Name(s)
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Project Number
S1801

Project Title
A Determination of the Optimal Dark Matter Model for the SPARC Galaxies

Abstract

Objectives/Goals
The main goal of this project is to provide one of the most in-depth analyses of the core vs. cusp controversy, which jeopardizes our current understanding of the universe, by analyzing 114 diverse galaxies. Although our accepted view of the universe, the CDM Paradigm, has had numerous important large-scale successes, I will show that it is inaccurate and thus incomplete at small scales. Finally, I will solidify arguments for the existence of dark matter, which is composed of theoretical particles that make up 85% of all mass in the universe but do not interact with light.

Methods/Materials
I analyzed 3 models that each predict the density of dark matter within a galaxy: the CDM-derived cusped NFW model as well as the cored Isothermic and Burkert models, derived from observations. I constructed a Python algorithm from scratch to read data on 114 galaxies gathered from the Spitzer space telescope (called SPARC galaxies), analyze it, and determine which of the 3 models best predicts the observed data for each individual galaxy. I also calculated a p-value, which is the probability that my results would be replicated if there was no dark matter.

Results
I found that 85% of the 114 SPARC galaxies preferred a cored profile and all galaxies except for one had a p-value of under 0.01, verifying the existence of dark matter. An unforeseen outcome was the diversity of rotational curves among galaxies with similar masses and asymptotic velocities.

Conclusions/Discussion
The extremely small p-values in my results provide important arguments for the existence of dark matter. Furthermore, CDM does not provide an explanation for the observed diversity of rotational curves. Finally, from the dominance of the cored profile over the cusped profile, it is implied that our current understanding of the universe (CDM) is missing a fundamental characteristic. However, by assuming that dark matter particles strongly interact with each other, galaxies can adopt cored profiles at inner regions while preserving the large-scale successes of CDM. Thus, new insight into what characteristics the dark matter particle could have is gained from my project.

Summary Statement
I demonstrate the inability of our current understanding of the universe to represent the small-scale structure of the universe and propose that strong self-interactions amongst dark matter particles could serve as a potential solution.

Help Received
I had some initial guidance in choosing a topic from a university professor and I met with him about once every week for 15-30 minutes, but implemented the idea by myself.