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Determination of Gravitational Fields and Escape Velocity from Galactic Density Profiles
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Background
➢ The objective is to determine the potential field and the escape velocity in a galaxy.
➢ The potential field aids in determining the escape velocities of various points in a galaxy.
   ○ Escape velocities help determine the amount of energy necessary to eject a celestial object from a galaxy.
➢ Resulting potential fields and escape velocity maps can aid the Galactic Astrodynamics Research Group in determining the velocities pulsar kicks can impart and modeling complex orbits.

Methods
➢ Simulate a model of the Milky Way galaxy’s potential field.
   ○ An analytic solution to the gravitational potential integral is not available for arbitrary shapes
➢ Utilize density and mass profiles for the galactic center and disk to infer the gravitational potential.
   ○ These density and mass profiles are for a disk, bulge, and dark matter halo.
➢ Use the gravitational potential field data to produce a map of the escape velocity required to escape the galaxy at various galactic points.

\[
\Phi(\mathbf{r}) = -G \int \frac{\rho(\mathbf{r'})}{|\mathbf{r} - \mathbf{r'}|} \, d^3\mathbf{r'}
\]
\[
V_{\text{esc}} = \sqrt{2|\Phi|}
\]

Results
➢ The current results are a gravitational potential map and a escape velocity map, shown to the right, based on the bulge and disk density.
➢ Fig 3 shows that the absolute and relative error for the uniform sphere model is acceptable.

Future Work
➢ Implement a Navarro Frenk White profile to model a dark matter halo around the galaxy.
   ○ This helps provide more accurate escape velocity data.
➢ Compute a rotation curve for the galaxy.
➢ Utilize the data obtained to model unique orbits
➢ Use adaptive grids to minimize error

Conclusion
➢ The gravitational potential fields generated with this model can aid greatly in determining a large array of galactic astrodynamical parameters, all of which will aid in further understanding the dynamics of galaxies.

References