# A study of star formation by H$\alpha$ emission of galaxies in the galaxy group NGC 4213

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**Abstract.** This research aims to study hydrogen alpha emission, corresponding to star formation of galaxies in the NGC 4213 group that has an average recession velocity of 6,821 km/s. The imaging observations with broad-band filters (B, V and $R_C$) and narrow-band filters ([S II] and Red-continuum) were carried out from the 2.4-m reflecting telescope at Thai National Observatory (TNO). There are 11 sample galaxies in this study, consisting of 2 elliptical, 2 lenticular and 7 spiral galaxies. It was found that the late-type galaxies tend to be bluer than early-type galaxies, due to these galaxies consist of relatively high proportion of blue stars. Furthermore, the equivalent width of hydrogen alpha ($EW(H\alpha)$) tends to increase as a function of morphological type. This indicates that star formation in late-type galaxies taking place more than the early-type galaxies. Furthermore, a ratio of the star formation rate to galaxy mass also increases slightly with the galaxy type. This could be due to the interaction between galaxy-galaxy or tidal interaction occurring within the galaxy group.

## 1. Introduction

Star formation in galaxies of low redshift galaxy groups and clusters have been extensively studied [1]. The $EW(H\alpha)$ was used as an effective probe of star formation region. The H$\alpha$ emission is a result of the interaction between galaxy-galaxy and tidal interaction occurring within the galaxy groups as the trigger for the massive star formation [2]. Thus, the measurement of the $EW(H\alpha)$ could be a good indicator for star formation regions occurring within galaxies. In addition, colors of galaxies also have correlated with the $EW(H\alpha)$ [3] and leading to explain the evolution of galaxy and star formation. The NGC 4213 Group was chosen to study because its redshift is appropriate to the limit of the observing instruments which is connected to the 2.4-m telescope at TNO, i.e. bandwidth of filters. Furthermore, the surface brightness of the sample galaxies must be enough to detect by the telescope with the CCD.

## 2. Methodology

### *2.1. Observations*

The sample galaxies were contained in galaxy group NGC 4213, centered at the position of R.A. 12h 15m, Dec. $23^\circ 57'$ that located in Coma Berenices constellation. This galaxy group has an average recessional velocity of about 6,821 $\mathrm{km\,s^{-1}}$ ($z \approx 0.02$) with average distance is about 100 Mpc. The imaging observations with broad-band filters (B, V and $R_C$) and narrow-band filters ([S II] and Red-continuum) were implemented from 2.4-m reflecting telescope at Thai National Observatory (TNO). The camera which is used to collect the light of sample galaxies is Apogee

U42 CCD. Its array size is 2048×2048 pixels and pixel size is 13.5×13.5 microns. The field of view of the CCD when connected to the 2.4-m focal length telescope is $4' \times 4'$ approximately.

**Table 1.** Data observations at Thai National Observatory.

| Filters | $\lambda$ (nm) | Exposure Times (s) |
|---|---|---|
| B | 445 | 900 |
| V | 551 | 600 |
| $R_C$ | 658 | 300 |
| Red-continuum | 645 | 900 |
| [S II] | 672 | 900 |

The observations were done on 22 March 2014. The exposure time for each filter was shown in Table 1. Many archive data; coordinates, velocities and redshifts, were accumulated from NASA/IPAC Extragalactic Database (NED) (url: ned.ipac.caltech.edu). The [S II] filter was applied to cover H$\alpha$ with neighboring line, [N II]. Because of the galaxy group has the low redshift (z $\approx$ 0.02), as a result, the centered wavelength of H$\alpha$ shift into [S II] transmission regions. The galaxies continuum subtraction was operated by using observed through a narrow-band Red-continuum filter.

### *2.2. Morphological type of sample galaxies*

Morphological type of the sample in this study was classified into Hubble system and de Vaucouleurs T-type. The dwarf elliptical galaxies were classified as dE and identified as an extra T-type -7. The morphological type will be used to analyze for dependence between star formation and galaxy evolution.

