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THE SPACE INTERFEROMETRY MISSION (SIM) -- REVOLUTIONARY ASTRONOMY, BREAKTHROUGH TECHNOLOGY

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The Space Interferometry Mission (SIM), with a target launch date of 2009, will be one of the premiere missions in the Astronomical Search for Origins (ASO) Program, the bold NASA endeavor to understand the origins of the galaxies, of planetary systems around distant stars, and perhaps the origins of life itself. This adventure of discovery will be enabled by an explosive growth of innovative technology, as exciting in its own right as the underlying scientific quest.

Over the past several years a consensus has formed around the idea that space based optical interferometers operating in the visible and infrared wavebands represent the next great leap forward in astronomy and astrophysics. Interferometry is the only known method to significantly improve (by orders of magnitude) the angular resolution of current astronomical telescopes and thereby meet several key scientific goals of the 21st century: measurement of stellar diameters, resolution of close binaries, detection, imaging, and spectroscopy of extra-solar planets, and the precise measurement of galactic and cosmic distance scales. Interferometers lend themselves to space application due to their extremely efficient use of weight and volume to achieve the goals of high resolution, high sensitivity imaging and astrometry. SIM will mark the first scientific use of this revolutionary observing technique in space. If it succeeds, it will presage the flight of the Terrestrial Planet Finder (TPF) and other larger and more ambitious Origins interferometers.

It is not surprising that such a huge step forward in observational power requires a concommitant leap in technological sophistication. SIM indeed drives the state-of-the-art in optomechanical and optoelectronic systems as well as presenting daunting challenges in precise stabilization of lightweight deployable structures and coordinated computer control of numerous optical surfaces. At 10 meters, the SIM structure must be deployed to an accuracy of about 0.5 cm and then stabilized to better than a micron of vibrational motion. Mechanical disturbances arising at the reaction control wheels must be isolated from entering the structure by approximately a factor of 100 over a broad frequency band. Residual structural vibrations must be compensated for by high bandwidth optical control systems capable of stabilizing optical pathlength through the system to order of 1 nanometer. Beyond this precise level of control are optical position knowledge requirements that drive the need for laser metrology capable of measuring, at sub-100 picometer resolution, the relative motion of optical fiducials such as corner cube reflectors. Tying these sensor and actuator systems together will be close to 100 closed loop realtime computer controlled servos. This represents a significant challenge for system integration and autonomous on-orbit operation.

The Jet Propulsion Laboratory (JPL) has been working for the better part of the last decade to develop and test this technology. Progressing from the derivation and flow-down of requirements through the laboratory demonstration of technology at the component level, the JPL program is now at the point of demonstrating interferometer technology at the system level in representative ground integration testbeds as well as in space. The paper will describe this work and will discuss plans for future development culminating in technology readiness for the Space Interferometry Mission.