IRDCs to Star Clusters: In Depth Study of the Structure, Evolution and Kinematics of Few Southern Massive Star Forming Regions

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by

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Abstract

The formation and the evolution of massive stars (M$\geq$ 8 M$_{\odot}$) are found to dominate the fate of their parental clouds and the host galaxies. This is primarily due to the enhanced feedback mechanisms from these stars that alter the environments on local, global and cosmic scales. The radiative feedback from massive stars causes the ionisation of neutral gas whereas the mechanical feedback effects such as supernovae explosions impart mechanical energy into the ambient interstellar medium (ISM), and can even vent energy into the galactic halo. The nucleosynthesis processes in massive stars and their core collapse supernovae play a crucial role in the chemical enrichment of the ISM that drive the chemical evolution in galaxies. While theoretical formulations have been proposed to explain their formation, observational studies of the early phases remain limited. Most of these observational works are designed to examine the large scale properties of a sample of massive star forming regions. While there are studies that focuses on individual regions, majority of them probe the northern Galactic sky.

In this context, we have carried out a multiwavelength study towards a selected number of massive star forming regions in the southern Galactic sky that are in different evolutionary stages. Our intention is to examine the properties and initial conditions related to the formation of massive stars across different evolutionary phases. We investigate the structure and kinematics of these star forming regions that gives a better insight into the complex interaction mechanisms between massive stars and their parental clouds. In this study, we have considered three star forming regions: a filamentary IRDC (G333.73+0.37) and two H II regions (IRAS 17256–361 and IRAS 17258–3637). In addition to these, we have also probed the star forming complex associated with IRAS 17256–3631 and IRAS 17258–3637, to investigate the large scale environment of massive stars.

We have conducted our observational study at infrared, submillimeter and radio wavelengths. Radio observations serve as a powerful tool to discern regions associated with newly formed massive stars as well as to identify the nature of the ionising sources. Far-infared and millimeter continuum data traces the emission from the cold and dense regions of molecular clouds that often appear as dark extinction features in the optical

images. Near and mid-infrared data on the other hand, are useful in examining the warm dust emission and young stellar objects (YSOs) in these regions. Spectral line data such as radio recombination lines and molecular lines are excellent for probing the complex kinematics of the ionised gas and molecular cloud.

The star formation activity in G333.73+0.37 and IRAS 17256–3631 has been scrutinized using a diverse range of tracers such as the presence of H II regions, infrared YSOs, maser spots etc. We find these regions to be in a star formation flurry. The molecular clouds associated with the regions are massive (M $\sim 10^4$ $M_\odot$). The typical dust temperatures and column densities are $15 - 35$ K and $\sim 10^{22}$ cm^{-2}, respectively. Molecular line studies reveal signatures of infall and/or outflow activity in both the clouds, consistent with results obtained from continuum analysis. We also detect an embedded infrared cluster in IRAS 17256–3631.

We have also used low frequency radio recombination lines (H172α and C172α) and molecular line data in an attempt to sample the velocity structure of the H II regions IRAS 17256–3631 and IRAS 17258–3637. We have successfully mapped the H172α RRL emission across these H II regions and we find velocity gradients in the ionised gas. Our findings suggest that the observed morphologies are governed by strong density gradients prevailing in the molecular clouds. We also observe signatures of pressure and dynamical broadening in the line widths of H172α RRLs. This is the first ever RRL mapping study of H II regions at low frequency bands.

Using low radio frequency wide band observations, we have detected large scale diffuse emission towards the star forming complex associated with the H II region IRAS 17256–3631 and IRAS 17258–3637. The emission has a shell-like morphology. Using radio spectral index analysis and complementary archival data, we identify this feature to be a previously unknown supernova remnant candidate SNR G351.7–1.2. The findings emphasize on the importance of low frequency observations in segregating the emission from SNRs that are associated with H II regions and molecular clouds.