### *2.3. Calculation of galaxy magnitudes and color indices*

The zero point of B band images, was calibrated by using magnitudes of reference stars. Then, the zero point was used to estimate the $B_{25}$ isophotes of galaxies with the ESP package of Starlink software (url: starlink.eao.hawaii.edu). The $B_{25}$ isophotes of all sample galaxies were applied to determine the magnitudes for the galaxies in B, V and $R_C$, and flux counts for [S II] and Red-continuum filter bands. After that, we obtained absolute magnitudes from distance modulus and calculated the color indices $(B - V)$.

### *2.4. Calculation of* H$\alpha$ + [N II] *equivalent width*

The H$\alpha$ + [N II] equivalent width (EW(H$\alpha$ + [N II])) is an indicator that will be used to study the star formation in the galaxy. EW(H$\alpha$ + [N II]) was calculated by using equation 1 [1, 4].

$$EW(H\alpha + [N\,II]) = \frac{\int T_n(\lambda) d\lambda}{T_n(6563(1+z))} \times \frac{C_{H_\alpha+[N\,II]}}{C_c} \tag{1}$$

where $T_n(\lambda)$ is the transmissivity of the [S II] filter, $z$ is the redshift of galaxy, $C_{H\alpha+[N\,II]}$ is the H$\alpha$ + [N II] flux counts, and $C_C$ is the continuum flux counts from Red-continuum filter.

### *2.5. Calculation of star formation rates (SFR)*

Unfortunately, the measured H$\alpha$ luminosity flux counts are typically contaminated with [N II] line counts. The [N II] lines are located two sides of the H$\alpha$ line ($\lambda$ 6563 Å) , at 6548 Å and 6584 Å. The bandwidth of the narrow-band [S II] filter is 30 Å approximately. When we used [S II] filter to detect H$\alpha$ emission line of the low redshift galaxies, the [N II] lines were included in the measured flux counts. So the [N II] components of the observed flux are needed to be removed before $SFR$ can be calculated [5, 6]. The $SFR$ is estimated from [N II] corrected H$\alpha$ luminosities using the same equation as James et al. (2005) [6]:

$$SFR(M_{\odot}yr^{-1}) = 7.94 \times 10^{-35} L_{H\alpha}(W) \tag{2}$$

here $SFR$ is in unit of $M_{\odot}yr^{-1}$ and H$\alpha$ luminosities are in unit of Watt.

## 3. Results

There are 11 sample galaxies in this study, consisting of 2 elliptical, 2 lenticular and 7 spiral galaxies, The figure 1 shows that the late-type galaxies tend to be bluer than early-type galaxies, this may be due to these galaxies consist of relatively high proportion of blue stars.

