

Tracing the 6-D Orbital and Formation History of the Complete M31 Satellite System

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The Milky Way (MW) halo has long been the local testing ground for the nature of dark matter, cosmic reionization, and for understanding key physics of galaxy formation. However, there is increasing evidence that the MW halo is not broadly representative. Here, we propose to image the entire M31 satellite system in order to establish a second local anchor point for understanding an entire galactic ecosystem. The exquisite astrometric and photometric capabilities of HST are the only way to (1) measure detailed star formation histories (SFHs); (2) provide secure distances using RR Lyrae; and (3) establish first-epoch imaging for proper-motion (PM) measurements at the distance of M31 (~ 0.8 Mpc) -- all to a precision comparable to the MW satellites. Specifically, we will obtain ACS/WFC3 imaging in F606W and F814W that reaches the oldest main sequence turnoff of the 23 M31 satellites that lack existing deep data. Combined with archival imaging, this program will lay the foundation to dynamically map the entire M31 system in full 6-D orbital phase space and establish M31 as the next frontier for testing dark matter, reionization, and the growth of galactic ecosystems across cosmic time. It is imperative to start this survey now. Measuring PMs with precisions similar to MW satellites (~ 40 km/s) requires an 8-12 year baseline. Full phase-space information will only be available in JWST's lifetime if we establish first-epoch imaging with HST now. Similar science in the next closest groups ($D \sim 3.5$ Mpc) requires the power of LUVOIR. The M31 satellites are among the few remaining areas in the Local Group for which HST can produce transformational science.