Summary of the thesis work of Manash Ranjan Samal

Massive stars play a dominant role in galaxy formation and evolution. In spite of the fact that they are both rare and short-living, they represent the major source of radiation energy in their stellar clusters. However, their formation and early evolution, and how they process local gas to induce new generation star formation is far from being clear. In his thesis Manash has tried to answer these essential and fundamental questions. He has published all his thesis work in the Astrophysical Journal as one of the leading authors (Samal et al., 2007, ApJ, 671, 555; Samal et al., 2010, ApJ, 714, 1015; Ojha, Samal, et al., 2011, ApJ, 738, 156; Samal et al., 2012, ApJ, 755, 20).

The formation of massive stars and their importance on star formation are still a process with many unknowns. A comprehensive theory of massive star formation is one of the major unsolved problems of astrophysics where several different explanations are possible. In his thesis Manash looked at these aspects based on observational perspectives. He utilized radio continuum imaging at low frequency bands using GMRT to see the ionized gas content from the massive stars and used optical (using 1m ST, 2m HCT and 2m IUCAA facilities), deep NIR (using 1.4m IRSF and 2m UH facilities) and *Spitzer* observations to identify and characterize the evolved massive OB stars and young protostars with disks/envelopes of the studied star-forming complexes. Whenever necessary he also implemented HIRES processed far-IR observations to study the cold component of dust. Combining multiwavelength observations he finally tried to interpret the effect of massive stars on the star formation process of the studied complexes. Among several other results, I summarize below few important results from his work:

– One of the main problems in massive star formation theory is how to overcome the radiation pressure to build a massive star. Using radio continuum observations in his work Manash identified dozens of UCHII regions (an early phase of massive stars) and then studied the evolution of embedded massive stars within these UCHII regions by applying sophisticated 2-D radiative transfer modeling to the observed SEDs. He showed that the observed SEDs can be well produced by an accretion model involving star, disk and envelope similar to low mass stars, but with a high accretion rate of $> 10^{-3}\ M_{\odot}/\mathrm{yr}$. He therefore showed that the high accretion rate is indeed necessary to suppress the radiation pressure.

– One of the questions often discussed in high mass star formation research is whether high and low mass stars form simultaneously, or whether the massive stars form first or last during the early cluster evolution. Of all the embedded clusters presented in his work, the cluster "S255-IR" is particularly rare and special, where Manash showed that though the cluster has produced many stars down to $0.1\ M_{\odot}$, but massive stars are indeed younger than low mass stars, suggesting that massive stars in this cluster have formed last, which was later confirmed by Zinchenko et al. (2012, ApJ, 755, 177) with molecular line observations. Manash is also one of the co-authors in this paper.

– In his thesis Manash discussed how radiation pressure can be effective to induce next generation star formation at the borders of HII regions. Triggered star formation in our Galaxy has always been discussed by two major processes such as "collect-and-collapse" and "radiative-driven-implosion." His thesis work shows that these are not the only processes responsible for triggered star formation in our Galaxy; the star formation can also be triggered at the waist of a bipolar HII region if the HII region formed in a filamentary cloud. Similarly, he showed and discussed that the collision between the dense swept-up neutral materials sandwiched between two adjacent expanding HII regions is also an effective way to produce second generation massive stars or clusters.