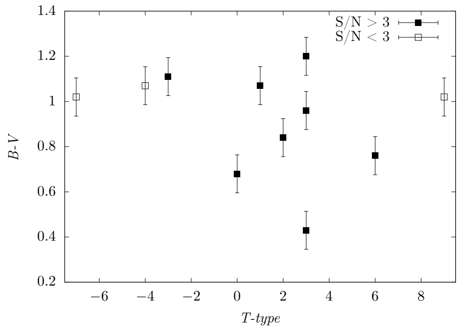


**Figure 1.** The $B - V$ color versus T-type diagram.

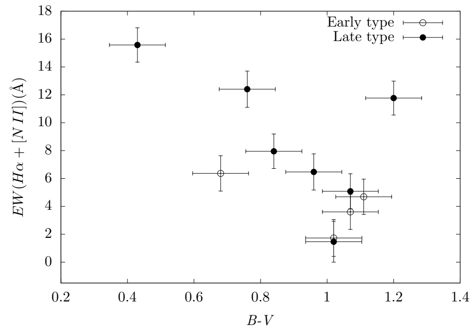


**Figure 2.** The diagram of H$\alpha$ + [N II] equivalent width against color indices.

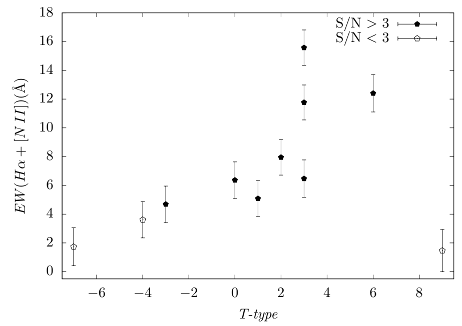


**Figure 3.** Distribution of H$\alpha$ + [N II] equivalent width as a function of T-types.

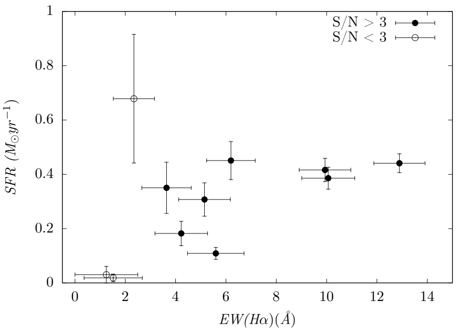


**Figure 4.** Distribution of star formation rate versus H$\alpha$ equivalent width.

From figure 2, it was found that the bluer galaxies, the galaxies having less color index, tend to have higher EW(H$\alpha$ + [N II]). As mentioned in the introduction, the $EW(H\alpha)$ could be the indicator for star formation regions occurring within galaxies. So the bluer galaxies tend to have more star formation activities than the redder galaxies. Furthermore, figure 3 is clearly seen that the EW(H$\alpha$ + [N II]) tends to increase as a function of morphological types; the EW(H$\alpha$ + [N II]) of late-type galaxies are much higher than early-types. This indicates that star formation in late-type galaxies taking place more than the early-type galaxies. Figure 4 displays the correlation between $SFR$ and $EW(H\alpha)$. This study found that the $SFR$ tends to increase with increasing $EW(H\alpha)$ that is consistent with Koopmann et al. (2001) [7].

## 4. Discussion and Conclusions

There are many main points that discussed in this paper. Initially, we research the relation between the $EW(H\alpha + [N\,II])$ and color $B - V$. It was found that the less color $B - V$ galaxies in galaxy group which is bluer compared with more color $B-V$ galaxies tend to have clearly higher $EW(H\alpha{+}[N\,II])$ which ensured from the confidence level equal to 90%. The H$\alpha$ emission is a result of the interaction between galaxy-galaxy and tidal interaction occurring within the galaxy groups as the trigger for the massive star formation [2]. Electrons of hydrogen atoms around the young massive stars were excited by ultraviolet emitted from the 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 hydrogen alpha that is the one of visible wavelength of Balmer series lines. Thus, the measurement of $EW(H\alpha+[N\,II])$ could be a good indicator for star formation regions occurring within galaxies [8, 9].

The $B-V$ color was studied among the morphological T-types, corresponding to the evolution of the galaxy sample. 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 with the 50% confidence level, because these galaxies consist of relatively high proportion of blue stars. Typically, blue stars are very 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 [10, 11], which is the main raw material for star formation. When these bluer late-type galaxies move closely together or fall into a group or cluster, gravitational potential of the galaxies can tidally interact to each other or interact to the entire group or cluster [2], resulting in a star formation more than gas-poor redder early-type galaxies.

The relation between the $EW(H\alpha)$ with the morphological T-types and $SFR$ showed that late-type galaxies tend to have higher $EW(H\alpha)$ than early-type. Moreover, $SFR$ also increased with increasing $EW(H\alpha)$. 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 $EW(H\alpha)$ and higher $SFR$. These parameters significantly correlate to each other with 75% confidence level.

From the previous discussion, the distribution of the $EW(H\alpha+[N\,II])$ among the same type galaxies lead to explain the evolution and tend to be correlated with star formation. It was also found that there was existence of the dispersion of the $EW(H\alpha+[N\,II])$ in the same Hubble type. Kennicutt and Kent (1983) [3] showed that the difference in $EW(H\alpha+[N\,II])$ for the same type of high star-forming galaxies (late-type) may be due to the variations in $SFR$ in each galaxy [3].

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