

Tidal transformation of M33: Evolution of the internal stellar structure of M33

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1. INTRODUCTION

The Triangulum Galaxy (M33) is a smaller object within the Local Group. It is an object currently bound by the Andromeda Galaxy (M31) and can be seen to be affected by M31's gravity. These effects can be seen to tidal morph the shape and density of M33. Over time, it can be simulated to see what kind of evolution M33 has undergone.

Galaxy evolution is not a simple path to follow. Many different things and materials change the way a galaxy evolves as it is not uncommon for tidal disruption to happen. In fact, Massive objects tend to have smaller satellites bound to it, just like M33 to M31. Since M31 is classed as a spiral galaxy, it would be interesting to note how gravity from another object plays a role, as we (Milky Way) is head straight into M31.

M33's evolutionary history is not yet so well understood. There is current speculation whether M33 had a recent close flyby with M31 ([Semeck et al. \(2018\)](#)) ([Sellwood et al. \(2019\)](#)) which can be seen by the HI bridge between M33 and M31 (this plays a role in deciphering early M33 star formation)([Chang et al. \(2019\)](#)). But in general, galaxy morphological evolution is not very well understood. First and foremost because of perspective (which we have the luxury of due to simulation data rather than observational) because the shape of a galaxy can change with the inclination. The Hubble classification scheme is not very useful and falls apart when thinking about where you view a galaxy from. An elliptical galaxy could very well be a spiral galaxy, but is viewed more edge on, therefore muddying the view of the spirals. Also, time is not a helpful factor as the timescale of these massive objects are also large, so relative velocities must be observed, simulated, and hopefully we have matching data.

Another factor is that again the timescale is very large, so any number of things could of happened to these objects way before our existence to make them the way they are. It is assumed to be a very common thing for galaxies to be disrupted, have flybys, collide, and even merge. The best we can do is look for clues and hints that can narrow down some possibilities, but again some of those are just speculation. Luckily however, it is a very obvious thing to see that M33 can be and is being tidally affected by M31. With this among other clues we can take these to simulate (the data we have currently).

2. PROPOSAL

2.1. *What specific questions will you be addressing?*

We are not attempting to speculate the past and validate whether M31 indeed had a flyby by M33 (and explain its previous tidal changes). We will use simulation data to answer how M33 will be affected by M31 and even the Milky Way as time continues from today. This can be seen through mass profiles. The morphological evolution can be seen through these profiles over time. The main areas we can see the disruption is through the change in M33's disk (does it get thicker? does it warp?).

2.2. *How will you approach the problem using the simulation data?*

The simulation data can present the rough density of the disk in a form of contours. In terms of the disk, the code from the mass profile (Lab 7) can be used to see the mass profile edge on in order to determine the thickness. If possible, an average thickness can be plotted as a function of time. In terms of warping, the face on code can be used to preview the shape of M33. Parameters for this (as a function of time) may not be so easy to find as the particles are constantly moving, but we can try to find the longest and shortest radius and plot those as a function of time (

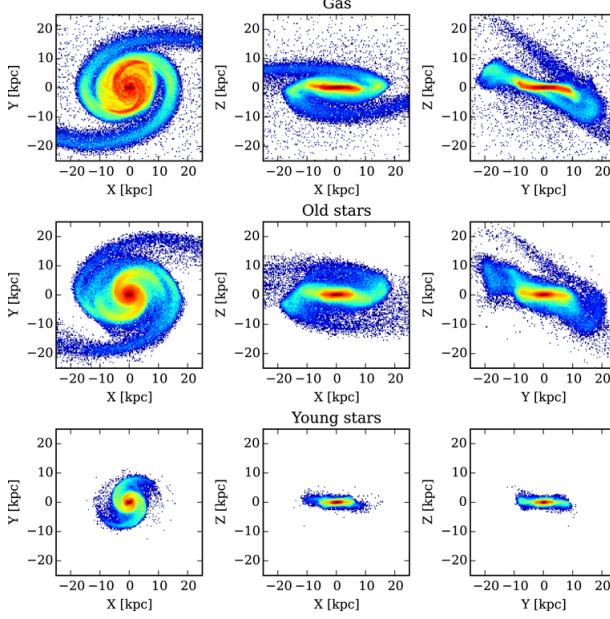


Figure 1. (Semczuk et al. (2018)) Surface density distributions seen from three different directions for the gas and —the old and young stellar particles for the simulated M33 at the time of the best match.

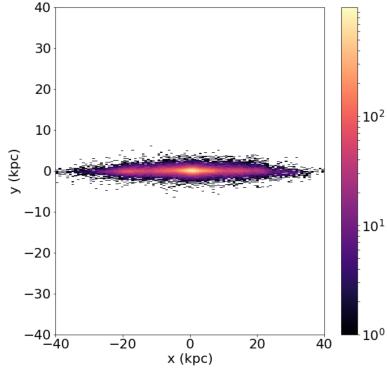


Figure 2. Edge on of M31 disk (Lab7). Here we can see the thickness of the disk and can determine the thickness as a function of radius. From there we can see the evolution over time.

and also compare with the edge on diagram mentioned earlier). This can be done by attempting to plot a r vs ϕ (angle) with respect to the center of M33. In Figure 2 and 3 we can see the mass profiles of M31. Since the simulation data can be viewed from any angle, it is quite trivial to see M33 edge on and face on.

2.3. Hypothesis & Motivating Science

Seeing as M33 is being tidally stripped, M33 will most certainly lose densities. Its mass profile will slowly diminish as mass flies off from the most concentrated areas. The loose objects will be stripped and the disk will thin. As for the circularity of the disk, the pull of M31 and MW will add energy to the objects thus increasing the remaining particles' energies. The Disk will become more oblong and oval-like as the mass is pulled back and forth from M33 and M31 (like a spring).

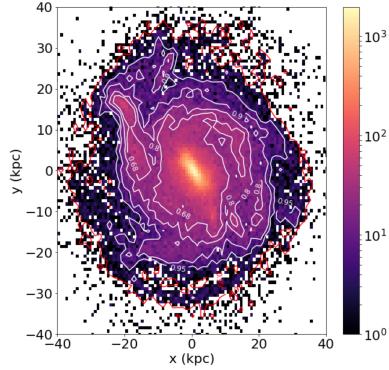


Figure 3. Face on of M31 disk (Lab7). Here we can see the mass profile contours. The radius and shape can be seen by eye, but the idea is to try and see if we can get a radius plot.

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