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Star Formation in Galactic Mergers

April 21, 2015

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Abstract

Studying the star formation rate (SFR) in galactic mergers at different stages of merging provides information on the formation of elliptical galaxies. The mergers that will be observed are Arp 240, Arp 242 and Arp 81. The different stages will provide information on the evolution of the SFR. The H_{α}-line will be used to determine the SFR. This requires two filters; the WFCS6725 narrow-band filter and the R-filter. The data obtained with the R-filter will be subtracted form the WFCS6725-data to filter the background.

I. Introduction

Elliptical galaxies are among the largest single star structures in the universe. They are composed of old stars and little to no dust. The discrepancy of dust and young stars are likely due to a period of a high (SFR) in the early stages of the evolution of these galaxies. It is widely believed that large elliptical galaxies are formed in the process of galactic merging[1]. When spiral galaxies collide, the SFR goes up due to merging molecular clouds. Resulting in a galaxy with a large number of stars and low amount of interstellar clouds. To better understand the formation of elliptical galaxies, we want to determine in what regions of merging galaxies star formation takes place and how the SFR evolves during the process of galactic merging.

II. Scientific justification

Star formation regions

Large scale star formation is the process where high density regions in large molecular clouds collapse due to its own gravity. After the cloud has collapsed the young star starts to emit radiation according to a blackbody-like spectrum. For low mass stars ($M < 10$ $M_{\odot}$) the majority of this radiation exceeds the maximum wavelength for the ionization of hydrogen of 912 Å. Stars with a mass higher than $M_{\odot}$ do emit a significant amount of radiation above this energy treshold which means they ionize the gas surrounding the star. This causing visible emission lines from the Balmer series in observations. There is a peak in this emission of high-energy photons emitted by stars with masses in the range of 30-40 $M_{\odot}$ [2]. Such stars have a life span of only 3-10 Myr, thus regions with a large amount of these stars are good indicators of how much star formation occurs in the area. The most commonly used emission line for this purpose is the H-alpha line. The H-alpha line corresponds to a wavelength of 6562.6 Å, thus it lies in the optical part of the electromagnetic spectrum. To determine the rates of star formation we aim to observe three different pairs of colliding galaxies which are in different stages or merging. In collisions of galaxies stars rarely come close enough to actually collide. Large molecular clouds however do interact because of their large size and mass. Such colliding clouds induce increased star formation due to higher density regions [3].

III. Technical justification

Selecting galaxies and filters

To get information about the SFR, we will be looking at the H_α-line given by $\lambda_{H_\alpha} = 6563$ Å. A narrow-band filter will be used to observe the H_α-line. However, the galaxies are at large distances thus their spectra will be redshifted. Therefore the H_α-line of the galaxies will not be in the range of the filter originally made for H_α-line observing. In selecting the galaxies we calculated the possible redshift ranges for the available narrow-band filters with equation 1.

$$z_{\text{min}}^{\text{max}} = \frac{\lambda_0 \pm \Delta\lambda}{\lambda} - 1 \tag{1}$$

Where the equation is used with the minus and plus sign for calculating z_{min} respectively z^{max}. With this information we selected three galaxy mergers at different stages of merging with approximately the same redshift. Information on the galaxies we want to observe is listed in table 1, images are displayed in figure 1-3 from early to final stage of merging. The H_α-line of these galaxies can be observed with the WFCS6725 filter available at the INT. The filtered is centered about $\lambda_0 = 6725$Å with a FWHM of 80Å. Because we only want to look at the H_α-line of the galaxies, it is also needed to observe them in the R-filter. By subtracting the data of the R-filter from the WFCS6725-filter, we will have a clear view of the H_α-line emission in the galaxies.

Observation planning and exposure time

Table 2 show the times at which the galaxies are at their highest point in the sky, making it the optimal time for observing. For the Arp 81 galaxy there is no data from the Sloan Digital Sky Survey (SSDS), making it out first target for observation. For the exposure time of the filters we looked at different previously done observations and compared them with our scientific goals. The H_α-filter will be exposed for 3×900 s, copying Hibbard and Gorkom, 1996[9]. In the R-filter, the signal-to-noise ratio (S/N) is much higher for shorter exposure time (see figure 2). To get a same order of magnitude for the S/N in the R-filter, we expose our image 3×100 s. The three galaxies are roughly at the same distance and the same redshift, so the exposure times will be the same for all the galaxies.

