Title: Modelling the Last Major Merger that Shaped the Milky Way

Authors: Istiak Akib, Francois Hammer, Yanbin Yang

The formation and present-day structure of the Milky Way (MW) were profoundly influenced by its last major merger, occurring ~9-10 Gyr ago with the Gaia-Sausage-Enceladus (GSE) progenitor. We present the first hydrodynamical simulation of this event, modelling it as a 1:3-1:4 major merger using the GIZMO code, to investigate how such an encounter imprints lasting signatures on stellar dynamics and Galactic structure.

Our simulations begin 12-13 Gyr ago with gas-rich proto-MW and GSE progenitors on a parabolic orbit, and follow their interaction through merger and subsequent secular evolution. The resulting system reproduces the observed kinematic distribution of GSE debris in the energy-angular momentum (E-Lz) plane, directly linking present-day stellar orbital properties to the Galaxy's merger history. We further show that globular clusters associated with GSE can preserve orbital memory of the merger epoch, providing an additional dynamical tracer connecting accreted populations to the Galaxy's assembly.

Crucially, the merger remnant also reproduces the key structural and dynamical properties of the MW: bulge/ bar and its rotation, thin and thick discs, spiral arms, surface mass density profile, rotation curve, gas fraction, and star formation history. This level of agreement with the observed properties of the MW enables us to use the model to infer its underlying mass distribution and to trace the formation and subsequent evolution of its major components within a fully cosmological context.

Our results offer a self-consistent framework in which stellar kinematics, orbital structure, and Galactic morphology jointly encode the MW's formation history, illustrating how major mergers shape galaxy evolution over cosmic time.