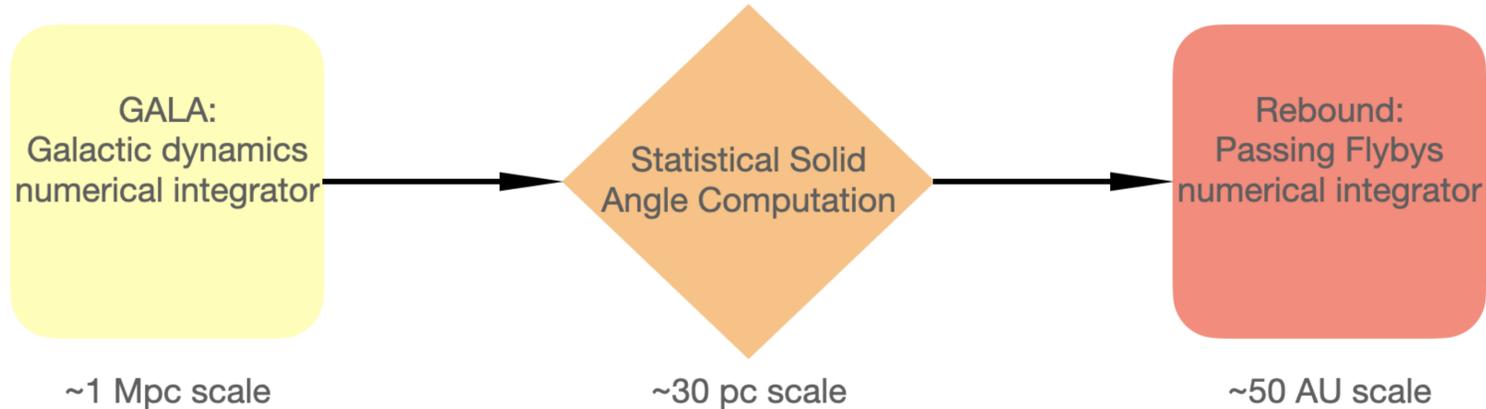


The Impact of Primordial Black Holes on Exoplanet Systems

Goal

Determine the distribution of all exoplanet orbits after close encounters with dense astrophysical objects.

Flow Diagram of Simulation.



Galactic Simulations

Given a star in a circular orbit around the Galactic Center, what is the frequency to which some PBH in the galaxy enters the neighborhood of the given star?

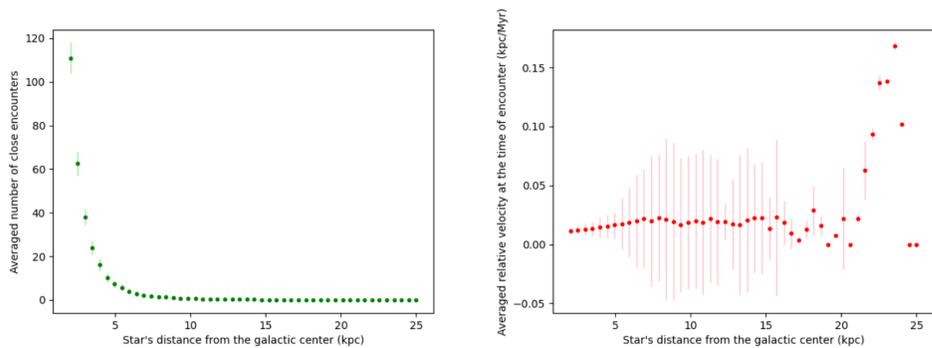


Figure 1. GALA outputs. Left. Number of close encounters as a function of the star's distance r from the Galactic Center. Right. Averaged relative velocity (km/s) between the PBH and the star at the time of close encounter. Each point is the average of 86 simulations.

Solid Angle

Given a PBH enters the neighborhood of a star, what is the probability that this PBH enters a region in which it can significantly perturb the orbits of the star's planet(s)?

