Synopsis

This thesis describes the results of HI 21cm-line and radio continuum studies of the Eridanus group of galaxies using ~ 200 hours of observations with the Giant Meter-wave Radio Telescope (GMRT).

In the hierarchical Universe, rich clusters with a few hundred to a few thousand of galaxies are formed via mergers of small groups. One of the differences between groups and clusters is their morphological mix. Clusters population is mostly the "featureless" ellipticals and lenticulars (S0's) while groups are generally populated with the "spectacular" spiral galaxies. Spirals are rich in gas and are forming stars at the current epoch, but, ellipticals and S0's are left with a little gas, and, are evolving passively. Studies in early 80's indicated that the fraction of early type (E+S0's) galaxies increases with increasing galaxy density spanning five orders of magnitudes. Studies on clusters at intermediate redshifts indicate that the S0's are most likely evolved spirals which could have lost their gas via interactions with the Intra-cluster medium. Several of the spirals in clusters are found to be HI deficient as compared to those in the field. The gas removal mechanisms, viz., ram-pressure and transport processes effective inside the hot ($10^8$ K) and dense ($10^{-2} - 10^{-3}$ cm$^{-3}$) cluster environment are able to explain some but not all of the observed HI deficiency in cluster spirals. It is realized that there could be other processes causing HI deficiency, but, the details are unclear.

The galaxy groups have a not so hot and not so dense environment for ram-pressure stripping and transport processes to be effective. The velocity dispersions in groups are also a factor of 3-4 lower than that in clusters, making ram-pressure further ineffective by at least an order of magnitude. Then, a group like Eridanus which has ~ 50 ellipticals and S0's as compared to a total of ~ 180 galaxies in the ~ 10 Mpc region raises questions on the origin of the ellipticals and the S0's in it. The Eridanus group has significant sub-clustering in the inner ~ 4 Mpc region. The Eridanus group is perhaps in earlier stages of a cluster formation where the small groups are merging together and more galaxies from the outer regions are being accreted. Our observations of HI in the Eridanus group revealed that the spiral galaxies in the inner 4 Mpc region are globally HI deficient by a factor of 3 - 5. The HI surface densities estimated over the optical
disk diameters of these galaxies are lower by a factor of $\sim 1.5$ compared to the field spirals. This was a hitherto unknown result in large groups like Eridanus. The detailed H\textsc{i} morphologies of the gas deficient galaxies in Eridanus indicate that tidal interactions between galaxies is most likely responsible for the H\textsc{i} deficiency. The H\textsc{i} images show gas in short filaments and wisps extending to galaxy halos. Several of the Eridanus galaxies also show H\textsc{i} and kinematical lopsidedness. Although qualitatively all such features can be understood by tidal interactions, quantitatively it still remains to be shown that galaxies can loose large amount of H\textsc{i} over their life-times via tidal interactions. The immediate conclusion is that in the hierarchical Universe, a good fraction of the H\textsc{i} deficiency in cluster galaxies could be of a pre-merger origin.

The near-infrared properties of disk galaxies in the Eridanus group suggest that the inclination corrected disk central surface brightnesses of galaxies have a scaling relationship with the disk scale lengths. The results hint that the high surface brightness galaxies (HSBs) and the low surface brightness galaxies (LSBs) occupy two distinct regions in their central surface brightnesses with a difference of $\sim 2$ mag at any given disk scale length. This result, if correct, can be an important input for theories of galaxy formation.

In this thesis, studies are also carried out on the Tully-Fisher (TF) relations in the Eridanus galaxies. The slopes of the TF relations in the Eridanus galaxies are $-8.4 \pm 0.8$ in the B-band, $-10.1 \pm 0.9$ in the R-band, and $-13.9 \pm 0.7$ in the K-band for a normal galaxy sample with flat HI rotation curves. These slopes are considerably different than those found in similar studies, e.g., in Ursa-Major galaxies the TF slopes are $-7.0 \pm 0.4$ in the B-band, $-8.1 \pm 0.4$ in the R-band, and $-10.1 \pm 0.5$ in the K-band. The TF relations in the Eridanus galaxies are found to have larger scatter ($\sigma \sim 0.5$) compared to other groups and clusters ($\sigma \sim 0.3$). The large TF scatter in the Eridanus group is seen both in the optical and in the near-infrared. This perhaps indicates that galaxies in the Eridanus group are not at similar distances. This conjecture is consistent with the notion that Eridanus is a loose group where galaxies/sub-groups are being accreted. The baryonic TF relations are constructed using the stellar and gas mass in galaxies. The baryonic TF relations have more or less identical slopes in all the wave-bands, implying that the nature of the TF relation is baryonic. The mean slope of the baryonic TF relation is $4.3 \pm 0.5$.

The radio -far infrared (FIR) correlation is also constructed for the Eridanus galaxies. The galaxies in the Eridanus group in general follow the same radio-FIR correlation as seen in the other field galaxies. Two galaxies, \textit{viz.}, NGC 1407 (E), the brightest galaxy in the group and NGC 1371 (S0/a) have significant radio-excess compared to the mean radio-FIR correlation in normal galaxies. NGC 1371 has five times radio-
excess and NGC 1407 has more than 70 times radio-excess. The GMRT 1.4 GHz radio continuum morphologies of these two galaxies revealed for the first time a low radio luminosity ($\log L_{1.4\,\text{GHz}} \sim 21 - 22\,\text{W}\,\text{Hz}^{-1}$) active galactic nucleus (AGN) with kpc-scale radio structures in both the galaxies. Two galaxies, viz., NGC 1377 (S0) and IC 1953 (SBC) are radio-deficient by factors of 40 and 4 respectively. These galaxies could be in their recent (a few Myr) phase of star-burst so that massive stars have heated the surrounding dust, but, have not undergone supernova explosions. There is a hint that galaxies in the inner 4 Mpc, high galaxy density regions, of the Eridanus group may have high occurrence of nuclear radio continuum emission. It could be due to a flow of gas toward their centres triggered during tidal interactions. The Eridanus group lacks in the powerful radio galaxies ($\log L_{1.4\,\text{GHz}} > 23\,\text{W}\,\text{Hz}^{-1}$) as seen in some clusters.

At the end of the thesis, three published research papers are presented. These three publications, based on the radio observations from the GMRT and the VLA, have no direct relevance to the main theme of the thesis. The first one is on the electron temperatures of some Galactic H II regions. It presents high resolution multi-frequency GMRT radio continuum images of three H II regions. The other two papers discuss H I and 18cm-OH lines from the two AGNs, viz., NGC 1052 and Mrk 1.