Draft version May 11, 2020
Typeset using LaTeX default style in AASTeX63

Galaxy Merger Sequence: Evolution of the MW Main Stellar Body throughout the Merger Sequence

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(Received 10 May, 2020)

1. INTRODUCTION

In general, evolution of the density profile of a galaxy over time is as a result of gas depletion within the galaxy. One way in which gas is depleted is through star formation. Milky Way (MW) is a typical SBc barred spiral galaxy and constantly forming 4 new stars every year within its arms (Hubble 1982). The closest massive galaxy in the Local Group next to it is the Andromeda galaxy (M31), which is also a spiral galaxy. According to Hubble Galaxy specification scheme, M31 is classified as SA(s)b galaxy classification. M31 is approximately 2.5 billion light-years or approximately 769.0 kilo-parsec away from us and predicted to head for a collision in about 3.75 billions years from now with the Milky Way (van der Marel et al. 2012), where Figure 1 demonstrate how both of the galaxy would look like in the process of merging. It would take another 2 billion years for MW and M31 to completely merge together or coalescence. In that course of time, both of these galaxies have already evolved into a green valley, which includes the red spiral galaxies as forming stars takes up a lot of its gas in each of the galaxy, stopping them from forming any new stars.

Figure 1. credits: NASA, ESA, Z. Levay (STScI), and O. Mellinger. Milky Way and Andromeda galaxy in the head on collision with each other.

Galaxy mergers strongly impact the gas and stellar density profiles of the galaxies before and after coalescence. Major merger can change the composition structure of the gas poor evolved MW entirely (Querejeta et al. 2015) in which causing the stellar disk density of the remnant to be increased. It happens when two galaxies with almost the same mass and small velocities headed towards each other, whether as close encounter or a head on collision. One of the ways to study the changes on the density profile of galaxies during mergers is using the cosmological simulations and comparing to observations (Brooks & Christensen 2016).

In this paper, we want to investigate the evolution of MW spiral galaxy where we take account of its stellar disk by looking at its density profile as it is making its way to combine with the M31 prior to the merging of components to form a different class of a galaxy, probably will form an elliptical one (van der Marel et al. 2012). We want to study if the disk density will be increased or decreased relative to progenitor. If the stellar density happens to be increasing, we can assume that the gas density would actually goes up as well. This would result in increasing star formation rate of the galaxies, according to the Kennicutt-Schmidt relation. We can also look at how the mass changes as both of the galaxies merging.

2. METHOD

The sérsic profile has the form of $\ln I(R) = \ln I_0 - kR^{1/n}$, where I_0 is the intensity at the center, n is the degree of curvature of the profile in which $n = 1$ is a great approximation for MW spiral galaxy, showing that it is less concentrated at the center. It will create an exponential profile by which the relation between the intensity and the radii be $I(R) \sim^{-bR}$ where $b = 2n - 1/3$. Sérsic profiles can also be used to describe dark matter halos, where the Sérsic index correlates with halo mass of elliptical galaxies.

We will calculate the mass enclosed of the stellar disk within a given radius of the center of mass position for Milky Way over time before we measure the density. First, we will need to find the total mass of the stellar disk of the Milky Way (Homework 3). Then, we will find the 3D coordinates of the center of mass position of the MW by using the formula given below

$$X_{\mathrm{COM}} = \frac{\sum x_i m_i}{\sum m_i}, \tag{1}$$

to compute the center of mass position for multiple snapshots (Homework 4). After that, we could calculate the mass enclosed of the stellar disks in a range of radius away from the calculated center of mass (Homework 5). We will be using the Hernquist Density Profile to compute the density in the remnant using

$$\rho(r) = \frac{Ma}{2\pi r} \frac{1}{(r+a)^3}. \tag{2}$$

Here 2 is the bulge-lense-disc decomposition of a merger from Querejeta et al. (2015).

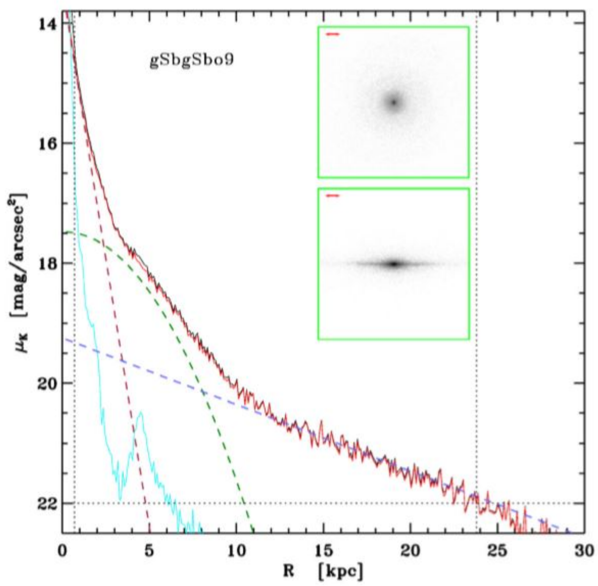

Figure 2. (Querejeta et al. 2015). Blue-dashed line is the fitted disc decomposition performed to an S0-like remnant with n ∼ 1 bulge using a model galaxy (gSbgSbo9). The red-dashed line is the fitted bulge and the green dashed line is the fitted lense component.

From the figure, we can see that the disk decomposition is decreasing as it is going away from the center. We can assume that the gas density profile will act similarly to the way of that the density profile of the stellar disk does. This way, we can estimate the rate of the star formation might be increasing.

3. HYPOTHESIS

The density profile of the MW stellar disk follows the sérsic profile with steep logarithmic slope at larger radii using n ∼ 1 for spiral galaxy. The changes that happened over time on the profile show that the mass and density of the galaxy is less concentrated compare to the one before MW and M31 merged (assumption).

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