INFRARED STUDY OF THE SOUTHERN GALACTIC STAR-FORMING REGIONS ASSOCIATED WITH IRAS 10049-5657 AND IRAS 10031-5632

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Abstract

We investigate the physical conditions of the interstellar medium and stellar components in the regions of the southern Galactic star-forming complexes associated with IRAS 10049-5657 and IRAS 10031-5632. These regions have been mapped simultaneously in two far-infrared bands (λ_{eff} ≈ 150 and 210 µm), with ~1′ angular resolution using the Tata Institute of Fundamental Research 1 m balloon-borne telescope. Spatial distribution of the temperature of cool dust and optical depth at 200 µm have been obtained taking advantage of the similar beams in the two bands. The HIRES processed Infrared Astronomical Satellite (IRAS) maps at 12, 25, 60, and 100 µm have been used for comparison. Using the Two Micron All Sky Survey near-infrared sources, we find the stellar populations of the embedded young clusters. A rich cluster of OB stars is seen in the IRAS 10049-5657 region. The fits to the stellar density radial profile of the cluster associated with IRAS 10049-5657 have been explored with the inverse radius profile as well as the King’s profile; the cluster radius is ~2 pc. The source in the cluster closest to the IRAS peak is IRA-7, which lies above the zero-age main-sequence curve of spectral type O5 in the color–magnitude diagram. Unlike IRAS 10049-5657, a small cluster comprising a few deeply embedded sources is seen at the location of IRAS 10031-5632. Self-consistent radiative transfer modeling aimed at extracting important physical and geometrical details of the two IRAS sources shows that the best-fit models are in good agreement with the observed spectral energy distributions. The geometric details of the associated cloud and optical depths (τ_100) have been estimated. A uniform density distribution of dust and gas is implied for both the sources. In addition, the infrared ionic fine-structure line emission from gas has been modeled for both the regions and compared with data from the IRAS low-resolution spectrometer. For IRAS 10049-5657, the observed and modeled luminosities for most lines agree within a factor of 4 while for IRAS 10031-5632 we find a discrepancy of a factor of 100 and it is likely that some basic assumptions of the model are not valid in this case.

Key words: H II regions – infrared: ISM – ISM: individual (IRAS 10049-5657, IRAS 10031-5632) – stars: formation

Online-only material: color figures

1. INTRODUCTION

H II regions are astronomical sources that represent early stages of deeply embedded high-mass (O or early B) stars. Their study can provide vital information about high-mass star formation as well as their interaction with the parent molecular cloud. Being deeply embedded in interstellar clouds including the dust component, almost all of their energy is absorbed and re-emitted in the infrared wave bands. IRAS 10049-5657 (G282.0-1.2) and IRAS 10031-5632 (G281.6-1.0) are Galactic star-forming regions in the southern sky, which are generally less studied. Radio measurements indicate that IRAS 10049-5657 is an extended H II region (Hill 1968; Manchester 1969).

A number of distance estimates to IRAS 10049-5657 can be found in the literature, ranging from 5.1 to 7.1 kpc. Here, we use the distance of 6.3 kpc estimated by Caswell & Haynes (1987) based on radio recombination line measurements (for R⊙ = 8.5 kpc and Galactic rotation velocity = 220 km s⁻¹ at R⊙). The distance to IRAS 10031-5632 is estimated to be 3.7 kpc (Caswell & Haynes 1987).

Recently, it has been concluded that the IRAS 10049-5657 complex harbors a very massive OB star cluster (Bik et al. 2005; Hanson et al. 2003). Bik et al. have carried out near-infrared (NIR) K-band spectroscopy of few members of this cluster and find two very massive (O3-O4) stars here. IRAS 10049-5657 has been studied as a part of surveys for the search of emission lines including masers. Formaldehyde absorption has been detected toward this source at 4.8 GHz (Whiteoak & Gardner 1974) and 14.5 GHz (Gardner & Whiteoak 1984). Whiteoak et al. (1982) detected CO (1-0) line emission from this source using the 4 m radio telescope of CSIRO. Searches for methanol transition (Peng & Whiteoak 1992), methanol maser (Schutte et al. 1993), and OH maser (Cohen et al. 1995) close to this source have led to negative results. IRAS 10049-5657 has been imaged by Puchalla et al. (2002) at 42 GHz using the Mobile Anisotropy Telescope on Cerro Toco (MAT/TOCO) and an integrated flux of 22.2 ± 2.1 Jy within a 0.3° circular beam has been obtained by them. Both IRAS 10049-5657 and IRAS 10031-5632 have been studied as part of the Parkes–MIT–NRAO (PMN) survey (Kuchar & Clark 1997). They find the peak radio flux density of IRAS 10049-5657 and IRAS 10031-5632 at 5 GHz to be 25.7 Jy beam⁻¹ and 1.0 Jy beam⁻¹, respectively, where the beam is ~4.9′. CS (2-1) line emission has been observed close to both the regions (Bronfman et al. 1996) using the Swedish-ESO Submillimetre Telescope (SEST). The IRAS low-resolution spectrum (LRS) of IRAS 10031-5632 shows strong [Ne II] emission line at
12.8 \( \mu \text{m} \) (de Muizon et al. 1990; Simpson & Rubin 1990), a relatively weak [S II] emission line at 18.7 \( \mu \text{m} \) as well as emission in the unidentified infrared bands (UIBs) at 7.7, 8.6, and 11.3 \( \mu \text{m} \) (Zavagno et al. 1992; de Muizon et al. 1990). Neither water vapor maser (Brau et al. 1989) nor methanol maser (Schutte et al. 1993) has been found close to IRAS 10031-5632.

The less-known southern Galactic massive star-forming regions are being studied under a long-term program that involves observing these sources in the far-infrared (FIR; Vig et al. 2007; Ojha et al. 2002; Karnik et al. 2001; Ghosh et al. 2000; Verma et al. 1994). In this paper, we present a systematic study of the star-forming regions associated with IRAS 10049-5657 and IRAS 10031-5632. The star-forming region associated with IRAS 10049-5657 is believed to harbor a cluster of very massive stars. IRAS 10031-5632 is, by contrast, a young star-forming region with few members belonging to the cluster. We have carried out an infrared study of these southern Galactic H\( \text{II} \) regions in detail with the aim of understanding the energetics, physical sizes, and the spatial distribution of interstellar dust and its temperature as well as the associated young clusters. Section 2 describes observations and other data sets used. Section 3 describes the results. Radiative transfer modeling of these sources is presented in Section 4. A comprehensive discussion of these sources is carried out in Section 5 and a brief summary is presented in Section 6.

