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SIM-Lite Instrument Description, Operation and Performance

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Abstract. SIM Lite Astrometric Observatory, a space borne mission to be located in a solar Earth-trailing orbit, will conduct high precision differential astrometry. During the 5-year mission, SIM Lite will search about 60 nearby Sun-like stars for exo-planets of mass down to one Earth mass, in the Habitable Zone of those stars. In addition, SIM Lite will survey the architecture of planetary systems of about 1000 stars of all ages and types. SIM Lite will also build a 4 micro-arc-second astrometric grid and perform global astrometry on a variety of astrophysics objects. The instrument consists of two Michelson stellar interferometers and a precision telescope. The Science interferometer is composed of two 50 cm collectors separated by a 6 meter baseline. The technology development was completed in 2005. The mission is now ready for full flight implementation.

The basic elements of a stellar interferometer are shown in Figure 1. Light from a distant source is collected at two points and combined using a beam splitter, where interference of the combined wavefronts produces fringes when the internal pathlength difference (or delay) compensates exactly for the external delay. The astrometric angle α between the interferometer baseline and the star can be found using the measured internal optical path difference x and the length of the baseline B. The external metrology system measures the distance between two fiducials (each made of corner cubes) forming the baseline and the internal metrology measures the optical path difference to the beam combiner from the two fiducials.

SIM Lite simultaneously employs two stellar interferometers and one telescope to perform astrometry. Precision astrometry requires knowledge of the baseline orientation to the same order of precision as the astrometric measurement. The second interferometer and the precision telescope acquire and lock on bright "guide" stars, keeping track of the uncontrolled rigid-body motions of the instrument, while the main interferometer switches between science targets, measuring projected angles between them. The guide interferometer measures the baseline orientation in the most sensitive direction while the high-precision telescope measures the baseline orientation in the other two directions.

Figure 2 shows the error budget for the planetary survey. 1.4 micro-arcsecond (μas) differential measurement accuracy between the target star and a set of reference stars can be achieved in 15 minutes in the narrow angle observation mode. The observation sequence starts with 15 seconds of observation time on the target star, T, during which interference fringes are collected. The observation is followed by about 15 seconds to slew and reposition the two siderostats and the optical delay line to acquire fringes on the first reference star, R1. Af-

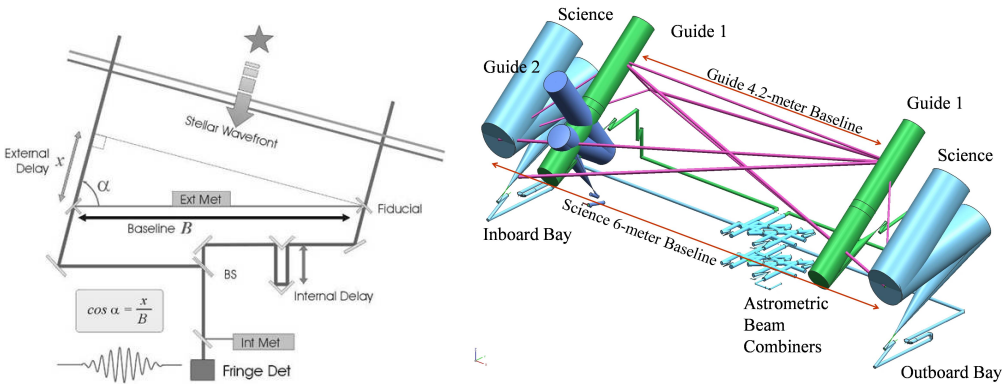

Figure 1. Astrometry with a Michelson stellar interferomete (Left picture). Optical configuration of the SIM Lite instrument (Right picture)

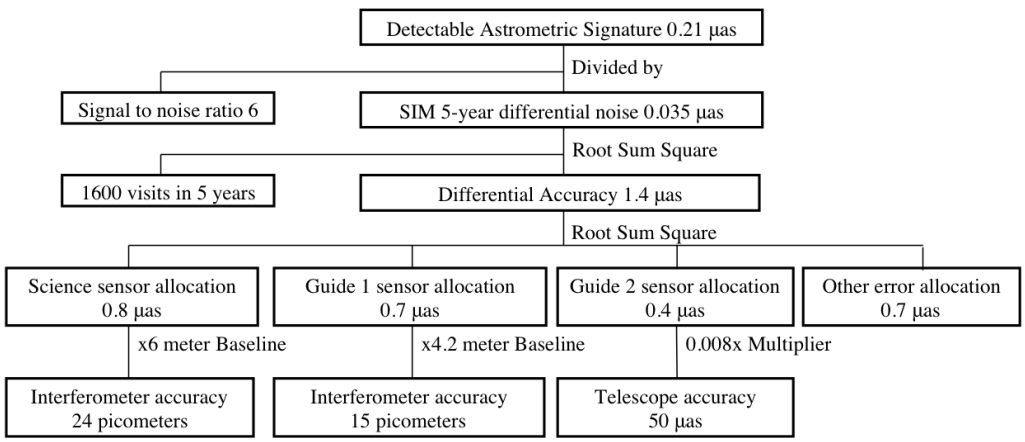

Figure 2. Narrow angle Differential Astrometry Error Budget

ter 30 seconds of observation on R1, the interferometer is slewed back to the same target star to be re-observed. Then, the instrument continue slewing and observing between the other reference stars and the target star. Once all the reference stars have been observed, the observation sequence is repeated from the beginning. After 1600 visits to the target star, sampled over 5 years, the astrometric noise is below 0.035 micro-arc-second, enabling detection of astrometric signatures of 0.2 micro-arc-second with a signal to noise ratio of 6. As a reference, the signature of the Earth is 0.3 micro-arc-second for an observer 10 parsecs away. The required performance of 24 and 15 picometers for the two interferometers and 50 micro-arc-seconds for the telescope has been experimentally demonstrated.

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