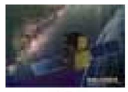
Current Status of Astrometry Satellite missions in Japan: JASMINE project series

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JASMINE Project series

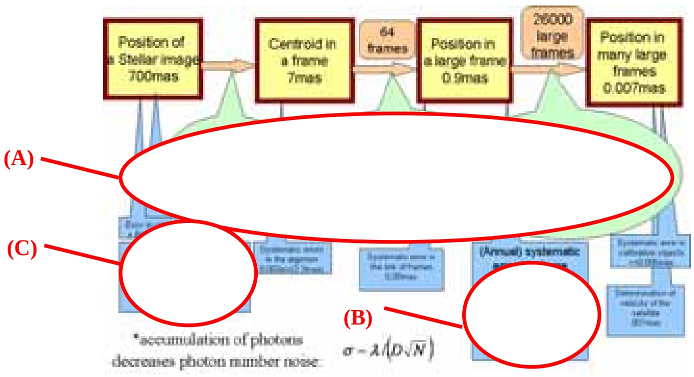
We are developing the following series of astrometry satellite missions at National Astronomical Observatory of Japan.

(1) Nano-JASMINE (an aperture size of 5cm with a weight of 35kg)
(2) Small-JASMINE (an aperture size of about 30cm)
(3) JASMINE (an aperture size of about 80cm)

These three projects have common technological issues. (A)Astrometry satellites are required to measure the positions of stars with high accuracy from the huge amount of data during the observational period. (B)The high stabilization of the thermal environment in the telescope is required. (C)The attitude-pointing stability of these satellites with sub-pixel accuracy is also required.

Technological issues for achieving our aim

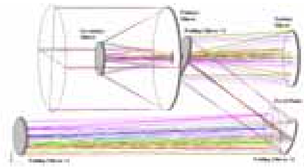
The figure shown below is the flow chart of achieving the target accuracy of astrometric parameters. In order to achieve our aim, we have the following three important issues. We show our status for each issue.



Instrument for Small JASMINE

Optics of JASMINE	Modified Korsch (3 mirror)
The diameter of the primary mirror	30cm
Focal length	4.9m
Focal plane on sky	0.87deg×0.87deg
Detector	HgCdTe
Target wavelength	2μm(1.5μm < λ <2.5μm)
Size of the detector	2K×2K
Pixel size	15 μm
Size of the detector	3cm×3cm
Number of detectors	4 (2×2)

	Material	thermal environment
Optics mirror	Fused Silica, CFRP	180K
Optics structure	CFRP	180K
detectors		80K



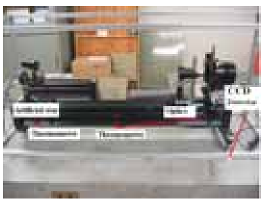
Requirement

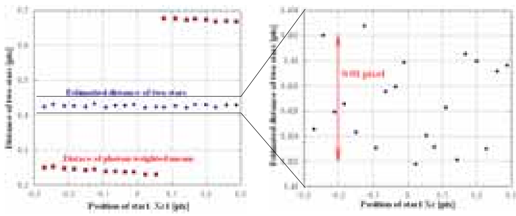
attitude control	0.1deg
attitude-pointing stability	280mas/3s
Thermal stability	~0.4K/0.25h @CTE10-7
orbit	Sun synchronous orbit altitude 600km

(A) Measuring the positions of stars with high accuracy

Measuring the positions of stars from a huge amount of data is the essence of astrometry. It is needed to exclude the systematic errors adequately for each image of stars in order to obtain the accurate positions. We have carried out a centroiding experiment for determining the positions of stars from about 10000 image data.

1. Determination of the position with a precision of about 10-2 pixel for one exposure

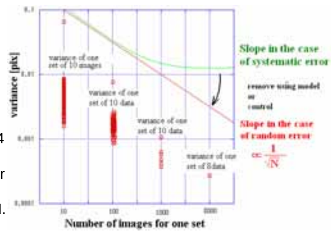




■Distance between the photon-weighted mean of two stars
◆Estimated distance between two stars
(Our algorithm are used: linear Correction)
We obtained the variance of less than 10^{-2}pixel for one exposure.

2. Determination of the position with a precision of about 10-4 pixel using about 104 images

We would like to determine a position of a star with a precision of about 10-4 pixel using about 104 images. However if there exist systematic error which we do not realize, variance does not decrease according to 1/√N.



variances decrease according to the slope in the case of random error. We do not find a systematic error which we do not realize.

(B) The high stabilization of the thermal environment in the telescope

In determining the position of stars with high accuracy from our observing data, we use the following algorithm.

Algorithm for our analysis

- Distortion of the image of the first and second order is solved from the observational data of adjacent images.
- We neglect the displacement of higher order (higher than third order) because the displacement is small enough.

We investigate the validity of our algorithm.

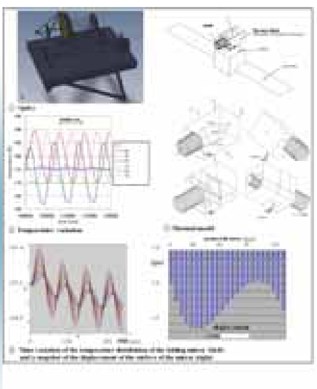
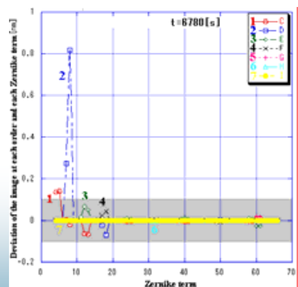


Image is distorted by the following deviation.
1. expansion or contraction of the mirror supporter
2. distortion of mirrors (especially in folding mirror 3)
3. distortion of the detector itself

Term 2 is the most important problem among these terms.

We examine the thermal structure analysis and obtain the distortion of images on the focal plane. Then we calculate the displacement of each order. First (red line) and second (blue line) order displacement are solved using the information of adjacent images. Then we do not care about the value of the first and second deviations. We require that more than third order displacement is less than the required value of 0.1 nm. As shown in the figure, The higher order displacement is less than 0.1nm.



(C) The attitude-pointing stability of these satellites with sub-pixel accuracy

We need high precision attitude-pointing stability with sub-pixel accuracy. Then, we develop a Tip-tilt mirror servo system in order to achieve a pointing stability with an accuracy of 280mas/3sec. We use star images for correction of pointing error. Now we prepare for experiment of TTM servo system.

TTM setup