2. OBSERVATIONS AND DATA REDUCTION

2.1. Far-Infrared Observations

The Galactic star-forming regions associated with IRAS 10049-5657 and IRAS 10031-5632 have been observed using the two-band FIR photometer system at the Cassegrain focus of the Tata Institute of Fundamental Research (TIFR) 100 cm (\( f/8 \)) balloon-borne telescope. The observations were carried out during the balloon flight from the TIFR Balloon Facility, Hyderabad, in India (latitude 17°47′ north, longitude 78°57′ east) on 1994 February 20. Details of the telescope and the observational procedure are given by Ghosh et al. (1988). The two FIR bands use a pair of 2\( \times \)3 composite silicon bolometer arrays, cooled to 0.3 K by liquid \(^{4}\)He, that view identical parts of the sky simultaneously. The field of view of each detector is 1.6. The absolute positions were established from the detections of cataloged stars with an optical photometer located at the focal plane of the telescope, simultaneously during the FIR observations. The planet Jupiter was observed at the beginning as well as at the end of the flight. The observations of Jupiter were used for the absolute flux calibration of the two-band FIR photometer (12 channels) as well as for the determination of the point-spread function (PSF). The spectral response of each band of the FIR photometer was determined in the laboratory using a Michelson interferometer and a Golay cell as a comparison detector. The two FIR wave bands will be referred to as 150 and 210 \( \mu \text{m} \) bands corresponding to the \( \lambda_{\text{eff}} \) for a 30 K source with \( \lambda^{-2} \) emissivity law.

The region around IRAS 10049-5657 (\( \sim 32′ \times 20′ \)) and IRAS 10031-5632 (\( \sim 25′ \times 18′ \)) was mapped by raster scanning of the region of the sky in cross-elevation with steps in elevation at the end of each scan. The FIR signals were gridred into a matrix with a pixel size of 0.3′ × 0.3′. The deconvolution of the observed chopped signal matrix was carried out using the maximum entropy method similar to that of Gull & Daniell (1978; for details see Ghosh et al. 1988). An angular resolution of \( \sim 1′ \) has been achieved in the FIR maps using this method.

2.2. Other Data Sets Used

2.2.1. IRAS

The data from the Infrared Astronomical Satellite (IRAS) survey in the four bands (12, 25, 60, and 100 \( \mu \text{m} \)) for IRAS 10049-5657 and IRAS 10031-5632 were processed with the high-resolution processing using maximum correlation method (HIRES; Aumann et al. 1990) at the Infrared Processing and Analysis Center (IPAC, Caltech) to obtain high angular resolution maps. The flux densities of the sources within a circular region of diameter 3′ (centered on the peak) have been extracted from these images. IRAS 10031-5632 appears in the IRAS LRS Catalog (IRAS Science Team 1986) while the LRS of IRAS 10049-5657 is presented by Volk & Cohen (1989). These spectra, in the wavelength range 8–22 \( \mu \text{m} \), along with the flux densities have been used for constructing the spectral energy distributions (SEDs).

2.2.2. MSX

The Midcourse Space Experiment\(^3\) (MSX) surveyed the entire Galactic plane within \( |b| \leq 5° \) in four mid-infrared wave bands: 8.3, 12.1, 14.7, and 21.3 \( \mu \text{m} \) at a spatial resolution of \( \sim 18′3 \) (Price et al. 2001). The panoramic images of the Galactic plane survey of MSX were taken from IPAC. The images of IRAS 10049-5657 and IRAS 10031-5632 were used to extract the sources and obtain the flux densities within a circular region of diameter 3′ in order to construct the SEDs. Point sources close to these star-forming regions have been selected from MSX Point Source Catalog (PSC) Version 2.3 (Egan et al. 2003) and cross-correlated with Two Micron All Sky Survey\(^4\) (2MASS) sources (see Section 2.2.3).

2.2.3. 2MASS

The point sources around the regions IRAS 10049-5657 and IRAS 10031-5632 were selected from the 2MASS PSC. The 2MASS PSC is complete down to \( J \leq 15.8, \ H \leq 15.1, \) and \( K_s \leq 14.3 \) mag for signal-to-noise ratio (S/N) \( > 10 \), in the absence of confusion. The 2MASS sources used in this study are those with good photometric quality (rdflg = 1–3). The \( J, \ H, \) and \( K_s \) magnitudes of the selected sources have been used to construct color–magnitude (CM) and color–color (CC) diagrams, which have been used to study the embedded clusters in these regions. The \( JHK_s \) magnitudes and images were taken from IPAC.

2.2.4. SUMSS

The Sydney University Molonglo Sky Survey (SUMSS) is a radio imaging survey of the sky south of declination \( \sim -30° \) (Bock et al. 1999). This survey uses the Molonglo Observatory Synthesis Telescope\(^5\) (MOST), operating at 843 MHz with a

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\(^3\) This research made use of data products from the MSX. Processing of the data was funded by the Ballistic Missile Defense Organization with additional support from the NASA Office of Space Science. This research has also made use of the NASA/IPAC Infrared Science Archive, which is operated by the Jet Propulsion Laboratory, Caltech, under contract with NASA.

\(^4\) This publication makes use of data products from the 2MASS, which is a joint project of the University of Massachusetts and IPAC/California Institute of Technology, funded by NASA and the NSF.

\(^5\) The MOST is operated by the University of Sydney and supported in parts by grants from the Australian Research Council.
3. RESULTS

In this section, we present the results obtained from the observations as well as from the available data. Since our study includes a wide wavelength range (NIR to radio), we classify our results according to those for the dust and gas components (interstellar medium) versus the stellar component for both regions, IRAS 10049-5657 and IRAS 10031-5632.

