Taking Measure of the Milky Way

Principal Investigator: Steven R. Majewski (Univ. Virginia)

Team Members:
John N. Bahcall (Inst. For Advanced Study), Douglas Geisler (Cerro Tololo Interamerican Observ.), Wolfgang Gieren (Univ de concepcion), Eva Grebel, (Univ. Washington), Carl Grillmair (Caltech), Michael Irwin (Cambridge Univ), Kathryn V. Johnston (Wesleyan Univ), Richard J. Patterson (Univ. Virginia), Neill I. Reid, Univ of Penn), David Spergel (Princeton Univ), Scott Tremaine (Princeton Univ Observ)

We intend to use SIM to make definitive measurements of fundamental structural and dynamical parameters of the Milky Way. The important niche in dynamical parameter space afforded by SIM can be exploited to resolve, with unprecedented precision, a number of classical problems of Galactic astronomy. In addition, we have developed new tests of the Galactic mass distribution specifically designed for data with the special properties of SIM products. Our proposed suite of experiments will utilize the SIM Astrometric Grid as well as complementary observations of star clusters and other strategically-selected, distant "test particles" for a definitive characterization of the major components (bulge, disk, halo, satellite system) of the Milky Way.

Specifically, our goals will be:

1 . The determination of two fundamental parameters that play a central role in virtually every problem in Galactic astronomy, namely

   (a) the solar distance to the center of the Milky Way, R_0

   (b) the solar angular velocity around the Galactic center, ω_0

2. The measurement of fundamental dynamical properties of the Milky Way, among them

   (a) the pattern speed of the central bar

   (b) the rotation field and velocity-dispersion tensor in the disk

   (c) the kinematics (mean rotational velocity and velocity dispersion tensor) of the halo as a function of position

3. The definition of the mass distribution of the Galaxy, which is dominated by the presence of dark matter. We intend to measure

   (a) the relative contribution of the disk and halo to the gravitational potential

   (b) the local volume and surface mass density of the disk

   (c) the shape, mass and extent of the dark halo of the Milky Way out to 250 kpc

Although we have divided the Key Project into several distinct projects, these projects are closely related and cannot be solved in isolation. For example, an accurate measurement of the Oort limit strongly constrains models of the spatial distribution of mass in the disk and the total mass of the inner halo, while an accurate determination of R_0 and Θ_{LSR} is needed to interpret the phase-space distribution of halo tracers and the kinematics of tidal tails. While the proposed SIM observations are meant specifically to address the definition of the fundamental structure and dynamics of the Galaxy, they also permit substantial inroads into numerous ancillary problems regarding stellar populations and the evolution of the Milky Way.

To the greatest extent possible, we will take advantage of the data already being obtained for sub-solar metallicity K giants in the SIM Astrometric Grid. These data, produced as part of the mission's baseline operations, will be supplemented by SIM observations of other targets, among them:(1) counterparts to the Astrometric Grid stars at greater distances, (2) a sample of disk Mira and Cepheid variables, (3) a sample of disk open clusters, (4) the brightest few stars in every Galactic globular cluster and satellite dwarf galaxy, and (5) stars in tidal tails of disrupted satellite galaxies and globular clusters.

While the primary goal of our Key Project is focused on the global spatio-dynamical properties of the Milky Way, and this goal dictates strictly the selection of our intended targets, we also intend to address the wealth of information these data will yield on Galactic stellar populations and the insight provided into the formation history of the Milky Way. Therefore, we intend to supplement the astrometric data with ground-based observations of abundances, radial velocities, and other properties, to maximize the benefits of the SIM data for analyses of stellar populations.

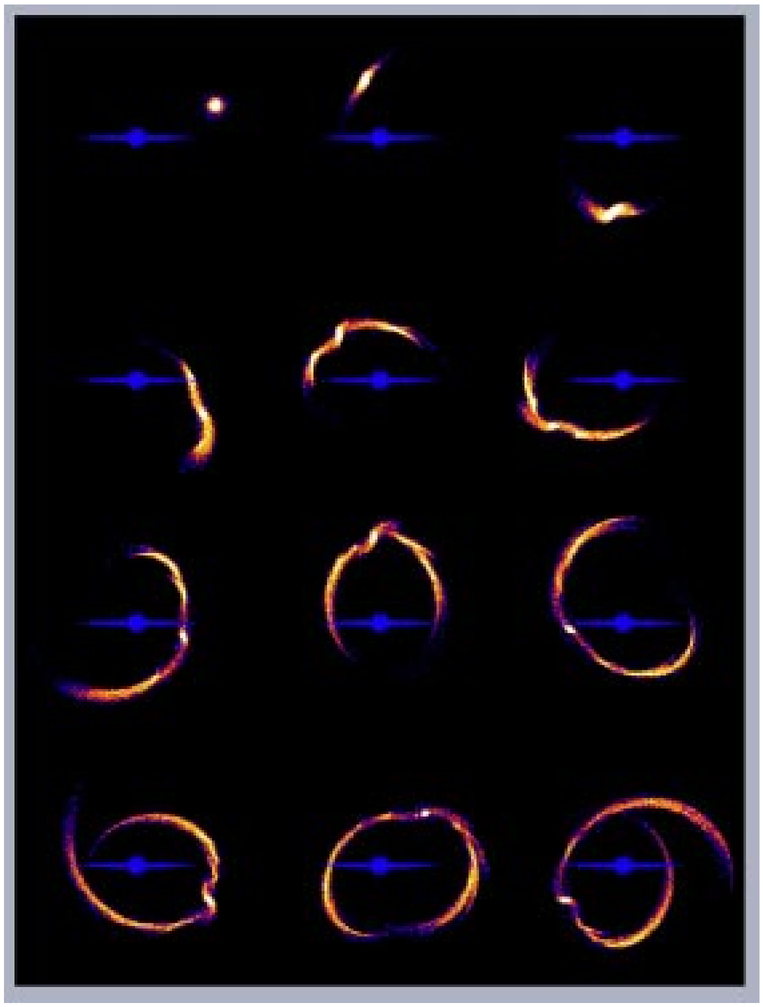

Figure 1: These images are taken from a simulation by K. V. Johnston of a satellite being torn apart by the Milky Way's tidal field. The simulation followed the satellite's evolution for several billion years. The Milky Way is represented in blue in the center, with the yellow satellite orbiting around it. The satellite itself appears much larger than it really is in these animations because the images were colored to emphasize the density of the stars being stripped from the satellite. We plan to use SIM to measure accurate proper motions of stars in the tidal debris streams of several Milky Way dSph satellites as a precise means to measure the Galactic potential as a function of radius in the halo.