Disc Stability – Lay Summary

In the past few decades, computational models of physical systems have made substantial contributions to many areas of research. Within the discipline of astrophysics specifically, the N-body simulation has been widely utilised. In this scheme, celestial objects are treated as point particles that interact solely through gravity. Calculating the force on each particle at every timestep enables the derivation of subsequent velocities and positions driving the evolution of a system. Through these simulations, we can model galaxies such as our own to investigate their structure and dynamics.

Early simulations of Milky-Way-like disc galaxies revealed that giving stars in a disc a purely circular velocity about the galactic centre leads to disc instability, with systems prone to clumping and forming a central bar-shaped structure. As a solution to this, Toomre, in 1964, proposed that stability is achieved only in ‘hot’ discs, where a random component to stellar motion is required to prevent clustering.

In this work, we simulated multiple disc galaxies modelled after the Milky Way using the N-body approach; an example of these simulated discs is shown in the image below. The variability in stellar velocity was changed between the test galaxies to investigate the effects of random motion on disc stability. Our results agree with Toomre’s conclusion that ‘cold’ discs are unstable to bar formation. However, we also find that excessively ‘hot’ discs exhibit other instabilities due to the high velocities encountered, such as large, non-circular stellar orbits, and even the ejection of stars from galaxies.