3.1. IRAS 10049-5657

3.1.1. Interstellar Medium

The deconvolved maps of IRAS 10049-5657 at 150 and 210 µm are presented in Figure 1. Figure 1 (left) shows emission from the IRAS 10049-5657 region at 150 µm while Figure 1 (right) shows the emission at 210 µm, from the complete region (32' × 20') mapped by the telescope. The angular size (50% contour level) of IRAS 10049-5657 at 150 and 210 µm is 0.7'. The FIR emission in these maps samples the cold dust around these regions. IRAS 10049-5657 is well resolved in both the bands. The FIR emission in this region shows an extension toward the northeast in both the bands. This emission toward the northeast extends to a larger scale in the 210 µm map in Figure 1 (right). Taking advantage of the simultaneous observations in the two bands, with an almost identical field of view, we have generated maps of the dust temperature (T_d) and optical depth at 200 µm (τ_200). The dust temperature T(150/210) and optical depth (τ_200) maps are shown in Figure 2. For these maps, we have assumed dust emissivity of the form ϵ_λ ∝ λ^−2. The temperature distribution shows plateaux of maximum (60 K) toward the northwest and southeast of the FIR peak. We have detected dust as cold as 20 K. The peak optical depth at 200 µm is determined to be 0.007 and is located at the position of the peak of FIR emission. Another peak is seen to the west of the maximum optical depth with an extension corresponding to the northeast. The IRAS-HIRES maps of the region around IRAS 10049-5657 at 12, 25, 60, and 100 µm are shown in Figure 3. The achieved angular resolutions are 0.7' × 0.5' at 12 and 25 µm, 1.4' × 1.1' at 60 µm, and 2.1' × 1.9' at 100 µm. The flux densities of IRAS 10049-5657 integrated over 3' diameter, centered on the peak, from the TIFR and IRAS-HIRES maps are listed in Table 1.

We have modeled thermal continuum emission from interstellar dust along with the emission in UIBs, using mid-IR data from the MSX Galactic Plane Survey in the 8.3, 12.1, 14.7, and 21.3 µm bands. This has been carried out using the scheme
Figure 3. IRAS-HIRES intensity maps for the region covering IRAS 10049-5657 at 12 μm (top left), 25 μm (top right), 60 μm (bottom left), and 100 μm (bottom right). The contours are at 1, 5, 10, 20, 40, 60, 80, 90, and 95% of the peak value of 272 Jy arcmin$^{-2}$, 1053 Jy arcmin$^{-2}$, 3367 Jy arcmin$^{-2}$, and 1423 Jy arcmin$^{-2}$ at 12, 25, 60, and 100 μm, respectively.

Table 1

| Source          | IRAS PSC | TIFR Images$^a$ | IRAS-HIRES Images$^a$ | MSX Images$^a$ |
|-----------------|----------|-----------------|-----------------------|----------------|
|                 |          | (Jy) for λ (μm) | (Jy)                  | (Jy)          |
| 10049-5657      | 100      | 6224            | 2166                  | 1486           |
|                 | 1147     | 8901            | 368                   | 642            |
|                 | 2534     | 7023            | 146                   | 373            |
|                 |          | 6146            | 148                   | 120            |
| 10031-5632      | 679      | 1574            | 215                   | 126            |
|                 | 1405     | 1381            | 25                    | 23             |
|                 |          | 1512            | 209                   | 15             |
|                 |          | 1166            | 168                   |                |

Note. $^a$ Fluxes obtained by integrating over a circular region of diameter 3′ centered on the peak.

developed by Ghosh & Ojha (2002). In this scheme, the emission from each (6′′ × 6′′) pixel in the MSX images is modeled to be a combination of two components: thermal continuum from the warm dust grains (gray body) and the emission from the UIB features falling within the MSX band. The scheme assumes that dust emissivity follows the power law of the form $\epsilon_\lambda \propto \lambda^{-1}$ and the total radiance due to UIBs in the 12 μm band is proportional to that in the 8 μm band. The spatial distribution of UIB emission predicted by this scheme is presented in Figure 4. The morphology of UIB emission shows extensions toward the southwest near the peak as well as toward the northwest at the fainter levels. The peak strength of the modeled UIB emission is $8.9 \times 10^{-5}$ W m$^{-2}$ Sr$^{-1}$ and is close ($\sim 16''$) to the IRAS position.

Table 1 also lists the flux densities of IRAS 10049-5657 from MSX maps integrated within a circular region of diameter 3′.

The SUMSS radio continuum emission from the region around IRAS 10049-5657 at 843 MHz is shown in Figure 5. A dynamic range of $\sim 700$ is achieved in this region (peak flux is 4.3 Jy beam$^{-1}$; root mean square (rms) noise is $\sim 6$ mJy beam$^{-1}$). The radio emission peaks at $(\alpha_{2000} = 10^h06^m41.15^s, \delta_{2000} = -57^\circ12'40'')$. The integrated radio flux density is $\sim 42.4$ Jy over 43.6 arcmin$^2$.

3.1.2. Stellar Component

The distribution of NIR sources (selected from 2MASS PSC) in the region around IRAS 10049-5657 was investigated.
higher density of sources close to the IRAS 10049-5657 region compared to neighboring regions implied an embedded cluster. We have used 2MASS sources to study the nature of embedded clusters. We first estimate the cluster radius. For this, we select a large region of radius 30′ around the cluster center. To determine the radial profile, the cluster region was divided into a number of concentric annuli with respect to the cluster center. The surface number density of stars was obtained by counting them in each 7″ annulus and dividing by the annulus area. The King’s model, \( f(r) \), and the inverse radius model, \( g(r) \), of the following functional forms are fitted to the surface density radial profile:

\[
 f(r) = a_k + \frac{f_o}{1 + (r/r_{ck})^2},
\]

\[
 g(r) = a_i + \frac{a_0}{r}.
\]

Figure 4. Spatial distribution of total radiance in UIBs for the region around IRAS 10049-5657 modeled using the MSX images. The contour levels are at 5, 10, 20, 30, 40, 50, 60, 65, 70, 80, 90, and 95% of the peak value of 8.9 × 10^{-5} \text{ W m}^{-2} \text{ Sr}^{-1}.

Figure 5. SUMSS radio flux density map for the region around IRAS 10049-5657 at 843 MHz. The contour levels are at 0.1, 1, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 95% of the peak flux of 4.3 Jy beam^{-1}. The synthesized beam is 43″ × 43″.

Figure 6. Radial profile of the surface number density for the cluster associated with IRAS 10049-5657 in log–log scale. Also plotted are the two fitted models—King’s model (solid) and inverse radius model (dotted). The horizontal, dashed line corresponds to the background field star level, which is \( \sim 3 \) stars pc^{-2}. Statistical errors (corresponding to the Poisson noise) are shown.

