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Thesis abstract

The structure and kinematics of the Magellanic stellar periphery

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The Large and Small Magellanic Clouds (LMC/SMC) are of fundamental importance in near-field cosmology. As the closest pair of interacting dwarf galaxies, they constitute the prototype system for studying the influence of tidal interactions on galaxy evolution. However, the orbital and interaction history of the Clouds — critical to understanding these influences — remains relatively unconstrained.

This thesis aims to understand the effects of past interactions between the Magellanic Clouds by performing the first dedicated kinematic study of the Magellanic stellar outskirts. Stars in these regions are strongly susceptible to external perturbations, and the resulting structural and kinematic signatures are persistent: evidenced by a wealth of substructure observed across the Magellanic periphery. To kinematically study these structures, I have developed and led the Magellanic Edges Survey (MagES), a spectroscopic study using the 2dF+AAOmega instrument on the Anglo-Australian Telescope, targeting ~8700 red clump and red giant branch stars across the periphery of the Clouds. In combination with astrometric measurements and high-precision photometry from the Gaia satellite, the survey provides 3D kinematics and abundance information critical for understanding the effects of dynamical perturbations on the Magellanic system.

As a first demonstration of the efficacy of MagES data, the kinematics of two fields in the northern LMC disk are investigated. These are found to exhibit relatively undisturbed disk-like kinematics, enabling calculation of the most distant direct mass estimate for the LMC.

Focus is then directed to a large arm-like substructure to the north of the LMC. This structure is determined to be made from disturbed LMC disk material, with its discrepant kinematics relative to the disk indicative that it was strongly perturbed during a recent interaction with the Milky Way. Comparison with dynamical models reveals the feature has not been closely influenced by close passages or disk crossings of the SMC around the LMC within the past Gyr, but earlier SMC passages may have contributed to its formation. These are the first kinematic constraints on the dynamical history of the Clouds prior to their most recent pericentric passage ~150 Myr ago.

Finally, the kinematic and structural properties of the outer LMC at galactocentric radii beyond 10 degrees are explored. The north-eastern LMC disk is remarkably undisturbed, with geometry and kinematics near-identical to those at smaller radii. In contrast, the western and southern LMC disk are highly disturbed, with deviations exceeding 25 km/s from equilibrium disk kinematics, and significantly elevated velocity dispersions. Red clump stars in these regions are also significantly brighter than expected for an undisturbed disk, indicating substantial warping. It is further demonstrated that several substructures to the south of the LMC, including two claw-like features and a long arm-like structure extending around the south-eastern disk, comprising predominantly LMC material — as opposed to SMC debris — but display strongly disturbed kinematics. Comparisons with dynamical models reveal the western LMC disk is likely significantly affected by an SMC crossing of the LMC disk plane ~400 Myr ago. However, southern substructures appear considerably more complex than observed in any models, plausibly requiring multiple previous interactions with the SMC to fully explain their observed dynamical properties.

In summary, the MagES data presented in this thesis provide a set of unprecedented empirical constraints on the interaction history of the Clouds that will be critical for guiding future numerical models aiming to accurately describe the complex evolution of the Magellanic system.

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