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# STAR FORMATION ACTIVITY OF GALAXIES IN A NEARBY COMPACT GROUP: THE NGC 4095 GROUP

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## ABSTRACT

This work aims to study the evolution of galaxies, located in the dense environment of the NGC 4095 compact group, which have recession velocities 6,000 $< v$ (km s$^{-1}$) $<$ 8,000. Imaging observations for $BVR_{\rm c}$ broad-band, and [S II] and red-continuum narrow-band were carried out with the 2.4 m Thai National Telescope (TNT) at Doi Inthanon, Chiang Mai, Thailand. The sample contains 13 galaxies, consisting of 8 spirals, 4 ellipticals and 1 irregular morphological type. Late type galaxies tend to be bluer than early type galaxies. The results show that most of the late type galaxies have ongoing star formation activity, which could be triggered by galaxy-galaxy or tidal interactions, and that young massive stars in these galaxies cause their colors to be bluer than the early type galaxies.

*Key words:* galaxies: star formation – galaxies: groups: individual (NGC 4095)

## 1. INTRODUCTION

Dense material could trigger star formation in galaxies, as it falls into clusters or compact groups. Evidence of disturbance is frequently found in rich clusters (Bretherton et al., 2013).

The galaxies in the sample are in a compact group located around NGC 4095, hereafter called the NGC 4095 group. The recession velocities of the target galaxies are in the range of about 6,000 – 8,000 km s$^{-1}$. This work aims to study physical properties and star formation activity represented by the equivalent width of the H$\alpha$ emission line for galaxy members in this group.

## 2. METHODS OF THE STUDY

### 2.1. Observations

Imaging data were obtained using the 2.4 m Thai National Telescope (TNT) at Doi Inthanon, Chiang Mai. The observations were taken during 25 - 27 February and 9 - 11 March 2014, using $BVR_{\rm c}$ broad-band, and [S II] and red-continuum narrow-band filters. The redshifts of target galaxies were collected from the NASA/IPAC Extragalactic Database (NED).

### 2.2. Morphological Types of the Sample Galaxies

The sample galaxies were classified follow the de Vaucouleurs' T-type system. An additional type, "11" was defined for spiral galaxies which are edge-on and do not clearly show structure. Furthermore, "pec" was used to mark peculiar galaxies.

### 2.3. Calculations of B and R Magnitudes and Color Indices

First, we used the Starlink package to calibrate the zero point and determine $B_{25}$ isophotes for each sample galaxy. Next, we measured $B$, $V$ and $R$ magnitudes, and [S II] and red-continuum flux counts. Finally, we calculated the absolute magnitudes and color indices.

### 2.4. Calculation of Hα Equivalent Width

The H$\alpha$ equivalent width, $EW$(H$\alpha$), is calculated by using the following equation (e.g., Gavazzi et al., 2006; Kriwattanawong et al., 2011):

$$EW(\mathrm{H}\alpha) = \frac{\int T_{\rm n}(\lambda)\mathrm{d}\lambda}{T_{\rm n}(6563(1+z))}\frac{C_{\mathrm{H}\alpha}}{C_{\rm C}} \qquad (1)$$

where $T_{\rm n}(\lambda)$ is the transmissivity of the [S II] filter, $z$ is the redshift of the galaxy, $C_{\mathrm{H}\alpha}$ is the H$\alpha$ emission line flux count, and $C_{\rm C}$ is the continuum flux count.

## 3. RESULTS

The $(B-V)$ versus $M_{\rm B}$ plot in Figure 1 shows 13 sample galaxies, consisting of 8 spirals, 4 ellipticals and 1 irregular morphological type. Five of them are peculiar galaxies; 3 spirals and 2 ellipticals. The eight brighter galaxies ($M_{\rm B} < -20$) tend to be redder than the others.

Figure 2 illustrates the $B-V$ color versus T-type plot. Our sample shows that late type galaxies tend to be bluer than early type ones. All sample galaxies having $M_{\rm B}$ fainter than $-20$ mag are late type galaxies.