Here, \( a_k \) and \( a_i \) are the fitted background constants for the King’s and inverse radius profile, respectively. For the King’s profile, \( f_o \) represents the core concentration at radius zero and \( r_{ck} \) is the core radius. The stellar density of the inverse profile at the core is represented by \( a_0 \). The radial profile of the observed star density as well as the fits are shown in Figure 6. A clear gradient in surface number density distribution confirms the existence of clustering (crowdiness) at the center of the region. The radial profile of the cluster merges with the background field at \( \sim 65″ \), yielding the extent of the cluster to be \( \sim 2 \) pc. The background level as estimated from the control field is \( \sim 3 \) stars pc^{-2}, which agrees well with the values of 3.3 ± 0.6 and 2.6 ± 0.2 stars pc^{-2} yielded by the inverse radius and King’s profile fitting, respectively. Note that these estimates of the stellar density toward the HII region when compared with the adjacent fields are unlikely to be affected by extinction (i.e., background stars) since the cluster is fairly distant.

Within a cluster radius of 65″ around the cluster center (\( \alpha_{2000} = 10^h06^m38.19, \delta_{2000} = -57°12′25″.2 \)), 89 sources were found. Of these, 45 were detected in the JHK_s-bands of 2MASS. Forty-four sources have been detected in either H- and K_s-bands or only K_s-band. We have discussed the nature of stellar populations in this region using the CM (\( J - H \) versus \( J \)) and the CC (\( J - H \) versus \( H - K \)) diagrams which are shown in Figure 7. We have assumed extinction values of \( A_J/A_V = 0.282, A_H/A_V = 0.175, \) and \( A_K_s/A_V = 0.112 \) from Rieke & Lebofsky (1985). All of the 2MASS magnitudes as well as the curves are in the Bessel & Brett (1988) system. In the CM diagram, the nearly vertical solid lines from left to right (with increasing \( J - H \)) represent the zero-age main-sequence (ZAMS) curves (for a distance of 6.3 kpc) reddened by \( A_V = 0, 15, \) and 30 mag, respectively. The slanting lines joining them trace the reddening vectors of these ZAMS stars. In the CC diagram, the loci of the main-sequence and giant branches are shown by the solid and dotted lines, respectively. The short-dashed line represents the locus of classical T-Tauri stars (Meyer et al. 1997). The parallel dot-dashed straight lines follow their reddening
vectors. The long-dashed line represents the locus of Herbig Ae/Be stars (Lada & Adams 1992). We classify the CC diagram into three regions, as shown in the figure (see Ojha et al. 2004). The “F” region is considered to be the region where field stars (main-sequence stars, giants), Class III and Class II objects with small infrared excess are located. The “T” region is where protostar-like Class I objects and Herbig Ae/Be stars are mostly located. In the Figure 7 (left) CM diagram, the 10 sources lying above the ZAMS curve of spectral type O9 are shown as asterisk symbols while 13 sources with infrared excess are shown as open circles. It is likely that few of these objects are foreground objects or bright background giants. The solid triangle represents a source lying above the ZAMS curve of spectral type O9 as well as having an infrared excess i.e. lying in the “T” region. The plus symbols represent the other sources.

(A color version of this figure is available in the online journal.)

3.2.1. Interstellar Medium

The intensity maps of the region around IRAS 10031-5632 are given in Table 1. The emission in the mid-infrared bands of IRAS 10031-5632 is unresolved at 150 µm but is extended at 210 µm map. At fainter levels, we observe large-scale extended emission, particularly toward the southeast. The HIRES-processed IRAS maps for the corresponding region around IRAS 10031-5632 are shown in Figure 9. The angular resolutions achieved in these maps are 0.9 × 0.5 at 12 and 25 µm, 1.4 × 1.1 at 60 µm, and 2.1′ × 1.9′ at 100 µm. The peak position and flux density details of IRAS 10031-5632 are given in Table 1. The emission in the mid-infrared bands of MSX has been used to model the peak UB emission which is 6.5 × 10⁻⁵ W m⁻² Sr⁻¹.

The SUMSS radio emission in region around IRAS 10031-5632 at 843 MHz is shown in Figure 10. The dynamic range of the radio map is ∼300 (peak flux is 652 mJy beam⁻¹; rms noise is ∼2 mJy beam⁻¹). The peak of radio emission is at α2000 = 10^h04m56s10, δ2000 = −56°46′38.0″. The integrated flux density is 1.1 Jy over 4.9 arcmin².

3.2.2. Stellar Component

We have used the 2MASS sources in the vicinity of IRAS 10031-5632 to study the stellar populations here. In a circular region of radius 1′ around the IRAS peak, 27 sources have been detected in the JHK_s bands or only K_s-band. The CM (H − K versus K) and CC (J − H versus H − K) diagrams of the sources detected in all the three bands are shown in Figure 11. The ZAMS curves in the CM diagram are for a distance of 1432 VIG ET AL. Vol. 136
Figure 8. Intensity map for the region around IRAS 10031-5632 at 150 µm (left) and 210 µm (right). While the 150 µm map shows emission from IRAS 10049-5657 region, the 210 µm map shows the complete region scanned by the FIR telescope. Contour levels are at 1, 5, 10, 20, 40, 60, 80, and 95% of the peak intensity of 712 Jy arcmin$^{-2}$ (left) and 220 Jy arcmin$^{-2}$ (right).

Figure 9. IRAS-HIRES intensity maps for the region covering IRAS 10031-5632 at 12 µm (top left), 25 µm (top right), 60 µm (bottom left), and 100 µm (bottom right). The contours in the emission maps are at 1, 5, 20, 40, 60, 80, 90, and 95% of the peak value of 41.8 Jy arcmin$^{-2}$, 774 Jy arcmin$^{-2}$, 1370 Jy arcmin$^{-2}$, and 486 Jy arcmin$^{-2}$ at 12, 25, 60, and 100 µm, respectively.

3.7 kpc reddened by $A_V = 0$, 15, and 30 mag, respectively. As in the case of IRAS 10049-5657, all the 2MASS magnitudes as well as the curves are in the Bessel & Brett (1988) system. The source lying above the ZAMS curve of spectral type O9 is represented by an asterisk while the filled triangle represents a source lying above the ZAMS curve of spectral type O9 and having an infrared excess. The seven sources detected only in $HK_s$-bands are shown as open squares in the figure. The remaining sources are denoted by crosses. An investigation into the distribution of 2MASS PSC sources in the region around IRAS 10031-5632 shows a few sources grouped together near the IRAS peak. For this cluster, we have been unable to determine the cluster radius owing to the low surface density of stars (very few excess stars close to the IRAS peak).

