Placing Constraints on Fuzzy Dark Matter Properties

University of New Hampshire

TRIO
RONALD E. MCNAIR POST-BACCALAUREATE ACHIEVEMENT PROGRAM

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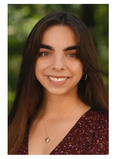

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Abstract

How might we possibly understand dark matter, its behavior, and its interactions?

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This proposed dark matter evolves into unique physical structures -- with cores of solitons – and is thus named Fuzzy Dark Matter (FDM).

We will be using `deeplenstronomy` to simulate gravitational lensing data in the scenario where solitons are present. We will be examining how FDM differs from Cold Dark Matter, and how the resulting data will compare to that of the Vera C. Rubin Observatory's Legacy Survey of Space and Time, and what this clarifies.

Dark Matter

What is dark matter?

- significant astrophysical evidence for presence of "missing matter"
- has a low mass
- invisible
- does not appear to interact with light or other radiation

It is beyond the standard model of physics and, therefore, is very elusive of our understanding.

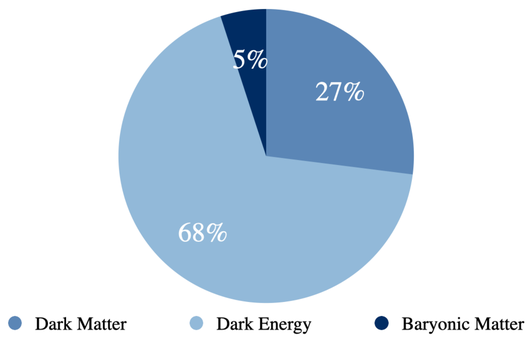


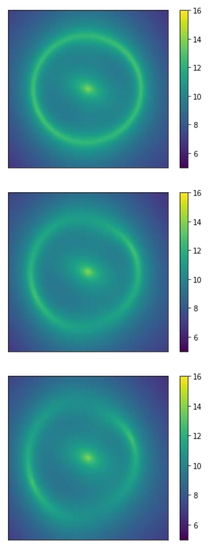
Figure 1-Dodelson, Scott. Gravitational lensing. Cambridge University Press, 2017.

Our Simulated Data

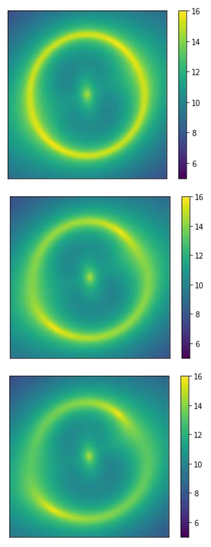
We create datasets that model dark matter with the both the cold dark matter Navarro-Frenk-White profile and the density profiles of the fuzzy dark matter model.

Note: plots are given on a log scale

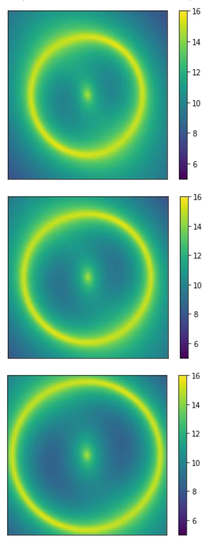
NFW Profile



NFW + Soliton core



Variations in the mass of soliton (NFW + Soliton core)



By studying gravitational lensing done in our simulations by FDM, we may clarify how differently lensing behaves under FDM, and if the differences in our simulated data are sufficient in telling the difference between FDM and CDM

deeplenstronomy

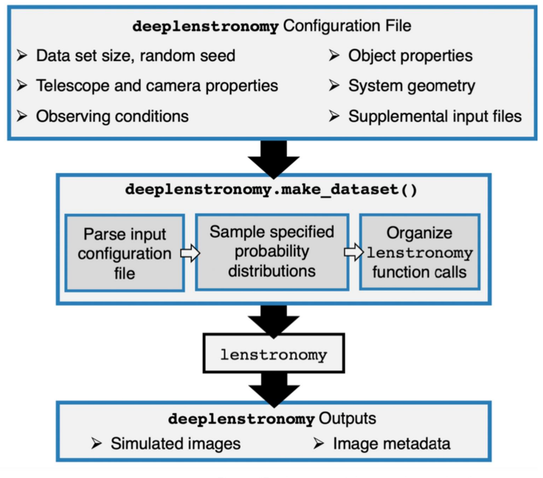
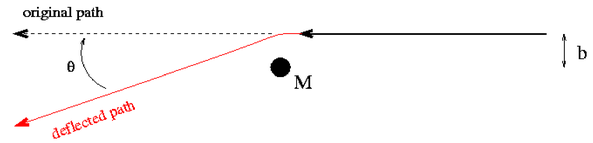


Figure 2- "Deeplenstronomy: A dataset simulation package for strong gravitational lensing."

Gravitational Lensing

The deflection of light is defined by the shortest distance following the curvature of spacetime.

By studying these curves, we may understand the path taken by the light.



The Legacy Survey of Space and Time

The Vera C. Rubin is currently undertaking the Legacy Survey of Space and Time (LSST), which will

- probe dark energy and dark matter
- take inventory of the solar system
- explore the transient optical sky
- map the milky ways
- discover thousands of new lenses

The images we have created are representative of the projected LSST findings.

This survey will deliver images and data to address some of the most pressing questions about the structure and evolution of the universe.

We will be using these resulting images to compare and thus understand how accurate those we simulated are.

(Paul A. Abell et al. LSST Science Book, Version 2.0. 12 2009)

Acknowledgments

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References

Dodelson, Scott. Gravitational lensing. Cambridge University Press, 2017.

Robert Morgan, Brian Nord, Simon Birrer, Joshus Yao-Yu Lin, Jason Poh,"Deeplenstronomy: A dataset simulation package for strong gravitational lensing." The Journal of Open Source Software. doi: 10.21105/joss.02854

Paul A. Abell et al. LSST Science Book, Version 2.0. 12 2009