Figure 3 illustrates the relationship between the $EW$(H$\alpha$) and T-type. Nine of thirteen galaxies show emission lines with $S/N > 3$, indicating a significant

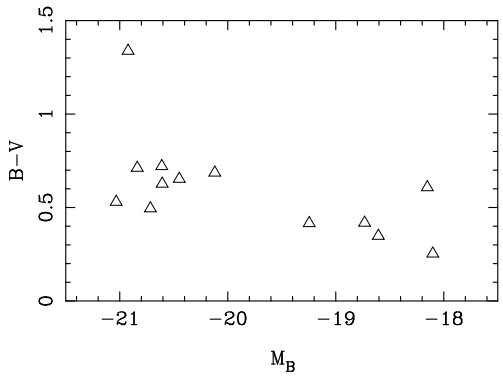


Figure 1. $B-V$ color vs. absolute magnitude $M_{\rm B}$ diagram.

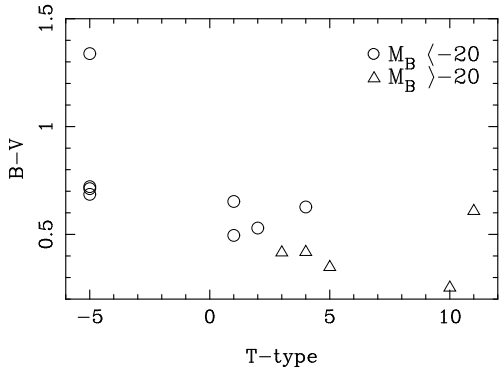


Figure 2. $B-V$ color vs. T-type diagram, separated by $M_{\rm B}$ $\sim -20$ mag.

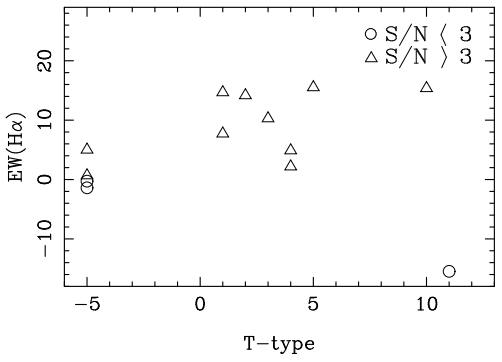


Figure 3. H$\alpha$ equivalent width vs. T-type diagram for the sample galaxies.

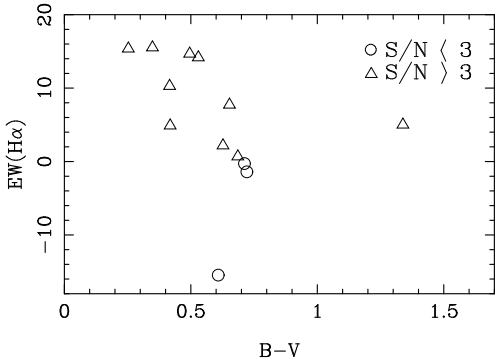


Figure 4. H$\alpha$ equivalent width vs. $B-V$ color diagram for the sample galaxies.

amount of star formation. Most late type galaxies tend to have higher H$\alpha$ emission than the early type galaxies. Most emission line galaxies ($S/N$(H$\alpha$) $> 3$) tend to be bluer than non-emission line galaxies as shown in Figure 4. This could be due to the formation of young massive stars in these emission line galaxies

## 4. DISCUSSION AND CONCLUSIONS

This study presents an investigation of star formation activity for thirteen sample galaxies in a nearby compact group, NGC 4095. Four elliptical galaxies are giants with $M_{\rm B} < -20$, while the others are late type. The late type galaxies tend to be bluer than the early galaxies, which could be due to OB star formation in the galaxies (Phillipps, 2005). Moreover, most of the late type galaxies tend to have higher H$\alpha$ emission than the early type ones. This implies that most active star forming galaxies are late type galaxies, similar to evidence found in the Virgo cluster by Gavazzi et al. (2006), that giant galaxies in the Virgo cluster have a current massive star formation rate per unit mass that increases from Sa to Scd. The results show that most of the late type galaxies in our sample have ongoing star formation, whereas the other galaxies, including the early type sample, are passive galaxies with little or no H$\alpha$ emission. Star formation in the emission line galaxies could be triggered by galaxy-galaxy or tidal interactions with the group potential well, during which material falls into the dense environment of this compact group. The results are similar to those found in eight low-redshift clusters (Moss, 2006) and consistent with the idea that molecular clouds of disk galaxies that are falling into the center of a cluster could be accelerated by tidal forces due to the cluster potential well, forming young stars (Valluri, 1993; Henriksen & Byrd, 2006).

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