4. RADIATIVE TRANSFER MODELING

In an attempt to obtain a self-consistent picture of these star-forming regions using all of the available data as well as to extract important physical parameters, we have carried out radiative transfer modeling of IRAS 10049-5657 and IRAS 10031-5632. The symmetric morphology of contours near the centrally located peak in the FIR maps
Figure 10. SUMSS radio flux density map for the region around IRAS 10031-5632 at 843 MHz. The contour levels are at 0.5, 1, 5, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 95% of the peak flux of 0.65 Jy beam$^{-1}$. The beam is 43$''$ x 43$''$.

supports the one-dimensional treatment of the radiative transfer modeling.

4.1. Continuum Emission

Each star-forming region is modeled as a spherically symmetric cloud of gas (hydrogen) and dust, powered by a centrally embedded source (single or cluster of ZAMS stars). The cloud is immersed in an average interstellar radiation field. The radiative transfer equations have been solved assuming a two-point boundary condition for the spherical cloud. The gas exists throughout the cloud, i.e., from the stellar surface to the edge of the cloud. The dust exists in a spherical shell with a cavity at the center. This is because close to the exciting source(s), the dust grains are destroyed when exposed to excessive radiative heating. Two commonly used types of interstellar dust are explored: the DL type (Draine & Lee 1984) and the MMP type (Mezger et al. 1982). In the spherical shell where gas and dust co-exist, the gas-to-dust ratio is held constant. Other details of this self-consistent scheme are given in Mookerjea & Ghosh (1999). The parameters explored are as follows: the geometrical dimensions of the cloud (primarily the radius of the dust-free cavity; the outer diameter is guided by the observed angular extent and the distance), radial density distribution law (three power-law exponents: $n(r) \sim r^0, r^{-1},$ or $r^{-2}$), radial optical depth due to dust, the nature of the embedded source(s) (single ZAMS star or a cluster, consistent with the total observed luminosity), relative abundances of different grain types (silicate, graphite), and the gas-to-dust ratio. The observational constraints include the SED due to thermal emission from the dust component, angular sizes at different wavelengths, and radio continuum emission from the H$\alpha$ region. The parameters corresponding to the best-fit models for the two sources are presented in Table 2. While no claim is made about the uniqueness of these parameter sets, the following comments in support of the robustness of the results are in order: a constant density radial profile provides the best fit for both regions and the $r^{-1}$ or $r^{-2}$ density profiles are conclusively ruled out by the observed SED; inner (dust-free) cavity radii lower than those derived result in short wavelength fluxes significantly higher than those observed and are thus ruled out; radio continuum emission is quite sensitive to the nature of the central energy source, viz., single star versus a cluster.

4.2. Line Emission from Gas

We have also modeled the infrared nebular/ionic fine-structure line emission from gas around IRAS 10049-5657 and
IRAS 10031-5632, using a sophisticated scheme that incorporates more details of the interstellar gas component. This scheme, developed by Mookerjea & Ghosh (1999), uses the photoionization code CLOUDY (Ferland 1996), which solves for statistical and thermal equilibria by balancing various ionization–neutralization processes as well as heating–cooling processes. The scheme additionally includes: (a) the exact structure of the cloud/H\textsc{ii} region (viz., central dust-free cavity) and (b) absorption effects of the dust component on the emergent line intensities. Typical H\textsc{ii} region abundance of the gas component has been taken into consideration.

The overall structure of the cloud is defined by the parameters that provide the best fit to the continuum SED (see Subsection 4.1). The first part of the calculations involve the pure gas inner shell and the emerging spectrum comprises continuum as well as line emission. This emergent continuum from the inner shell provides the inner surface boundary condition for the second shell comprising gas and dust. The line emission from the inner shell is transported outward through extinction by the dust column in the second shell. Similarly, line emission originating from the second shell is transported considering the absorption effects of the dust grains lying between the emission zone and the outer surface of the second shell. The final predicted emergent line luminosity includes both components. A total of 27 spectral lines in the wavelength range 2.5–200 µm have been considered. To compare the predictions of the model with the spectral lines detected in the IRAS-LRS spectra of IRAS 10049-5657 and IRAS 10031-5632, we convolve the model predicted spectrum with IRAS-LRS instrument profile in the wavelength range 8–22 µm. However, to show the complete absorption effects of the dust component on the emergent line spectrum for the wavelength range 2.5–200 µm, the spectral lines have been convolved with Infrared Space Observatory-Short Wavelength Spectrometer (ISO-SWS) and -Long Wavelength Spectrometer (ISO-LWS) typical spectral resolutions of 1000 for 2.5 ≤ λ < 12 µm, 20000 for 12 ≤ λ < 45 µm, 8100 for 45 ≤ λ < 75 µm, and 6800 for 75 ≤ λ < 200 µm while predicting the expected emergent spectrum.

### 4.3. IRAS 10049-5657

The SED for IRAS 10049-5657 is constructed using the flux densities in the two TIFR bands, the four IRAS bands (from HIRES maps), the IRAS-LRS data, and the four MSX bands. The flux densities used in the SED are the fluxes integrated over a circular region of diameter 3’ around the peak. The total luminosity is 1 × 10^6 L\(_\odot\) for a distance of 6.3 kpc. Figure 12 (left) shows the observed SED and the predicted spectrum from the best-fit model. This best-fit model implies a uniform dust and gas density distribution with the embedded energy source as a single ZAMS star of type O5-O4 (see Table 2). The inner cloud dust radius is 0.008 pc while the outer cloud radius is 4.2 pc. The optical depth at 100 µm is 0.002. The radius of the ionized gas from the model is 2.8 pc. The observed angular sizes are explained by this model. The measured radio flux density, ~25 Jy at 843 MHz, is obtained by integrating within a circular region of 2.8 pc around the radio peak. This flux is quite high and cannot be explained by the model as the predicted radio flux from the model is 4 Jy for the gas-to-dust ratio of 100:1 by mass. The dust composition for Si:Gr is 11:89 for the DL type region of 2.8 pc around the radio peak. This flux is quite high and cannot be explained by the model as the predicted radio flux from the model is 4 Jy for the gas-to-dust ratio of 100:1 by mass. The dust composition for Si:Gr is 11:89 for the DL type region of 2.8 pc around the radio peak.