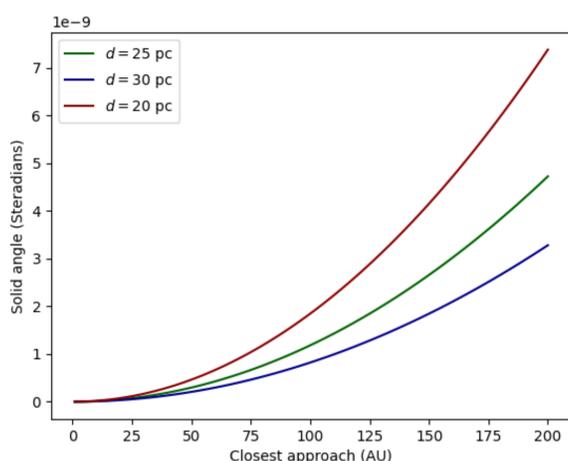


Figure 2. Left. Graphical representation of the solid angle computation scenario. Right. The specified solid angle that a PBH with initial distance d from the star results in a closest approach r from the star.

Simulating Close Encounters

Given a PBH that enters the planet perturbing region, statistically what are the effects on the orbital parameters?

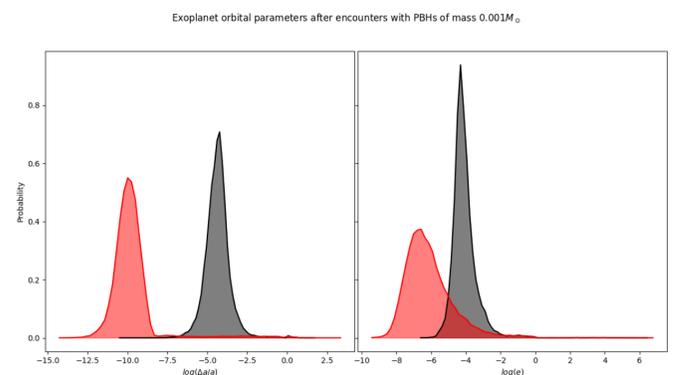


Figure 3. Distribution of the resulting orbital parameters of Jupiter-like exoplanets after stellar encounters (red) and both stellar and PBH encounters (black). Flyby PBHs have mass $10^{-3}M_{\odot}$ and velocity 100 km/s, with impact parameter drawn from a distribution of $15R[0, 1]AU$.

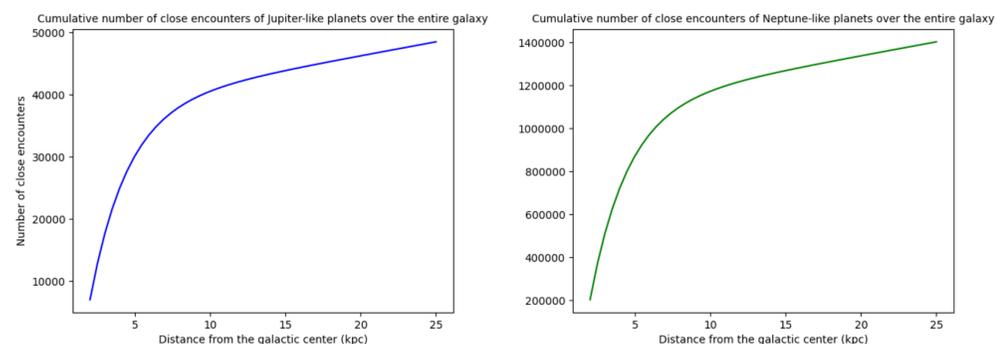


Figure 4. Given 10^9 initial PBHs over the entire galaxy, the expected cumulative number of Jupiter-like (left) planets and Neptune-like (right) planets within distance r from the center of the galaxy that encounters a PBH within 15AU (left) and 90AU (right) over the age of the galaxy (≈ 10 billion years).

Conclusion

- Studied the statistics of the eccentricity and semimajor axis distributions of exoplanets
- Estimated the number of Jupiter (Neptune)-like exoplanets that have encountered a primordial black hole
- The methodology can help the Kepler mission in searching for earth-like exoplanets across the Milky Way
- The methodology can be applied to cutting-edge large exoplanet datasets obtained by the James Webb Telescope to test for the existence of populations of dense astrophysical objects

Note: all images and figures created by the researcher unless otherwise noted.