Synthesis Imaging at Optical Wavelength with SIM

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Synthesis Imaging with SIM

The Space Interferometry Mission (SIM) will be the first space astrophysics instrument to provide a capability for synthesis imaging at optical wavelengths, offering the promise of imaging high-surface-brightness targets with more than 4 times the best resolution attainable with the Advanced Camera on the Hubble Space Telescope. The present SIM design includes astrometric science interferometers at 8 and at 10 meters, and a guide interferometer at 5.5 meters which can also be used for science targets. By using data from all 3 baselines and combining observations taken at many small increments in roll angle, SIM can image a field of view of $\sim 1''$ with a resolution of FWHM $\approx 0.008''$ at λ500 nm. The point spread function (PSF) of the images produced directly from this data show many low-level spurious responses spread over the entire image. However, the truly incredible phase stability of SIM's interferometers means that these responses can all be calculated to a very high degree of accuracy, opening the way for the application of image restoration algorithms such as those popular in radio astronomy. Which restoration methods are best for SIM data, and how to incorporate additional constraints (such as HST imaging of the same fields), are topics of ongoing studies at the Space Telescope Science Institute in Baltimore.

Imaging Science with SIM

SIM imaging will be especially useful on crowded fields containing many high-brightness targets. Such fields include the central regions of galaxies out to the Virgo cluster (including active nucleii and jets), and the swarms of stars in the cores of Galactic globular clusters. There are indications that the central regions of some globular clusters may contain black holes, similar to the situation currently thought to occur in the centers of many galaxies. These massive objects dramatically affect the motions of nearby stars. Images made with SIM at several epochs spread over the lifetime of the mission will yield positions, proper motions, and perhaps even accelerations of cluster stars, providing unique new information on the masses of central black holes. If SIM were to fly tomorrow, we would plan on observing the nucleus of the nearby spiral M 31 and the central core of the Galactic globular cluster M 15 (see Figure 1); however, the specific targets to be observed first will be chosen a year or two before launch, depending on the latest developments at that time.

As an indication of the capability of SIM to image complex fields, Figure 2 shows a simulation for the nuclear star cluster in the core of M 31. The positions of stars as faint as V = 21 mag can be determined in this simulation to a precision of better than $0.0005''$. The motion of a typical star in this field will produce a position shift of $\sim 0.0008''$ after 5 years.

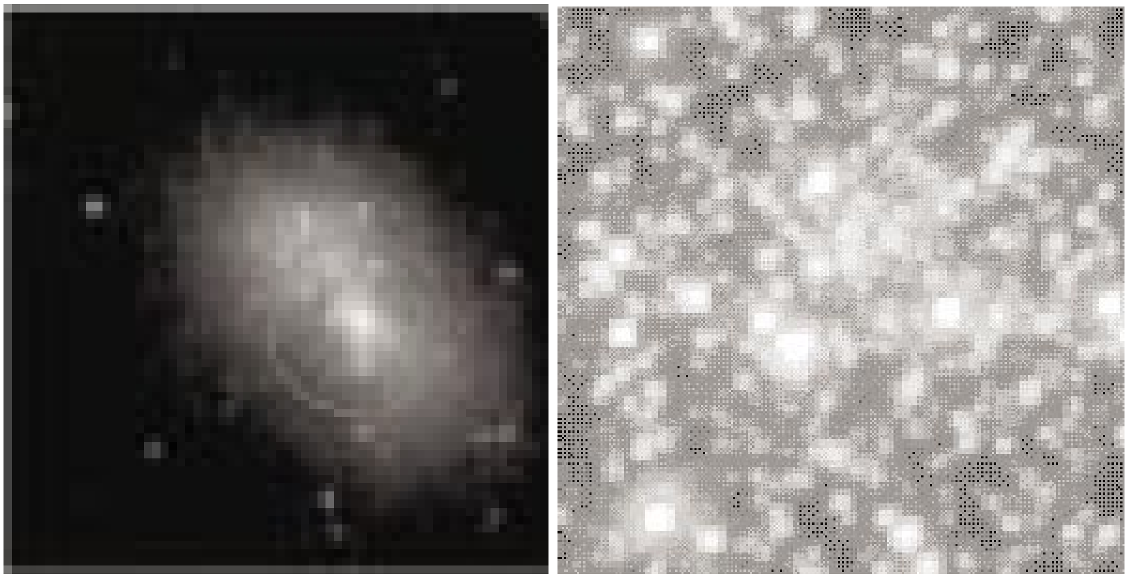

Figure 1: HST images of our two highest priority targets. a) The central 3.5″ of M 31 in a greyscale representation that emphasizes B-band and UV light. The circle denotes a 1.2″ diameter aperture, close to the expected SIM field of view. The SIM imaging-mode resolution will be $\approx 0.7\%$ of the size of the circle. b) The nuclear region of the globular cluster M 15 at the same scale as the left panel. The adopted stretch only slows the brighter stars ($V \sim< 17$); the proposed SIM data will yield proper motions for stars as faint as $V = 21$–22.

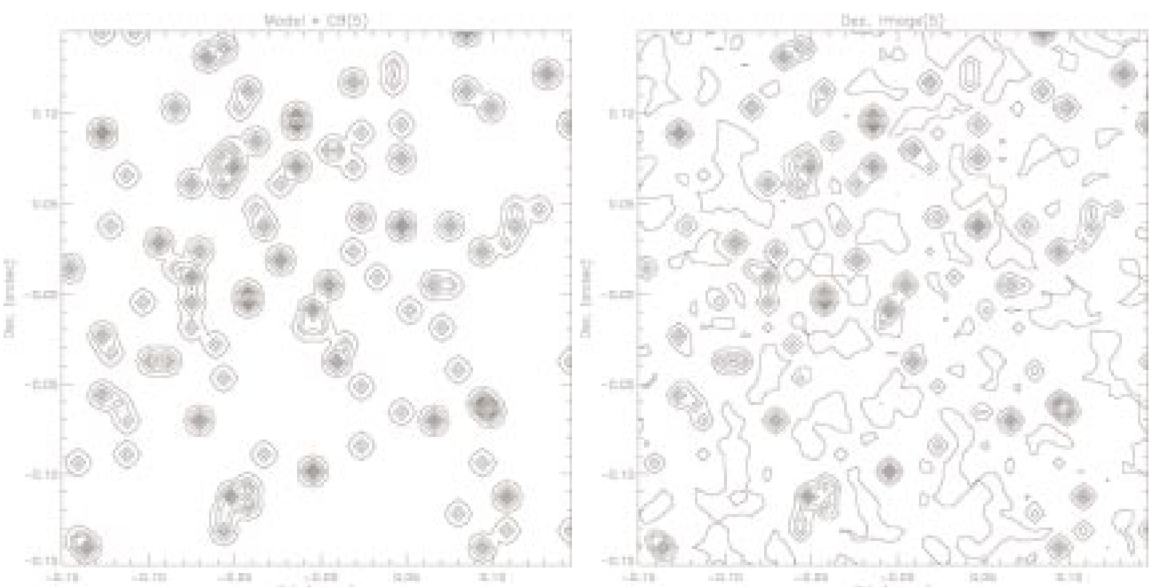

Figure 2: a) input source model for the nuclear star cluster in M 31. The stars in this simulation range from 21 to 23 mag in V. b) reconstructed image after 1200 CLEAN iterations. The simulation is for a total on-source integration time of 4 h and a "full" set of SIM baselines.