

Scientific goals of *Nano-JASMINE*

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Abstract. *Nano-JASMINE* is an ultrasmall Japanese satellite (with a weight of 35 kg), designed to carry out an astrometric mission. The target accuracy is 3 milliarcseconds (mas) for stars brighter than magnitude 7.5 at *z*w-band wavelengths of 0.6–1.0 μm . The observational strategy is the same as that of *Gaia* and *Hipparcos*. The time span of 20 years since the *Hipparcos* mission will enable us to update the proper motion data obtained at that time. With the help of these updated measurements, we expect that some stars will be resolved into multiple stars. In addition, taking advantage of the small primary mirror (with a diameter of 5 cm), we can measure bright stars which cannot be observed with *Gaia* because of saturation limits. The core data reduction for the *Nano-JASMINE* mission will use *Gaia*'s Astrometric Global Iterative Solution (AGIS). A collaboration between the *Gaia* AGIS and *Nano-JASMINE* teams was initiated in 2007.

Keywords. astrometry

1. Introduction

Nano-JASMINE is a challenging project with as goal astrometric observations of the entire sky using an ultrasmall satellite. The satellite bus system was developed by members of the Department of Aerospace and Aeronautics at the University of Tokyo, while the mission instruments have been developed by members of the National Astronomical Observatory of Japan and Kyoto University. The flight model was constructed in October 2010 (see Fig. 1), and system tests are almost completed. We use an old radio telescope, designed for astronomy, as a ground station to receive scientific data, achieving a downlink speed of 100 kbps.

This satellite mission was planned as the second global space astrometric mission. However, it will now become the third mission, following *Gaia*, since the launch site's construction has been delayed. It will achieve the same order of astrometric accuracy (2–3 mas) as *Hipparcos* (1 mas). As 20 years have passed since the *Hipparcos* mission, we will be able to measure proper motions with an order-of-magnitude higher accuracy by combining the data from that time with measurements which will be obtained as part of the current mission. The specifications of the satellite are listed in Table 1.

2. Scientific Goals

Nano-JASMINE will achieve the same order of accuracy as *Hipparcos*. The accuracy map was derived using the code written by *Gaia* members Daniel Michalik and Berry Hole. Fig. 2 is a relatively optimistic estimation of the errors. All issues which were taken into account for the *Hipparcos* data have been considered. Even if *Nano-JASMINE*'s performance would result in lower-accuracy measurements than those of *Hipparcos*, the number of stars we expect to observe with *Nano-JASMINE* is approximately 5×10^5 , which is approximately $4 \times$ larger than the number of stars observed by *Hipparcos* (1.2×10^5). Consequently, we can expect more refined results than obtained with *Hipparcos* in relation to some scientific themes, such as constraints on the parameterized post-Newtonian (PPN) formalism's γ parameter.

By taking advantage of the 20-year baseline, proper motion data will be updated by up to 0.1 mas yr^{-1} (see Michalik, this volume). This update leads to improvements of binary parameters, so that we expect that several stars will be identified as binary stars. Such an identification will not be feasible if we depend on either the *Hipparcos* data alone or the *Nano-JASMINE* data for 2.5 years of operations. A combination of both data sets is indispensable. Statistical information on kinematic motions of stars is a good tracer of the invisible 'dark matter' through gravity. *Nano-JASMINE* will achieve unprecedented accuracy for proper motions of stars in the solar neighborhood, enabling us to investigate the nature of dark matter.