References

[1] Barnes, J. Nature, vol. 338, March 9, 1989, p. 123-126

[2] Kennicutt R. et al. "Star Formation in the Milky Way and nearby galaxies". Annual Review of Astronomy and Astrophysics, vol. 50, p.531-608

[3] Schweizer, F. Starbursts: From 30 Doradus to Lyman Break Galaxies, Held in Cambridge, UK, $6-10$ September 2004. Edited by R. de Grijs and R.M. Gonzalez Delgado. Astrophysics & Space Science Library, Vol. 329. Dordrecht: Springer, 2005, p.143

[4] https://ned.ipac.caltech.edu/

[5] http://catserver.ing.iac.es/filter/list.php?instrument=WFC

[6] http://hubblesite.org/newscenter/archive/releases/2008/16/image/by/

[7] http://hubblesite.org/newscenter/archive/releases/2002/11/image/d/

[8] http://hubblesite.org/newscenter/archive/releases/2008/16/image/bu/

[9] "HI, HII, and R-Band Observations of a Galactic Merger Sequence", Hibbard, J. E.; van Gorkom, J. H., 1996AJ....111..655H

Figure 1: *Arp 240; Interacting galaxies NGC 5257 (left) and NGC 5258 (right), image by the HST. These galaxies are of similar mass and size. It can be seen that the galaxies are connected by a dim bridge of stars. [8]. -Early stage of merging*

Figure 2: *Arp 242; The Mice galaxy, image by the HST. The tidal forces of the gravitational interacting have triggered star formation in certain areas of the galaxies. In the left galaxy the blue patch is home to clusters of young, blue stars. Blue regions can also be seen in the tail of the right galaxy. [7]. -Intermediate stage of merging.*

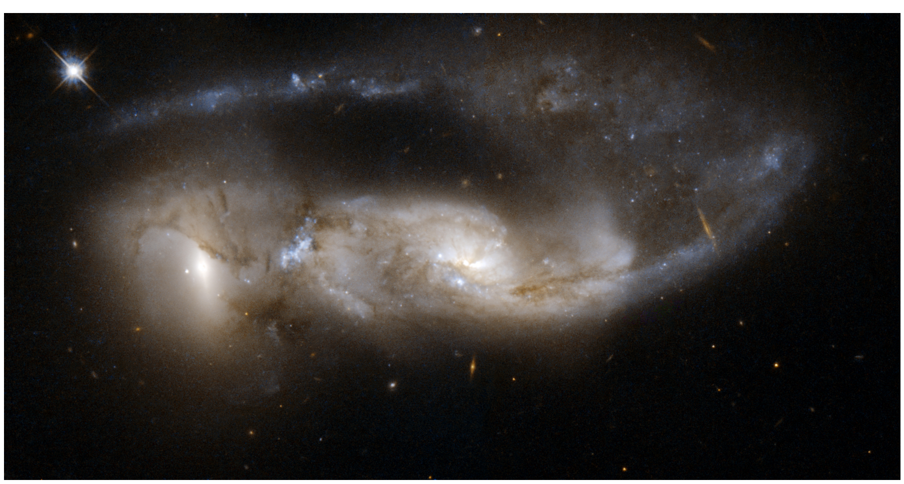

Figure 3: *Arp 81; Merging galaxies NGC 6621 (left) and NGC 6622 (right), image taken by the Hubble Space Telescope (HST). It can be seen that the collision has pulled a long tail out of NGC 6621 and has triggered extensive star formation in the overlapping regions of the galaxies. [6]. -Final stage of merging.*

Galaxy	RA [hh mm ss]	DEC [hh mm ss]	Magnitude	z	Distance [Mpc]
Arp 81	18 12 57.6	+68 21 32	13.6	0.0211	87.0
Arp 242	12 46 10.7	+30 43 38	13.0	0.0225	95.9
Arp 240	13 39 55.3	+00 50 07	14.1	0.0220	98.2

Table 1: *Information on the targeted galaxies; coordinates* (RA; DEC), *apparent magnitude, redshift z and distance in* Mpc.*[4]*

Date	Arp 81	Arp 240	Arp 242
Monday 02-05	04:27	00:12	23:18
Tuesday 03-05	04:39	00:06	23:13
Wednesday 04-05	04:39	00:00	23:10
Thursday 05-05	04:36	00:00	23:03
Friday 06-05	04:24	23:55	23:00
Saturday 07-05	04:21	23:51	22:55

Table 2: *Peak altitudes for the galaxies; date* [dd : mm], *time* [hh : mm]. *With a peak altitude of 51* [degrees]. *This information was acquired from the INT staralt software.*