Draft version March 16, 2023
Typeset using LaTeX default style in AASTeX631

Tidal Debris from M33: Stellar Streams of M33*

Muzoun Alzaabi

1. INTRODUCTION

Tidal debris from M33, including stellar streams formed during and after the MW-M31 merger, is essential to our understanding of galaxy evolution. Gravitational forces between interacting galaxies can cause tidal disruptions, leading to the formation of extended streams of stars and gas. These tidal debris structures offer valuable insights into the history of galaxy interactions and mergers, as well as the distribution and properties of dark matter.

The Milky Way (MW) is part of the Local Group, a small group of galaxies that also includes the Andromeda galaxy (M31) and the Triangulum galaxy (M33), which are the three most massive spiral galaxies in the group. A canonical model of the MW-M31-M33 system, as presented in (Figure1), is crucial for understanding the formation and evolution of tidal debris and stellar streams from M33. Studying the canonical model allows researchers to simulate and predict the dynamical interactions between these galaxies, which lead to the formation of tidal debris and stellar streams. Van der Marel et al. (2012) investigated the past interactions, future dynamical evolution, and possible outcomes of the interactions between the MW, M31, and M33 galaxies, using observationally constrained initial conditions and detailed models of M33 in their calculations.

Understanding galaxy formation history, particularly in the context of the cold dark matter (CDM) cosmogony, is of utmost importance. Satellite galaxy tidal tails, such as those in the M33 system, provide valuable insight into the Milky Way's formation history and help test CDM theory (Choi, Weinberg, Katz et al., 2007). Furthermore, high-resolution idealized simulations are necessary for understanding the dynamical mechanisms governing subhalo evolution and the formation of tidal tails (Choi, Weinberg, Katz et al., 2007). This information is crucial for interpreting tidal tail fossil signatures, which can reveal galaxy formation history and probe dark matter halo structures.

Exploring the future of the M31-MW-M33 system, as studied by van der Marel et al. (2012), may result in the formation of tidal debris from M33. This research considers the possibility of M33 colliding with the MW before M31 and accreting tidal debris from the MW-M31 interaction, potentially including the Sun. Investigating the dynamical evolution of the MW-M31-M33 system and its possible outcomes helps to understand the formation and evolution of tidal tails and stellar streams in M33 during and after the MW-M31 merger.

A remaining open question in the field is the relative three-dimensional motion between M31 and the other two galaxies (van der Marel et al., 2012). Although the line-of-sight velocities of M31 and M33 are well established, and

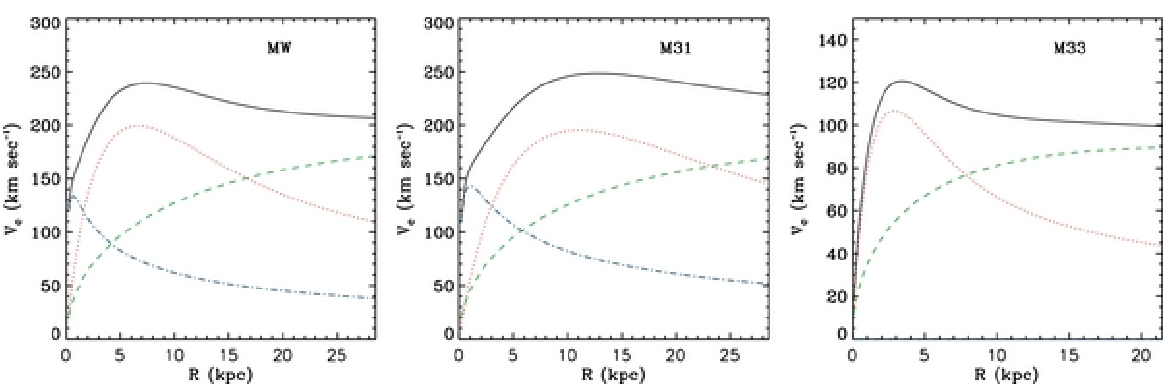

Figure 1. Model rotation curves (black solid curves) of the galaxies MW, M31, and M33 by (van der Marel et al., 2012) These rotation curves are an essential component of the canonical model, as they provide a basis for understanding the dynamics of the galaxies and their interactions in the context of the MW-M31-M33 system.

* Released on March 16 , 2022

M33's proper motion has been measured through water masers, M31's proper-motion measurement remains elusive. Upcoming space missions and ground-based radial velocity experiments will provide full phase-space information for Milky Way stars, offering valuable data on tidal tails and their role in the Milky Way's formation history. By studying the physical processes responsible for satellite galaxy disruption and induced tidal tail morphology, researchers can better understand galaxy formation and evolution, including tidal debris and stellar stream formation in systems like M33 during and after the MW-M31 merger (Choi, Weinberg, Katz et al., 2007).

2. THE PROPOSAL

This project will focus on writing a code to select "stream" stars - M33 stars that are outside the Jacobi Radius at any given point in time .This code is essential for studying the Tidal Debris from M33 during and after the MW-M31 merger and its enable effectively identify and analyze the stars that have been stripped away from M33 due to gravitational interactions with the MW and M31. These stars constitute the tidal debris and stellar streams that are integral to understanding the dynamics and evolution of the merging galaxies.

2.1. *Hypothesis and approach*

By selecting stars outside the Jacobi Radius, give a focus on the tidal features and disentangle them from the main body of M33. This allows for a more detailed study of the properties of tidal debris, such as their distribution, density, and chemical composition.This approach significantly contributes to our understanding of the complex processes involved in galaxy formation, interactions, and evolution.

The hypothesis is that to write a code to select "stream" stars - M33 stars that are outside the Jacobi Radius at any given point in time . This will allow us to identify and analyze the tidal debris and stellar streams that result from the interaction of M33 with the MW and M31 during and after their merger. This code expect to find that the tidal forces exerted by the MW and M31 on M33 will lead to the stripping of stars and gas from the outer regions of M33, forming distinct tidal features in the form of stellar streams and extended structures.

This approach to the problem of studying tidal debris and stellar streams in M33 during and after the MW-M31 merger is using a simulation data following of initial code ideas of :

1. Identify all particles belonging to M33 based on their initial positions and velocities.
2. Calculate the Jacobi radius at each point in time for M33 based on the position and mass of M31 and the distance between M33 and M31.
3. For each snapshot in time, identify all particles belonging to M33 that are outside the Jacobi radius.

REFERENCES

Amorisco, N. C. 2017, MNRAS, 464, 2882

Choi, J.-H., Weinberg, M. D., Katz, N. 2007, MNRAS, 381, 987

van der Marel, R. P., Besla, G., Cox, T. J., Sohn, S. T., Anderson, J. 2012, ApJ, 753, 9