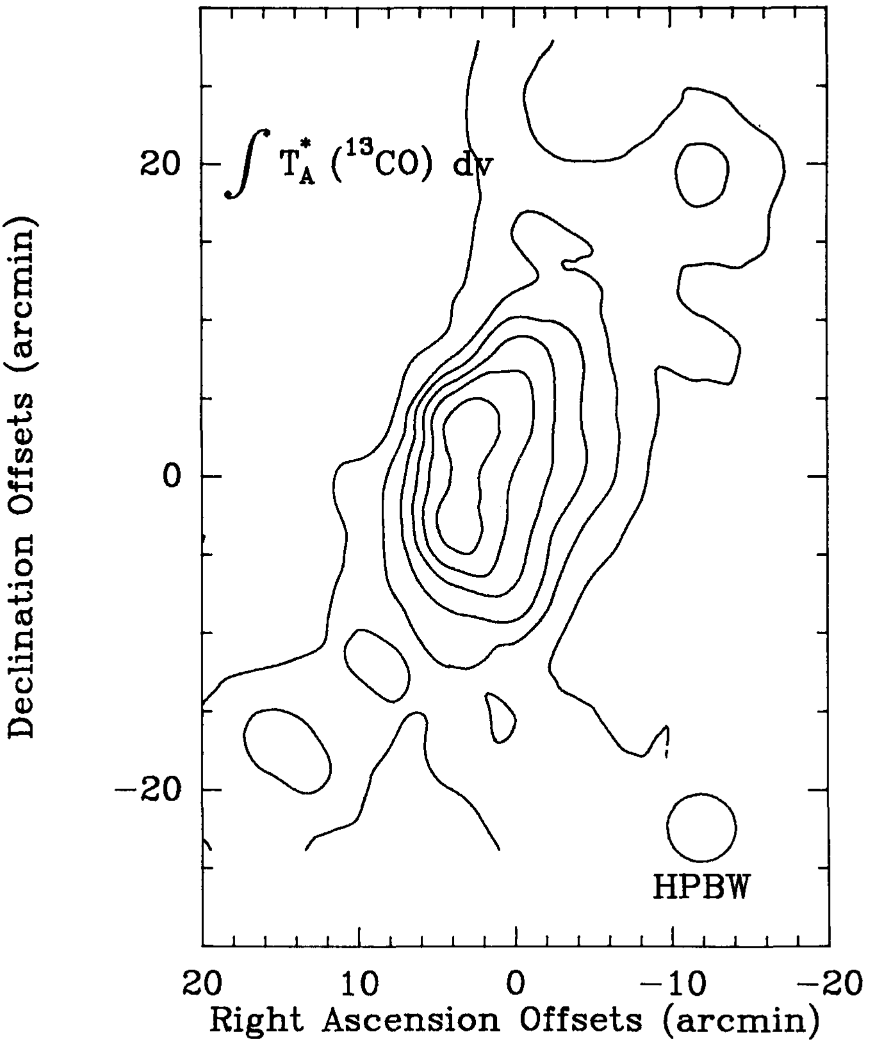

Fig. 3. Integrated intensity map of the ^{13}CO (J=1-0) emission line of the S187 molecular cloud. The angular resolution is 4'.4 and the reference position is : α_{1950} = $1^h19^m48^s$, δ_{1950} = 61°35'.

Following the usual technique (Evans 1980), we calculated the mean dust temperature to be $\langle T_{12/25} \rangle$ = 191 K (1σ=22 K) and $\langle T_{60/100} \rangle$ = 33 K (1σ=5 K). $T_{12/25}$ and $T_{60/100}$ dust temperature maps (not shown here) present temperature gradients of opposite behaviour. This is consistent with the presence of two grain populations, one with thermal emission and the other with non-thermal emission. The total amount of dust emitting at 100 μm was derived to be 1.6 $M_\odot$.

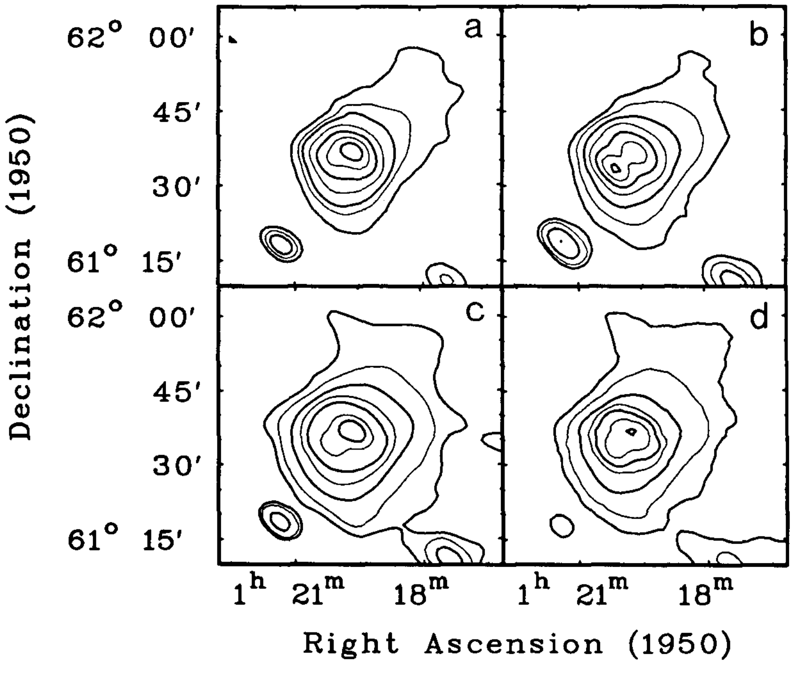

Fig. 4. The IR continuum maps of S187 (IRAS co-added data) (a) 12μm, (b) 25μm (c) 60μm, (d) 100μm.

5. Discussion

What we have shown here is an overview of part of our S187 data bank. We have not fully explored it yet, we still have monochromatic Hα CCD frames, BVR stellar photometry of the area and the IRAS point source catalog to look into. We also have to integrate the multifrequency data together. This will be delt with in a forthcoming paper. However it appears for now that the most massive star in the area is a B0 star, that S187 may be partly a reflection nebula, that the HI gas is closely linked to the molecular gas and that the exciting star seems to be heating dust across the entire surface of the molecular cloud facing the observer.

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