CHAPTER 5

Discussion and Conclusions

This research was conducted to investigate the eleven sample galaxies in the galaxy group NGC 4213. The observation images was implemented by using broad-band filters (B, V and R_C) and narrow-band filters ([S II] and Red-continuum), connected to the 2.4-m Thai National Telescope. The important physical properties ; magnitudes, colors, morphological types, semi-major axes, ellipticity and position angles were determined to understand the nature of the sample galaxies. The $H\alpha$ + [N II] equivalent widths were calculated to ascertain the young massive star formation activities by equation of Gavazzi et al. (2006) and Kriwattanawong et al. (2011). After that, we use the [N II] correction ratio (Lee et al., 2009) to improve the $H\alpha$ + [N II] flux counts in order to compute the star formation rates (James et al., 2004) in the sample galaxies. Furthermore, the galaxy masses and the mass of the NGC 4213 Group were estimated by using method of Girardi et al. (2002) and Phillipps (2005), respectively, to analyze the tidal interaction occurring within the galaxy group in term of the perturbation parameters. This analysis lead to comprehend the evolution of the galaxies.

5.1 Discussion and Conclusions

There are many main points discussed in this research. Firstly, this study researches property of $B-V$ color among the galaxy types. The Hubble and de Vaucouleurs systems were used to classify the sample galaxies into two main types; early-type and late-type. It was found that the late-type galaxies tend to be bluer than early-type galaxies, because these galaxies consist of relatively high proportion of blue stars. Typically, blue stars are massive stars with high surface temperature, that are formed not long ago. This is consistent with a lot of gas found in the late-type galaxies, particularly in the galactic disks (Pohlen et al., 2010; Boselli et al., 2002). This is the main raw material for star formation.

When these late-type galaxies move closely together or fall into a group or cluster, gravitational potential of the galaxies will tidally interact to each other or interact to the entire group or cluster (Boselli and Gavazzi, 2006; Moss, 2006), resulting in a star formation more than early-type, which are redder gas-poor galaxies. On the other hand, Koopmann and Kenney (2004) proposed that intracluster medium-interstellar medium (ICM-ISM) stripping and the tidal interaction of the Virgo spiral galaxies are the major mechanisms affecting in the decreased star formation rates. Moreover, minor mergers or recent tidal interactions have also influenced their morphologies.

Secondly, the study of relation between the $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$ and $B - V$ color found that the less $B - V$ galaxies which is bluer compared with more $B - V$ color galaxies tend to have clearly higher $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$. The H$\alpha$ emission is a result of the massive star formation triggered by the interaction between galaxy-galaxy and tidal interaction occurring within the galaxy groups (Boselli and Gavazzi, 2006; Henriksen and Byrd, 1996). Electrons of hydrogen atoms around the young massive stars were excited by ultraviolet emitted from the young massive stars and transit from the ground state to the second exited state (n = 3). After that they fall back into the first excited state (n = 2) and release the energy as the Hα that is the one of visible wavelength of Balmer series lines. Thus, the measurement of $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$ could be a good indicator for star formation regions occurring within galaxies (Fossati et al., 2013; Kennicutt, 1998).

Thirdly, the relation between the $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$ with the morphological T-types and the $EW(\mathrm{H}\alpha)$ with the SFR showed that late-type galaxies tend to have higher $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$ than early-type. Moreover, SFR also increased with increasing $EW(\mathrm{H}\alpha)$. It was implied that star formation in late-type galaxies taking place more than the early-type galaxies that is consistent with the bluer galaxies were late-type with higher $EW(\mathrm{H}\alpha)$ and higher SFR. The distribution of the $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$ among galaxies of the Hubble types in figure 4.6 shows that the evolution of the galaxies tend to correlate with star formation. Furthermore, there was an appearance of the dispersion of the $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$ in the same Hubble type. Kennicutt and Kent (1983) showed that the difference in $EW(\mathrm{H}\alpha + [\mathrm{N\,II}])$ for the same type of galaxy may be due to several factors such as instrumental uncertainties, including the uncertainty caused by magnitude measurement, the nuclear emission from H II regions in the disk and bulge of the galaxies, extinction by interstellar dust within a galaxy that may absorb the Hα line. These factors can affect significantly to the $EW(\text{H}\alpha + [\text{N II}])$ measurement for the low star formation galaxies (early-type). But for the high star formation galaxies (late-type), the important factor that contributes to the dispersion of the $EW(\text{H}\alpha + [\text{N II}])$ in the same type is the variations in star formation rate in each galaxy (Kennicutt and Kent, 1983).

Consequently, the normalized SFR was estimated. Since the $nSFR$ is very high significant directly proportion with $EW(\text{H}\alpha)$(see figure 4.13). Therefore, the $EW(\text{H}\alpha)$ may be well used to demonstrate the quantitative star formation activities in the galaxy members of the galaxy groups, that consistent with, e.g. Fossati et al. (2013), Kennicutt (1983), Gavazzi et al. (2002) and Thomas et al. (2008).

Finally, we investigated the environmental factors affecting the star formation and the evolution of the sample galaxies. We focused on the tidal interactions between galaxy-galaxy and galaxy-group because NGC 4213 Group is quite compact and the sample galaxies are neighboring location. Since Boselli and Gavazzi (2006) and Byrd and Valtonen (1990) provided the perturbation parameters to explain the efficiency of the tidal interactions. For galaxy-galaxy interactions, it was found that there are only 3 values show the relatively efficient perturbation, while other values are too small and out of critical range (see table 4.2). Boselli and Gavazzi (2006) clarified that, the tidal interaction among the cluster galaxies will be happened in a short timescale, even though it occur frequently. Hence the perturbation effects are not very severe. Meanwhile, the galaxy-group interactions give more efficient effect than galaxy-galaxy interactions. From the critical range of the perturbation parameter, 8 sample galaxies may be significantly disturbed and stimulated the star formation including morphological transformation simultaneously (Boselli and Gavazzi, 2006). Fujita (1998) showed that the molecular cloud from the disk can be accelerated by the tidal force of the cluster potential well during falls into the cluster center. The increasing of kinetic pressure in the interstellar medium can be consumed rapidly by a process of galaxy-group or galaxy-cluster to form young massive stars (Boselli and Gavazzi, 2006).

5.2 Further Work

For this research, we undergone many restrictions due to the Thai National Telescope and filter pass band limitation, in order to observe the fainter and larger redshift than this sample galaxies. Otherwise we cannot observe the sample galaxies in some wavebands. Thus our results of the research should be improved by these further work as follow:

1) The precision of the results may be improved by collection of the other 15 galaxy members of NGC 4213 Group from available optical images and spectral lines of SDSS database to analyze with our sample galaxies that observed from TNO.

2) The metallicities of the sample galaxies could be estimated to confirm the evolution of the galaxies.

3) The star formation activities in the sample galaxies can be cross-checked by using other methods such as far-infrared luminosity, radio luminosity or direct ultraviolet from massive stars.