IRAS 10031-5657 is constructed using the flux densities in two TIFR bands, the four IRAS bands (from HIRES maps), the IRAS-LRS data, and the four MSX bands. The flux densities used in the SED are the fluxes integrated over a circular region of diameter 3’ around the peak. The total luminosity is 1 × 10^6 L\(_\odot\) for a distance of 6.3 kpc. Figure 12 (left) shows the observed SED and the predicted spectrum from the best-fit model. This best-fit model implies a uniform dust and gas density distribution with the embedded energy source as a single ZAMS star of type O5-O4 (see Table 2). The inner cloud dust radius is 0.008 pc while the outer cloud radius is 4.2 pc. The optical depth at 100 µm is 0.002. The radius of the ionized gas from the model is 2.8 pc. The observed angular sizes are explained by this model. The measured radio flux density, ~25 Jy at 843 MHz, is obtained by integrating within a circular region of 2.8 pc around the radio peak. This flux is quite high and cannot be explained by the model as the predicted radio flux from the model is 4 Jy for the gas-to-dust ratio of 100:1 by mass. The dust composition for Si:Gr is 11:89 for the DL type region of 2.8 pc around the radio peak.

The SED for IRAS 10049-5657 and IRAS 10031-5632 is constructed using the flux densities in two TIFR bands, the four IRAS bands (from HIRES maps), the IRAS-LRS data, and the four MSX bands. The flux densities used in the SED are the fluxes integrated over a circular region of diameter 3’ around the peak. The total luminosity is 1 × 10^6 L\(_\odot\) for a distance of 6.3 kpc. Figure 12 (left) shows the observed SED and the predicted spectrum from the best-fit model. This best-fit model implies a uniform dust and gas density distribution with the embedded energy source as a single ZAMS star of type O5-O4 (see Table 2). The inner cloud dust radius is 0.008 pc while the outer cloud radius is 4.2 pc. The optical depth at 100 µm is 0.002. The radius of the ionized gas from the model is 2.8 pc. The observed angular sizes are explained by this model. The measured radio flux density, ~25 Jy at 843 MHz, is obtained by integrating within a circular region of 2.8 pc around the radio peak. This flux is quite high and cannot be explained by the model as the predicted radio flux from the model is 4 Jy for the gas-to-dust ratio of 100:1 by mass. The dust composition for Si:Gr is 11:89 for the DL type region of 2.8 pc around the radio peak.
the predicted emergent spectrum from our radiative transfer model. See the text and Table 2 for details of model parameters. Right: emergent spectrum predicted by Dline to obtain the line emission. For IRAS 10049-5657, the “brighter” lines, [Ne ii] at 12.8 µm, [Ne iii] at 15.5 µm, [S iii] at 18.7 µm, and [Ar iii] at 21.8 µm, are detected. The luminosities of these lines as well as the ratios of line-to-continuum are listed in Table 3.

We compare the luminosities as well as the ratios of line-to-continuum of the predicted lines from the model (convolved with the IRAS-LRS instrument profile) with respect to those observed. The line-to-continuum ratios for the “LRS-convolved” model are listed in Table 3. We find that the ratios of luminosities (model/observations) for the lines [Ne ii], [Ne iii], and [S iii] agree within a factor of 4. For the [Ar iii] line, we find that the observed value is ∼13 times larger than the modeled value. However, it is to be noted that the [Ar iii] line is close to the edge of the wavelength range of the spectrometer and could have instrumental uncertainties. The lines [Ar iii] at 9.0 µm and [S iv] at 10.5 µm are barely detected although the model predicts them to be bright.

4.4. IRAS 10031-5632

The SED for IRAS 10031-5632 has been constructed using flux densities (integrated over a circular region of 3’ diameter centered on the peak) from the MSX, IRAS-HIRES as well as the TIFR maps. The IRAS-LRS spectrum has also been used in the construction of the SED. The spectrum shows a strong silicate feature. For IRAS 10031-5632, the total luminosity is 4.2 × 10^4 L☉ (d ~ 3.7 kpc). We have used a single ZAMS star of spectral type O9 as the centrally exciting source. The best-fit radiative transfer model along with the observed SED is shown in Figure 13 (left), and the parameters of the best-fit model are given in Table 2. This model implies a uniform density distribution of gas and dust. The optical depth at 100 µm (from the model) is 0.07. The ratio of silicates and graphite dust grains is estimated to be 62:38. The radio flux predicted by the model at 843 MHz is 0.07 Jy for a gas-to-dust ratio of 100 by mass, and the radius of the ionized region is 0.03 pc. This is comparable to the measured radio flux density of 0.04 Jy at 843 MHz (obtained by integrating the flux within a circular region of radius 0.03 pc centered on the radio peak). A dust mass of 24 M☉ is obtained from the model.

For IRAS 10031-5632, 17 nebular/ionic lines satisfy the detectability criterion. The luminosities of the lines as well as the ratio of luminosities of each line with respect to the continuum (for the model convolved with the LRS spectral resolution) are also listed in Table 4. Figure 13 (right) shows the emerging spectrum from the model. In addition, following the method in Section 4.3, we have searched for lines in the LRS spectrum of
IRAS 10031-5632. The [Ne II] line at 12.8 \( \mu \)m is clearly detected with a luminosity of 30 \( L_\odot \). Among the other lines in the range of LRS, we find that [Ar III] at 9.0 \( \mu \)m and [S III] at 18.7 \( \mu \)m also show detections. A comparison of the luminosities of the detected lines with the predicted values shows that the observed luminosities are much higher than the modeled ones. Table 4 also lists the ratio of line-to-continuum for these lines. A comparison of these ratios shows that the model ratios are a factor of \( \sim 100 \) lower than those observed. This can be attributed to the elevated level of the continuum from the model. A comparison of the model SED with the observed one in Figure 3 (left) shows that the radiative transfer model in the mid-infrared overestimates the observed LRS spectrum. Much larger discrepancies between the observed and predicted line emissions for IRAS 10031-5632 may be understood as follows. Our scheme for predicting the line emission utilizes the description of the cloud, which is obtained from modeling the continuum emission from the dust component distributed throughout the cloud. In contrast, emission of the specific ionic lines under discussion, viz., [S III], [Ne II], and [Ar III], are expected to originate from the innermost part of the H II region (due to high ionization potentials). In addition, the lower excitation of the central source (ZAMS O9) for this source makes these line emissions more sensitive to the precise physical details (e.g., inhomogeneities like clumpiness) in the immediate vicinity of the star. Since the emission of forbidden lines depends on the square of the local density, denser clumps in an inhomogeneous medium will show enhanced emission compared with an equivalent uniform medium. Hence, a clumpy medium around the exciting star in IRAS 10031-5632 could help explain the observed higher nebular line luminosities. This scenario is also consistent with the higher radio continuum emission observed.

