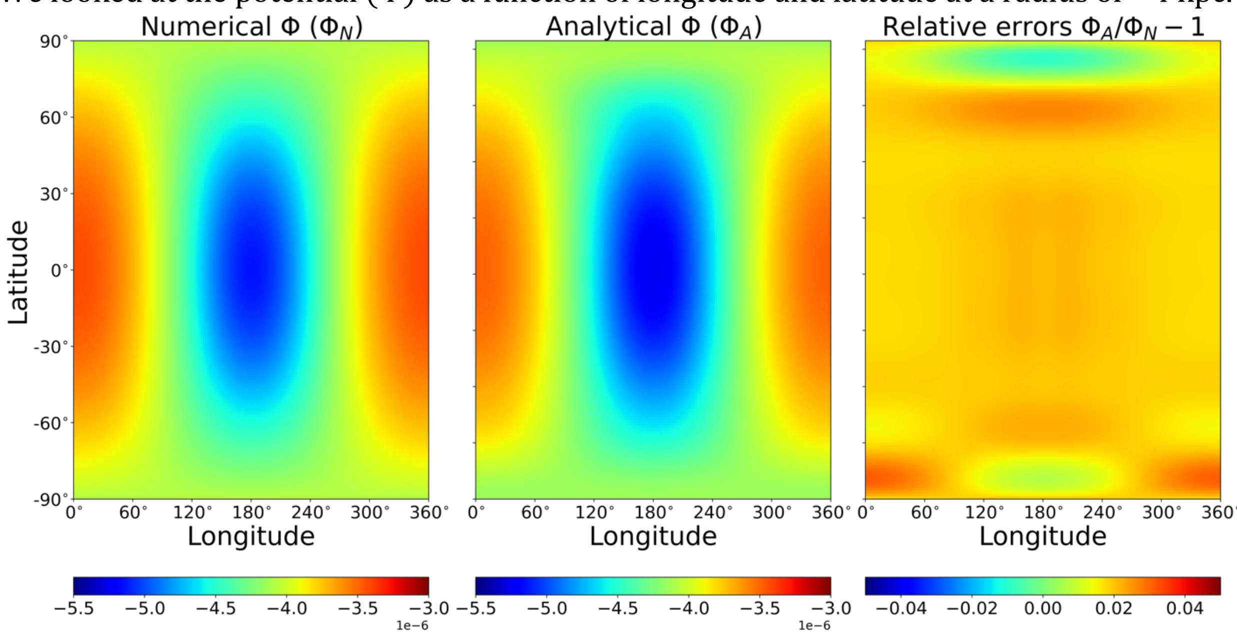
Stellar evolution in a fuzzy dark matter halo – Parasar Thulasiram. Supervisor: Dr. Xinyu Li

Fuzzy dark matter (FDM) is a candidate theory of dark matter in which the proposed dark matter particles each have a very low mass ($m \lesssim 10^{-22}$ eV) and so their collective behaviour can be modelled using wave mechanics. As such, wave interference phenomena can occur such as dark matter "granules" during constructive interference and dark matter "vortices" during destructive interference. Simple solutions to the FDM equations also yield "solitonic" cores, which can help solve the cuspy halo problem in ΛCDM. We ultimately want to simulate an FDM halo with orbiting stars to see if it can reproduce observations.

Our research aims to include some of the phenomenology predicted to occur during the evolution of solitonic cores, such as core oscillations and random walks. These result from wave interference and have not yet been included in past studies. At a high-level, we followed a different method analogous to the standard Schwarzschild method but for waves. We then developed tools to calculate the gravitational potential which determine how the stars move in the vicinity of a dark matter halo. In particular, we fit the spherical harmonic amplitudes of the density profile using the Schwarzschild method, then use them to calculate the amplitudes of the potential. This solution is computationally inexpensive.

To test the code, we simulated a ball of radius ~2 kpc with a 3D gaussian mass distribution. We looked at the potential (Φ) as a function of longitude and latitude at a radius of ~4 kpc.



This shows that the numerical calculation agrees with the analytical prediction within 5%, with the structure in the errors most likely coming from interpolation error in the analytical calculation, as it was only done on a 10x10 grid.

To continue this work, we would first fix some of the bugs occuring while calculating the gravitational field. Once this is done, we can begin some basic stellar dynamic simulations around a fixed halo. We can then look at stellar evolution in response to soliton evolution and compare our results against observed galactic rotation curves.