Spiral structure in galaxies
Dinesh Beniwal (1811061)

Introduction

What Process Creates And Maintains The Beautiful Spiral Arms Around Spiral Galaxies? Astronomy enthusiasts always wonder about this question. From basic observations, the reasoning says that the farthest stars move faster than inner stars in galaxies, violating Kepler's law. But the directed implication of Kepler's law ends up with the "wind-up problem" of the spiral arms [3]. Observations have shown galaxies' inner parts rotate faster than their outer parts. In that case, do the spiral arms' internal parts move faster than their outer parts? That would mean the galaxy would wind up so much, thinning out its spiral structure and eventually destroying it. Hence the fundamental physics of why galaxies have spirals is known, but the details remain controversial.

Proposed research

Astrophysicists around the world came up with a different explanations, such as the 'density waves' [7], as to why the spiral structure in galaxies exists. A detailed exploration of these theories and their ability to fit the observed data along with related simulation results should be carried out in this course research project.

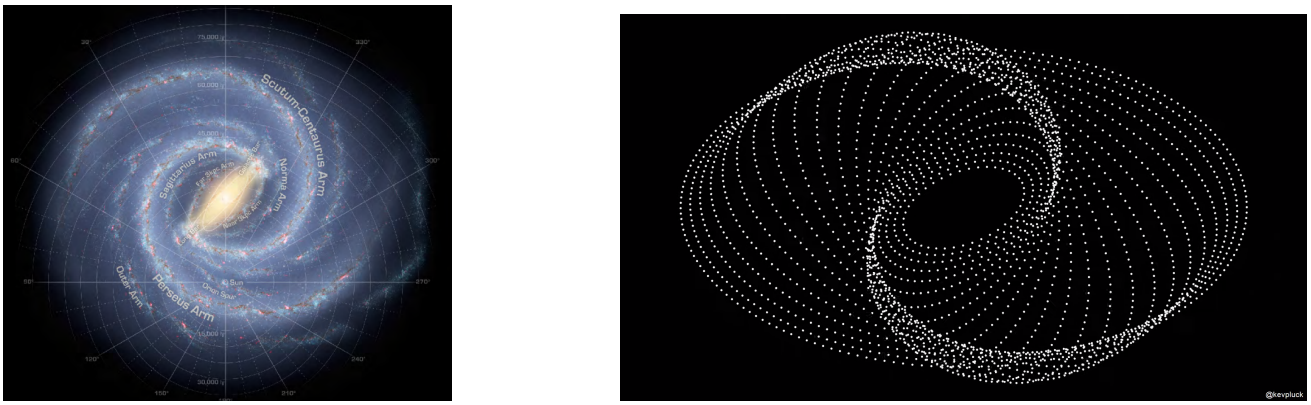

Figure 1: (Left) Milky Way Bar and Arms. Here, we see the Milky Way Galaxy as it would look from above. This image, assembled from data from NASA's WISE mission, shows that the Milky Way Galaxy has a modest bar in its central regions[1]. (Right) Stimulated distorted orbits due to the pull form nearby galaxies or collisions.

Methods

Some good references, such as: 'Astrophysicists at the University of Arkansas have discovered a mechanism for the formation of the spiral arms in disk galaxies,'[7] will be explored along with other references[5][6][8]. I will study the fundamental theories from the book 'Astronomy'[1](Figure 1(left) shows the spiral structure of the Milky Way galaxy) and early references[2][4].

Moreover, I will make use of a recent review that compiled current observational data. In addition, I am also planning to add some simulation results for better understanding such as Figure 1(right) shows the distorted and pulled around orbits due to nearby galaxies.

Timeline

The work will be submitted before the end semester exam, i.e., before 28 Nov 2022. This will give us ten weeks on the project. I will first spend two weeks learning the basics of galaxies and their formation, followed by two weeks of learning the theories that explain the project topic. The next three weeks will be spent studying observational and theoretical results from the literature and corresponding simulations. The final three weeks will be spent making the website while continuing to consult with the instructor to make the report an exciting read containing structured information.

Summary

I propose to review the literature on the topic 'Spiral structure of galaxies' along with the current status of research. The project report will be precise enough to get to know the field with up-to-date (recent) research and projects.

References

[1] SIDNEY C. WOLFF ANDREW FRAKNOI, DAVID MORRISON. Astronomy. OpenStax CNX, 2022. ISBN ISBN 13: 9781951693503.

[2] E Athanassoula. The spiral structure of galaxies. Physics Reports, 114(5):319–403, 1984. ISSN 0370-1573. doi: https://doi.org/10.1016/0370-1573(84)90156-X. URL https://www.sciencedirect.com/science/article/pii/037015738490156X.

[3] Deborah Byrd. How do spiral galaxies keep their shape? 2017.

[4] Debra Meloy Elmegreen and Bruce G. Elmegreen. Arm Classifications for Spiral Galaxies. ApJ, 314:3, March 1987. doi: 10.1086/165034.

[5] C. C. Lin and G. Bertin. Formation and maintenance of spiral structure in galaxies. Symposium - International Astronomical Union, 106:513–532, 1985. doi: 10.1017/S0074180900243052.

[6] Ryan Miller, Daniel Kennefick, Julia Kennefick, Mohamed Shameer Abdeen, Erik Monson, Rafael T Eufrasio, Douglas W Shields, and Benjamin L Davis. Investigating the origins of spiral structure in disk galaxies through a multiwavelength study. The Astrophysical Journal, 874(2):177, apr 2019. doi: 10.3847/1538-4357/ab0d26. URL https://doi.org/10.3847/1538-4357/ab0d26.

[7] Hamed Pour-Imani, Daniel Kennefick, Julia Kennefick, Benjamin L. Davis, Douglas W. Shields, and Mohamed Shameer Abdeen. STRONG EVIDENCE FOR THE DENSITY-WAVE THEORY OF SPIRAL STRUCTURE IN DISK GALAXIES. The Astrophysical Journal, 827(1):L2, aug 2016. doi: 10.3847/2041-8205/827/1/l2. URL https://doi.org/10.3847/2041-8205/827/1/l2.

[8] Ye Xu, Mark Reid, Thomas Dame, Karl Menten, Nobuyuki Sakai, Jingjing Li, Andreas Brunthaler, Luca Moscadelli, Bo Zhang, and Xingwu Zheng. The local spiral structure of the milky way. Science Advances, 2(9): e1600878, 2016. doi: 10.1126/sciadv.1600878. URL https://www.science.org/doi/abs/10.1126/sciadv.1600878.