5. DISCUSSION

5.1. IRAS 10049-5657

Using the FIR map of IRAS 10049-5657 (Figure 1), we see an extension of the dust emission toward the northeast. This is also seen in the 60 and 100 \( \mu \)m emission IRAS-HIRES maps of this region, as shown in Figure 3. The IRAS-HIRES mid-infrared emission from warm dust, however, shows an extension toward the west. This western extension is also clearly seen in the MSX maps. The flux densities from the TIFR maps at 150 and 210 \( \mu \)m have been used to compute the mass of dust using the formulation of Hildebrand (1983) and Sandell (2000). For a temperature of 30 K, the dust mass obtained is \( \sim 21 M_\odot \). As can be seen from Figure 5, a northeast extension also seen in the cold dust emission is also observed for the ionized gas. The total flux of 42.4 Jy at 843 MHz can be compared with the flux density of 40 Jy (beam \( \sim 14^\prime \)) at 1410 MHz (Manchester 1969).

From the CM (\( J - H \) versus \( J \)) diagram of the 2MASS sources (Figure 7 left) within the cluster radius (\( \sim 65^\prime \)), we see that there are 11 sources lying above the ZAMS curve of O9. These 11 sources are designated as IRA-1, ..., IRA-11, and a list of their positions and magnitudes is given in Table 5. However, it is important to note that the spectral types inferred from the CM diagram are the earliest possible spectral type (upper limits) when the stars have infrared excess. Sources with infrared excess can be found from the CC (\( J - H \) versus \( H - K \)) diagram. In the CC diagram (see Figure 7), eight “asterisks” lie in the band occupied by reddened ZAMS stars. One source, IRA-7 (shown as a triangle lying in the “T” region), shows an infrared excess while IRA-10 lies to the left of the reddening band of the ZAMS objects (drawn from the top of the main-sequence branch) in the CC diagram. The upper left part of the CC diagram is not an allowed region for young stellar objects (YSOs; Lada & Adams 1992). IRA-10 is faint in the \( J \)-band (16.9 \( \pm \) 0.2 mag) with larger errors although it is relatively brighter in the \( H \)- (14.2 \( \pm \) 0.02 mag) and \( K_s \)- (13.2 \( \pm \) 0.04) bands as compared with the \( J \)-band. One possibility of explaining the NIR colors of IRA-10 as well as its position in the CC diagram is that IRA-10 could comprise two or more unresolved sources. The sources lying near the unreddened main sequence in the CC diagram are possibly foreground sources not associated with the cluster. A small but significant fraction of cluster stars lies outside and to the right of the reddening band of the ZAMS stars. These are...
mostly YSOs with intrinsic color excess. Fourteen objects lie in this infrared excess zone, i.e., in the “T” and “P” regions. By dereddening the stars (on the CC diagram) that fall within the reddening vectors encompassing the main-sequence stars, we find the visual extinction ($A_V$) toward each star. The individual extinction values range from $A_V \sim 0$ to $17$ mag. From the CM diagram, we find that the extinction values of most “asterisks” lie at about $A_V \sim 15–18$ mag.

Figure 14 shows the 2MASS $K_s$-band image of the region around IRAS 10049-5647 in gray scale. The 2MASS image of this region shows diffuse emission apart from the sources (earlier than spectral type O9) clustered together. It is interesting to note the clustering of these sources close to the IRAS peak and the distribution of the other such stars in the northeast–southwest direction, which is the direction of extension of the ionized gas as well as the cold dust. The morphology of emission in the UIB as well as the emission from warm dust in MSX bands also shows extension along the southwest direction. The brightest infrared source among the selected 2MASS sources is IRA-11. IRA-7 is closest ($\sim$2.7") to the IRAS peak, is of spectral type earlier than O5, and has an infrared excess. This is consistent with the spectral type determined by Bik et al. (2005) for IRA-7 (referred to as 10049nr411 in their paper) using high-resolution $K$-band spectra. They find that it is of spectral type O3-O4. Recent multi-epoch radial velocity measurements by Apai et al. (2007) show large amplitude variations in radial velocities pointing toward IRA-7 being a massive binary system (50 and 20 $M_\odot$). Bik et al. (2005) have also carried out spectroscopy of IRA-3 (10049nr324) and find it to be of spectral type O3-O4/O5-O6. This is consistent with its ZAMS spectral type, O5-O6, obtained from the CM diagram. It is interesting to note that the “asterisk” closest to the radio peak is IRA-8. The CM diagram indicates IRA-8 to be of ZAMS spectral type O9-O6.

We have also cross-correlated the MSX PSC sources, with those from 2MASS PSC which lie within the cluster radius. There are two such MSX PSC sources, namely G282.0341-01.1810 and G282.0176-01.1793 (hereafter M1 and M2, respectively; listed in Table 6). M1 coincides (1.3") with an infrared excess source, 2MASS-J10064115-5712377 ($J \sim 16.0 \pm 0.2$, $H \sim 14.9 \pm 0.2$, $K_s \sim 13.5 \pm 0.3$). M2 coincides (2") with a source detected only in the $K_s$-band, 2MASS-J10063592-5711563 ($K_s \sim 14.1 \pm 0.2$ mag). From the 2MASS-MSX CC diagram ($F_{21}/F_8$ versus $F_8/F_{12}$; Lumsden et al. 2002, their Figure 9), we find that these sources lie in the region generally covered by compact HI regions and massive YSOs. We can, therefore, conclude that these are young stars associated with the cluster.

### 5.2. IRAS 10031-5632

The dust emission around IRAS 10031-5632 is compact (unresolved) at 150 $\mu$m, as well as at the IRAS-HIRES wave bands. IRAS 10031-5632 is also not resolved in the SUMSS radio map. However, IRAS 10031-5632 is barely resolved in the 210 $\mu$m map. Deconvolving the beam from 210 $\mu$m image gives us $\sim 0.9$″ as an estimate of its size. The total mass obtained using the flux density at 210 $\mu$m from the TIFR map is $\sim 7 M_\odot$ for a temperature of 30 K. However, from the radiative transfer modeling, we obtain a larger dust mass of 24 $M_\odot$. The total radio flux density is 1.1 Jy. Considering that the radio flux is from a single ionizing ZAMS star, we use the formulation of Schraml & Mezger (1969) and Panagia (1973) to estimate its spectral type. We find it to be of ZAMS spectral type O9-O8.5. This can be compared with the ZAMS spectral type of O9 obtained from the FIR luminosity.

