A Giant Step: from Milli- to Micro-arcsecond Astrometry
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Development of a very small telescope for a milli-arcsec space astrometry

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Abstract. We are preparing a reflecting telescope for Nano-JASMINE, a very small satellite for global space astrometry of milli-arcsecond accuracy. The telescope has a 5-cm diameter primary mirror and a beam-combiner in front of it. It occupies only about 12x12x17cm and is entirely made out of aluminum alloy. The telescope and its surrounding structures are carefully designed for thermal stability of the optics, especially to control changes in the relative angle of the beam-combiner.

Keywords. astrometry, space vehicles: instruments, telescopes

1. The Nano-JASMINE Telescope

Nano-JASMINE satellite, which weighs about 14kg, will survey all-sky in wavelength around z-band using a CCD in time-delayed-integration (TDI) mode. In this mission, we are going to demonstrate a global astrometry observation with a small satellite. In the case of success, a new astrometric catalog with a few mas accuracies could produce proper motions accurate to 0.1 mas yr^{-1}, when combining with Hipparcos catalog (Kobayashi *et al.* 2006).

For Nano-JASMINE, we are developing a very small telescope that is specified in Table 1. Similar to Hipparcos, we place a dual-angled flat mirror, called beam-combiner, in front of the primary mirror so that we could simultaneously expose two different field-of-views separated by 99.5 degrees in order to execute wide-field astrometry.

2. Developement and current status

We made all telescope parts, including the mirrors, out of aluminum alloy using an ultra-precise milling machine, however, we could not fabricate aspherical mirrors satisfactory (for details, see Suganuma *et al.* 2006). Figure 1 shows a picture of a proto-model of the telescope, together with its optical layout. A diffraction-limited performance of the telescope optics was confirmed both by wavefront measurements and imaging experiments.

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Table 1. Specifications of Nano-JASMINE Telescope

Effective Aperture	ϕ=5cm, divided into two by a beam-combiner.
Focal Length	167cm (F/33)
Optics Type	Ritchey-Chretien type, followed by three folding mirrors.
Field of View	0.5 × 0.5 deg
Basic Angle	99.5 deg
Wavelength	z-band ($\lambda \sim 0.9\mu$)
CCD	1024×1024 pix (1.76 arcsec/pix)
Operating Temperature	-50 - -100°C

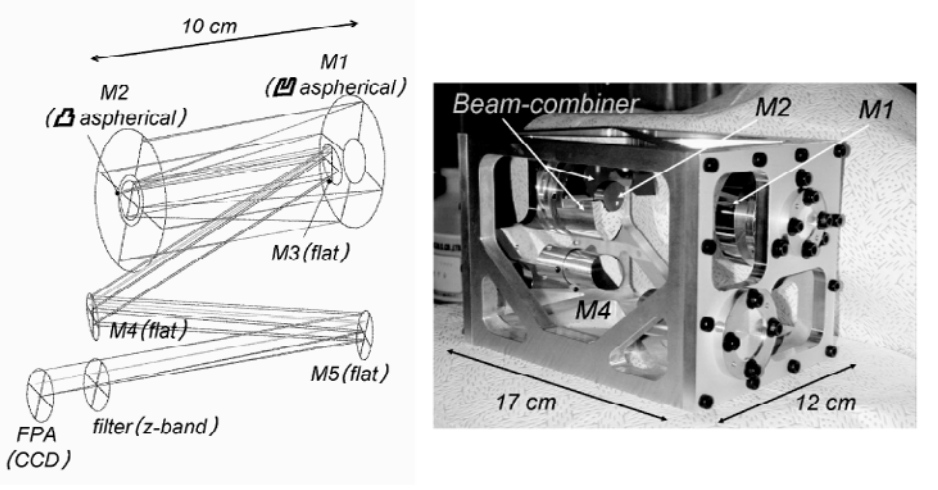

Figure 1. *Left:* Optical layout of Nano-JASMINE telescope. A beam-combiner that should appear around the M2 is omitted here. *Right:* Assembled proto-model of the telescope. All parts are figured out of aluminum alloy except the gold coat on the optical reflecting surfaces.

The surrounding structures are designed to cool down the telescope and the CCD radiatively below -50°C . Also, the telescope is well-insulated from exterior structures to minimize the thermal gradients in the optics and their time variation during the orbital period of the satellite. We made a realistic thermal design that passively controls the changes in the relative angle of the beam-combiner within a sub-milliarcsecond.

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