**An Observational Search for the Large Magellanic Cloud’s Dynamical Impact on the Milky Way**

The Large Magellanic Cloud (LMC) is on its first infall to the Milky Way (MW) and is expected to significantly perturb the MW’s dark and stellar halos due to its large mass (~10% of the MW). The proximity of the interaction between the LMC and MW presents a crucial opportunity for studying the dynamics of galaxy mergers. Recent dark matter (DM) only *N*-body simulations of the LMC/MW interaction predict that the passage of the LMC has formed non-equilibrium structures in the MW’s halo, however this phenomenon has not been confirmed observationally. We propose to conduct the first-ever observational search for the effect of the LMC on the MW’s halo by utilizing the all-sky coverage and best-available astrometric accuracy of the *Gaia* and *WISE* surveys. To maximize the chance of a detection, we will select a sample of giant stars at 60 < Rgal < 100 kpc where the LMC’s effect is strong and contamination from other effects is minimized. Using these stars as tracers, we will construct a novel map of the LMC-induced structure in the density field of the MW’s halo. Our map will constrain the orbit of the LMC and by extension the LMC and MW masses. Our results will also establish whether the common assumption that the MW’s halo is in dynamical equilibrium is valid, which has important consequences for any study of MW dynamics. Furthermore, comparisons to *N*-body simulations can be used to probe the physics of the DM particle.

**Original Abstract:** Gravitational interactions between the Large Magellanic Cloud (LMC) and the stellar and dark matter halo of the Milky Way are expected to give rise to disequilibrium phenomena in the outer Milky Way. A local wake is predicted to trail the orbit of the LMC, while a large-scale over-density is predicted to exist across a large area of the northern Galactic hemisphere. Here we present the detection of both the local wake and Northern over-density (here- after the “collective response”) in an all-sky star map of the Galaxy based on 1301 stars at 60 < Rgal < 100 kpc. The location of the wake is in good agreement with an N-body simulation that includes the dynamical effect of the LMC on the Milky Way halo. The density contrast of the wake and collective response are both stronger in the data than in the simulation. The detection of a strong local wake is independent evidence that the Magellanic Clouds are on their first orbit around the Milky Way. The wake traces the path of the LMC, which will provide insight into the orbit of the LMC, which in turn is a sensitive probe of the mass of the LMC and the Milky Way. These data demonstrate that the outer halo is not in dynamical equilibrium, as is often assumed. The morphology and strength of the wake could be used to test the nature of dark matter and gravity.

**Paper Link:** <https://ui.adsabs.harvard.edu/abs/2021Natur.592..534C/abstract>