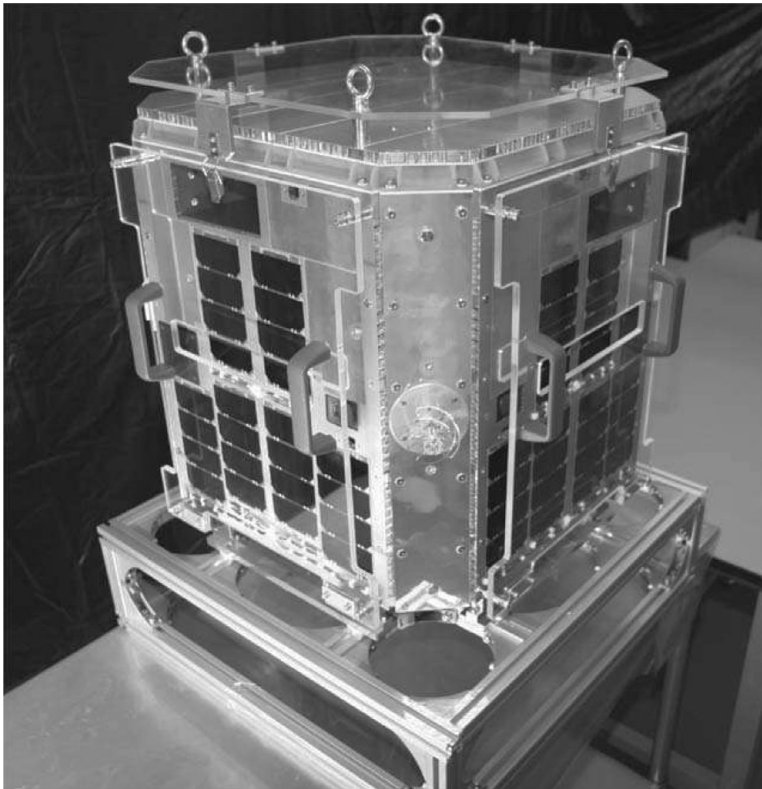


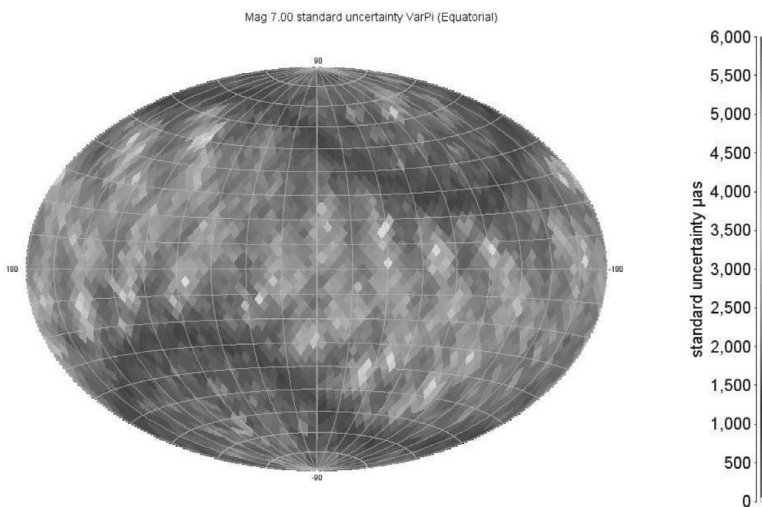
Figure 1. *Nano-JASMINE* flight model. The satellite was fabricated in October 2010 and its system tests have meanwhile been completed. Now that we have performed the regular 'health checks,' the satellite is ready for launch.

Table 1. Specifications of the *Nano-JASMINE* satellite and its catalogues.

Size	50 cm cubic form
Weight	35 kg
Launch date	November 2013–March 2014
Orbit	Sun-synchronous orbit at an altitude of 800 km
Obs. wavelength	<i>zw</i> band (0.6–1.0 μm)
Aperture size of the primary mirror	5.25 cm
Focal length	1.67 m
Detector	Full depletion CCD with 1k \times 1k pixels
Number of stars	520,000 stars brighter than ~ 9 mag 200,000 stars brighter than 7.5 mag
Position accuracy	2–3 mas @ < 7.5 mag, 3–4 mas @ 9 mag
Parallax accuracy	3–4 mas @ < 7.5 mag, 4–5 mas @ 9 mag
Proper motion accuracy	2–4 mas yr $^{-1}$ @ < 5 mag, 3–6 mas yr $^{-1}$ @ 9 mag ~ 0.1 mas yr $^{-1}$ @ < 7.5 mag (~ 0.2 mas yr $^{-1}$ @ 9 mag) combined with <i>N-J</i> and <i>Hipparcos</i> catalogs (see Michalik, this volume)
Catalog	2015 proper motion (half-mission data + <i>Hipparcos</i>) 2016–2017 all astrometric parameters (3 years of data)
Comments	We target stars fainter than ~ 2 mag. Other targets: Binaries

3. Data Analysis

The core data reduction for the *Nano-JASMINE* mission will be done with *Gaia*'s Astrometric Global Iterative Solution (AGIS). A collaboration between the *Gaia agis* and *Nano-JASMINE* teams for the *Nano-JASMINE* data reduction started in 2007.

**Figure 2.** Parallax accuracy map of *Nano-JASMINE* based on 2 years of observations.

A data analysis team in Japan performs the IDT (initial data treatment). This includes centroiding and identification of stars. Some members at the Tokyo University of Marine Science and Technology and at Shiga University also contribute to the development of the IDT software. The attitude model is based on a spline model as adopted for *Gaia* modeling. The orbital modeling is also based on spline interpolation of Global Positioning System data. Radiation damage of the CCD, pixel response, attitude smearing, and charge smearing due to TDI (time-delayed integration) operations have been incorporated in the centroiding tasks (Yamada *et al.* 2012).

Nano-JASMINE does not have detectors for photometry. This means that we need a reference catalog to obtain the colors of our target stars for astrometric correction. A reference database based on the UCAC3 has been created. We will perform all necessary simulations so that we can estimate the accuracy using this catalog, HILS (Hardware In The Loop Simulator) outputs, and a realistic noise model of the detectors.

Since *Nano-JASMINE* is supposed to be launched into a Sun-synchronous orbit, we predict that it will suffer from more significant attitude noise than *Gaia*, which will be operated near the second Lagrange point (L2). We are therefore working on attitude modeling using auto-regressive (AR) models, in collaboration with an IBM Tokyo Research team.

References

Yamada, Y., Hara, T., Yoshioka, S., *et al.* 2012, *ASP Conf. Ser.*, 461, 585