Formation and Evolution of Galaxy Bulges
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JASMINE – design and method of data reduction

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Abstract. Japan Astrometry Satellite Mission for Infrared Exploration (JASMINE) aims to construct a map of the Galactic bulge with 10 μ arc sec accuracy. We use z-band CCD for avoiding dust absorption, and observe about 10 × 20 degrees area around the Galactic bulge region. Because the stellar density is very high, each FOVs can be combined with high accuracy. With 5 years observation, we will construct 10 μ arc sec accurate map.

In this poster, I will show the observation strategy, design of JASMINE hardware, reduction scheme, and error budget. We also construct simulation software named JASMINE Simulator. We also show the simulation results and design of software.

Keywords. astrometry, infrared:galaxies

JASMINE observes bulge stars with single telescope and creates accurate map with block adjustment algorithms. Each observation is corresponding to "Small Frame". By adjusting several thousand Small Frames with about 10 hours observations, we get a "Large Frame". Also by adjusting about 2000 Large Frames, we can get astrometric parameters of bulge stars with high accuracy.

The JASMINE telescope is three mirror system. The telescope has very long focal length because the PSF size should be larger than several pixels for centroiding. There are 4 plane mirrors to fold the long optical path. The diameter of the primary mirror is 75 cm, and the focal length is 22.5 m. So, the diffraction limit of our telescope will be about 100 milliarcsec. The size of each FOV is $0.7^\circ \times 0.7^\circ$. From the picture of each FOV, relative distance between stars in the FOV are calculated about 1/200 diffraction limit accuracy with about 10 second exposure. Observation covers the bulge 20 × 10 degrees region with about 5 year mission. By adjusting 10^7 FOVs, we can solve the astrometric parameters of 10 μ arcsec accuracy. It is very important to prevent or monitor the deformation of mirror and telescope frames for adjusting FOVs with high accuracy.

The average density of the stars with $z > 14$ is about 10000 per square degrees, in the galactic bulge. So we can adjust each frames with very high accuracy with the block adjustment algorithms. Several thousands of stars are observed within each "Small frame", we may expect that the accuracy of determining plate parameters is about 30 times better than that of each stellar observation from the simple statistical considerations. The problems in position estimation processes are some degeneracies to systematic deformation of FOV coordinates.

The CCD detector which is sensitive to z-band(0.9μm) is under construction in collaboration of Subaru telescope and Japanese company. It is back illuminated full depletion N-type CCD (see Kamata *et al.* 2006). We also consider the K-band array detector as another option.

As mentioned above, the stabilization or monitoring FOV size is important for controlling cumulative errors. For the purpose of monitoring the length variation of the "Small frame", we are now developing high accuracy angle monitor with laser interferometer. By using laser interferometer technique which is developed in the gravitational wave detection, deformations of instruments will be monitored. We are now constructing heterodyne Mach-Zehnder type laser interferometer as the geometry monitoring instrument for JASMINE telescope.

Because the density of stars are very high in bulge region, the beam combiner is not needed, which is used in HIPPARCOS and GAIA for avoiding accumulate error in plate adjustment. Our satellite has single telescope without beam combiner and like the ordinary space telescope. We are also constructing the data reduction schemes. Different from HIPPARCOS, we observe very dense region and a part of celestial sphere, some reduction method which is confirmed in HIPPARCOS mission may not be applied. There are some systematic errors which originate from the partial observation. For avoiding errors, we are also reconsidering the data reduction schemes.

We have already done some preliminary numerical computations. From these simulations (see Yamada *et al.* 2007a), it is very important to monitor the time variations of viewing angle. By modifying the data reduction algorithm, requirements for the angular size stability becomes 10 times smaller than ordinary reduction algorithm.

For checking observational strategy and accuracy, we are now constructing a simulation tool named "JASMINE Simulator" (see Yamada *et al.* 2007b). This software is designed to do end-to-end simulation of JASMINE observation. The software includes both the galactic model and satellite model, and it can adopt very wide range time-scale simulations, from photon level to mission lifetime.

Mission component such as telescope, detector, OBC, attitude control system, etc. are implemented as Observer and Observable. These are designed to get event, treat it, and throw event to down stream components. Each photon, control signal, and disturbance is implemented as "Event".

Now we are planned to Nano-JASMINE, the technical demonstrator for JASMINE mission. The simulator frameworks and implementations of each component are also applied to Nano-JASMINE and will be checked.

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