Unlike the case of IRAS 10049-5657, we do not see a rich cluster with a large number of stars around IRAS 10031-5632. Rather, a small group comprising a few stars is seen close to this region. There are seven sources (labeled as IRB-1 to IRB-7) clustered close to the FIR (IRAS) peak of which two, IRB-1 and IRB-5, are detected in all three ($J$, $H$, and $K_s$) bands. The 2MASS designation and flux details of these sources are given in Table 7. From the CM diagram ($H-K$ versus $K_s$; Figure 11 left), it is observed that IRB-1 is of ZAMS spectral type earlier than O5. It is to be noted that this spectral type of IRB-1 obtained from NIR study is the earlier possible spectral type (upper limit) as it shows an infrared excess. IRB-5 is, however, of later spectral type, B3-B2. It lies among a well-defined group of stellar sources which have lower extinction values ($A_V \sim 5$ mag). From the CC diagram ($J-H$ versus $H-K$), it is found to lie near the main-sequence curve. Therefore, it is possible that IRB-5 is not associated with the cluster, but is a foreground source. The other five sources are detected in the $H$- and $K_s$- or only in $K_s$-bands. The source closest ($\sim 1.5$") to the IRAS peak, IRB-3, is detected in the $H$- (15.1 ± 0.2 mag) and $K_s$- (12.8 ± 0.1 mag) bands but not detected in the $J$-band. From the CM diagram, it is found that IRB-3 is a heavily extincted early spectral type (O9-O6) ZAMS star. It is located at the peak of 843 MHz radio emission. The other four sources, IRB-2, IRB-4, IRB-6, and IRB-7, are detected only in the $K_s$-band. This implies that these are deeply embedded objects. Thus, among

Table 5
Details of 2MASS PSC Sources Earlier than O9 Around IRAS 10049-5657

| 2MASS PSC Designation | Name* | $\alpha_{2000}$ (deg) | $\delta_{2000}$ (deg) | $J$ (mag) | $H$ (mag) | $K_s$ (mag) |
|-----------------------|-------|-----------------------|-----------------------|-----------|-----------|------------|
| J1006334-5713064 IRA-1 | 151.639294 | $-57.218468$ | $13.18 \pm 0.05$ | $11.41 \pm 0.05$ | $10.66 \pm 0.04$ |
| J10063408-5713079 IRA-2 | 151.624008 | $-57.218887$ | $13.57 \pm 0.02$ | $12.28 \pm 0.02$ | $11.79 \pm 0.02$ |
| J10063696-5712372 IRA-3 | 151.654013 | $-57.210342$ | $14.46 \pm 0.03$ | $12.72 \pm 0.03$ | $11.84 \pm 0.02$ |
| J10063849-5712827 IRA-4 | 151.660405 | $-57.207985$ | $14.57 \pm 0.08$ | $12.90 \pm 0.12$ | $11.92 \pm 0.06$ |
| J10063875-5712243 IRA-5 | 151.661484 | $-57.207676$ | $14.56 \pm 0.09$ | $12.75 \pm 0.12$ | $11.80 \pm 0.10$ |
| J10063940-5712198 IRA-6 | 151.661490 | $-57.205513$ | $13.79 \pm 0.03$ | $11.97 \pm 0.05$ | $10.95 \pm 0.04$ |
| J10063949-5712299 IRA-7 | 151.665464 | $-57.208324$ | $12.89 \pm 0.04$ | $11.44 \pm 0.06$ | $10.36 \pm 0.04$ |
| J10064088-5712327 IRA-8 | 151.670346 | $-57.209087$ | $14.97 \pm 0.09$ | $13.20 \pm 0.08$ | $12.13 \pm 0.10$ |
| J10064153-5712003 IRA-9 | 151.673054 | $-57.200969$ | $14.77 \pm 0.03$ | $12.90 \pm 0.03$ | $11.89 \pm 0.04$ |
| J10064211-5712041 IRA-10 | 151.675482 | $-57.201160$ | $16.88 \pm 0.18$ | $14.21 \pm 0.02$ | $13.17 \pm 0.04$ |
| J10064217-5712231 IRA-11 | 151.675725 | $-57.206444$ | $11.33 \pm 0.02$ | $9.96 \pm 0.03$ | $9.38 \pm 0.03$ |

Note. * Short name used in the present work.
the small number of cluster members, the majority of them are deeply embedded, indicating that the star formation here is in an early stage. The 2MASS image of the region around IRAS 10031-5632 is shown in Figure 15. The sources lying above the ZAMS curve of spectral type O9 are shown as asterisk symbols while the “asterisk” having an infrared excess is shown as a solid triangle. The open squares represent sources detected either in the $H$- and $K_s$-bands or only in the $K_s$-band. The other sources are represented with plus symbols. The seven sources discussed above are labeled as “IRB” in the figure. It
is interesting to note the presence of young objects (detected in the $H$- and $K_s$-bands) clustered near the IRAS peak. In the IRAS 10031-5632 region, we find that there is 1 MSX PSC source within 1′ radius centered on the IRAS peak, G281.5857-00.9706 (designated as M3 and listed in Table 6). M3 could possibly be associated with either IRB-3 (~2.8′) or IRB-2 (~2.8′). In both the cases, we obtain the 2MASS-MSX colors ($F_{21}/F_8$ and $F_8/F_{K}$; Lumsden et al. 2002) and observe that M3 lies in the general region covered by compact H ii regions.

6. SUMMARY

The massive star-forming regions associated with IRAS 10049-5657 and IRAS 10031-5632 have been studied using the infrared (near, mid, and far) wave bands. The dust and gas environments as well as the stellar sources have been probed using data from the TIFR balloon-borne telescope, MSX, SUMSS, and 2MASS. The spatial distributions of FIR emission from cold dust at 150 and 210 μm have been obtained along with maps of optical depth ($\tau_{200}$) and color temperature, $T(150/210)$. Using MSX data, the emission from warm dust and UIBs in the IRAS 10049-5657 region has been studied. The IRAS 10049-5657 region shows the presence of a rich cluster of OB stars which gives rise to a strong radio continuum (~42 Jy at 843 MHz). The cluster radius is estimated to be ~26′, and within the cluster radius there are 11 2MASS sources lying above the ZAMS curve of spectral type O9 from the 2MASS CM diagram. Self-consistent radiative transfer modeling constrained by observations has been carried out for both the sources. The geometric details of the clouds, the dust composition, and optical depths, etc. have been obtained from the best-fit models. We have also carried out modeling of line emission from IRAS 10049-5657 and IRAS 10031-5632 using a scheme based on CLOUDY. The predictions of the model for emission in the ionic lines are closer to LRS detections for IRAS 10049-5657 than for IRAS 10031-5632. We speculate that for IRAS 10031-5632 some of the basic assumptions of the modeling scheme are not valid.

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