Open and Globular Cluster Distances for Extragalactic, Galactic, and Stellar Astrophysics

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One of the hallmarks of SIM's few-milliarcsecond astrometric precision is its ability to obtain accurate parallax measurements across more than half of the Galaxy. On the Milky Way analog below, the best space-based parallaxes to date lie within the yellow dot marked "Sun".

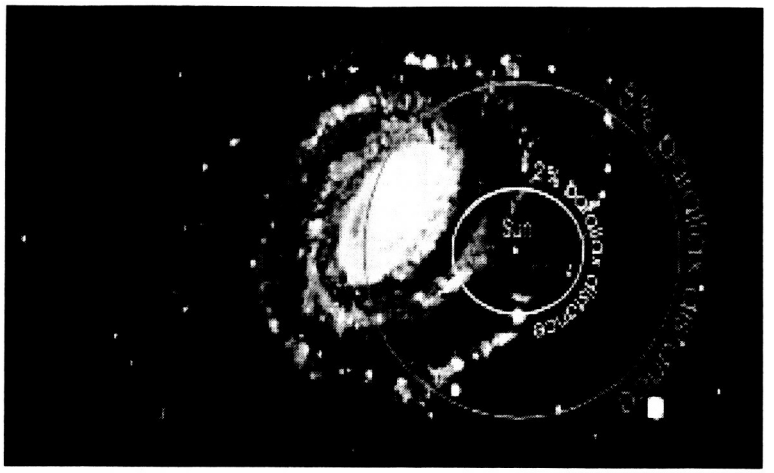

Figure 1: SIM's astrometric precision will allow parallax distances to be measured with 5% accuracy well past the Galactic center, and distances of stars within $\sim$ 3 Kpc to measured with less than 2% uncertainty. This 3 Kpc shell contains the "near half" of the traditional extragalactic distance ladder: RR Lyrae variables and Cepheid variables that range over all [Fe/H], plus many star clusters used for main-sequence fitting.

The "open and globular" project obtains parallax distances to a set of star clusters. One important goal is to pinpoint the zeropoint of the distance scale for main-sequence fitting. Another goal is to improve stellar evolutionary isochrones and integrated light models. Another goal is to use the clusters themselves to address unsolved problems of late-stage stellar evolution and Galactic and extragalactic chemical evolution. The clusters to be observed are chosen to span the widest possible range of abundance and age, to be as rich as possible, and to be as well-studied as possible.

- This project will solve all distance-scale issues involving main-sequence fitting. It will also vastly improve the precision of distance measurement techniques that depend on stellar colors or luminosity functions such as the surface brightness fluctuation magnitude method for local galaxies. In combination with other (guest observer) SIM projects to pinpoint RR Lyrae and Cepheid distances, one-percent extragalactic distances will be within our grasp, with a corresponding improvement in the precision of measurements of galaxy luminosities, sizes, large-scale flows, and dark matter content and a corresponding improvement in the cosmological parameters.

- This project will provide a definitive collection of star cluster color-magnitude diagrams for calibration of stellar evolutionary isochrones. With true distance measured with SIM and abundances from high-resolution spectroscopy, there will be virtually no "wiggle room"

for isochrone fits: any isochrones that are computed must pass through each cluster's color-magnitude diagram with least-square errors less than the post-SIM observational errors. There is an accompanying program of photometry and spectroscopy to insure that isochrones of almost any age and metallicity will have observational analogs available for comparison. I refer to this collection of parameter-spanning clusters as the "cluster network."

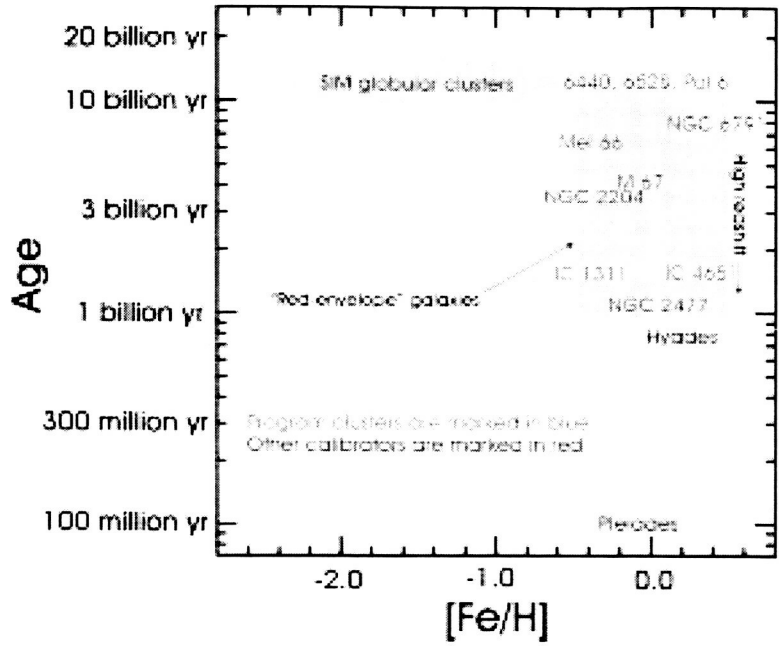

Figure 2: An age-metallicity diagram in which the targeted Galactic star clusters appear. The ellipse marked "SIM globular clusters" refers to the Chaboyer Key Project that targets the old, metal-poor cluster population. These clusters are also part of the "network," as are the nearby Hyades and Pleiades whose distances were pinpointed by Hipparchos. The ten clusters targeted by this proposal are marked in blue with ages between 1 and 12 billion years and [Fe/H] between -0.5 and +0.5. A box marked "red-envelope galaxies" refers to the appropriate age and metallicity range for non-star forming (red) galaxies at redshifts less than about 2. Longer lookback times at higher redshift mean that one is looking at younger galaxies.

- The "cluster network" calibration will yield better isochrones and better integrated-light models for use in studies of extragalactic stellar populations. The benchmark targets we have adopted are non-star forming galaxies at high redshift for which good spectra will be available by 2015. Our goal is to derive 5% mean ages for these galaxies, thus uncovering their formation history. The figure above illustrates the ages and abundances of the selected clusters in comparison to the parameter space of the target red envelope galaxies.

- In addition to these science goals, the "open and globular" project will support cluster age studies, Galactic chemical evolution studies through tie-ins to data on the rest of the Galaxy's open and globular clusters, extragalactic chemical evolution studies through synthetic integrated-light studies, and stellar evolution studies of the helium-burning stages of stellar evolution as manifested in the target clusters.