New Method for Astrometric Measurements in Space Mission, JASMINE

Taihei Yano, Naoteru Gouda (National Astronomical Observatory, Japan), Yoshiyuki Yamada (Kyoto University)

JASMINE

JASMINE is the acronym of the Japan Astrometry Satellite Mission for Infrared (z-band :0.9 micron) Exploration, and is planned to be launched around 2015. The main objective of JASMINE is to study the fundamental structure and evolution of the Milky Way Galaxy. Another important objective is to investigate stellar physics. In order to accomplish these objectives, JASMINE will measure trigonometric parallaxes, positions and proper motions of about ten million stars during the observational program, with the precision of 10 microarcsec at z =14mag.

Instrument

Optics of JASMINE	Modified Korsch(3 mirror)
The diameter of the primary mirror	75cm
Focal length	22.5m (F30)
Size of the focal plane	25cm×25cm
Focal plane on sky	0.63deg×0.63deg
Detector	Back Illuminated Fully Depleted
Target wavelength	0.9μm
Size of the detector	2K×2K
Pixel size	15 μm
Size of the detector	3cm×3cm
Number of the detector	64 (8×8)
Pixel on sky	140mas

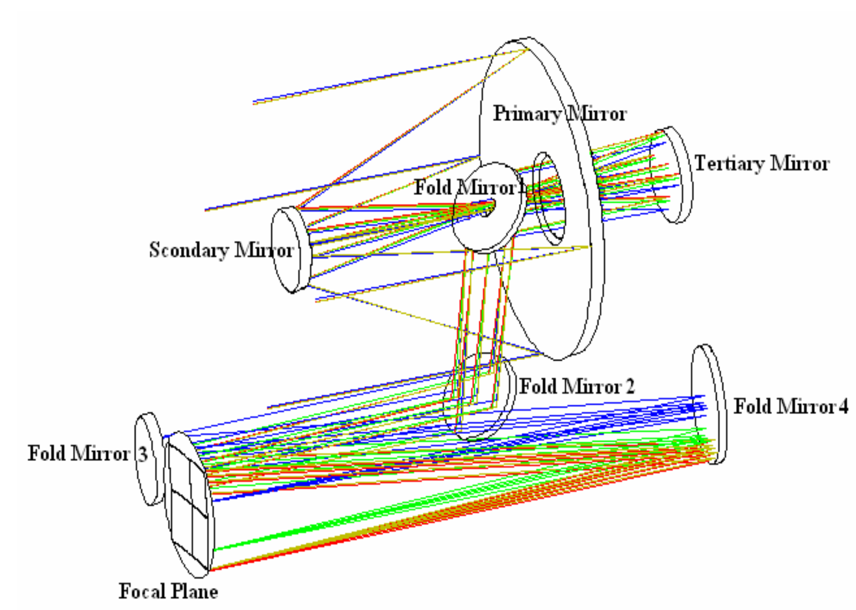
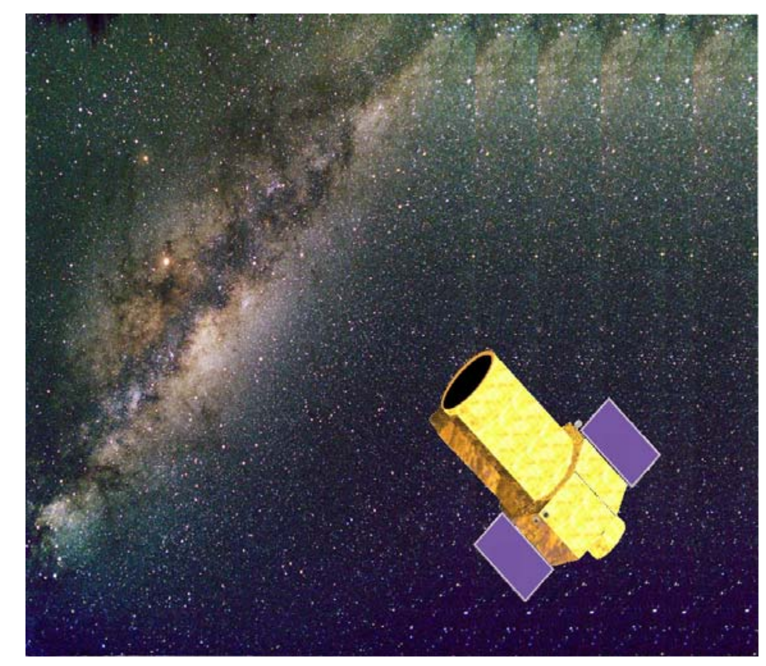


Fig 0 Optics of JASMINE(3mirror system)



An artist's impression of JASMINE

Method

The telescope is designed to have only one field of view, which is different from the designs of other astrometric satellites like Hipparcos and GAIA. JASMINE will take overlapping fields of view without any gaps to survey an area of about 20°×10°around the Galactic bulge (See figure 1). Accordingly we make a ``large frame'' (20°×10°) by linking the small frames(0.6°×0.6°) using stars in the overlapping region. JASMINE will observe the restricted regions around the Galactic bulge repeatedly during the mission life of about 5 years.

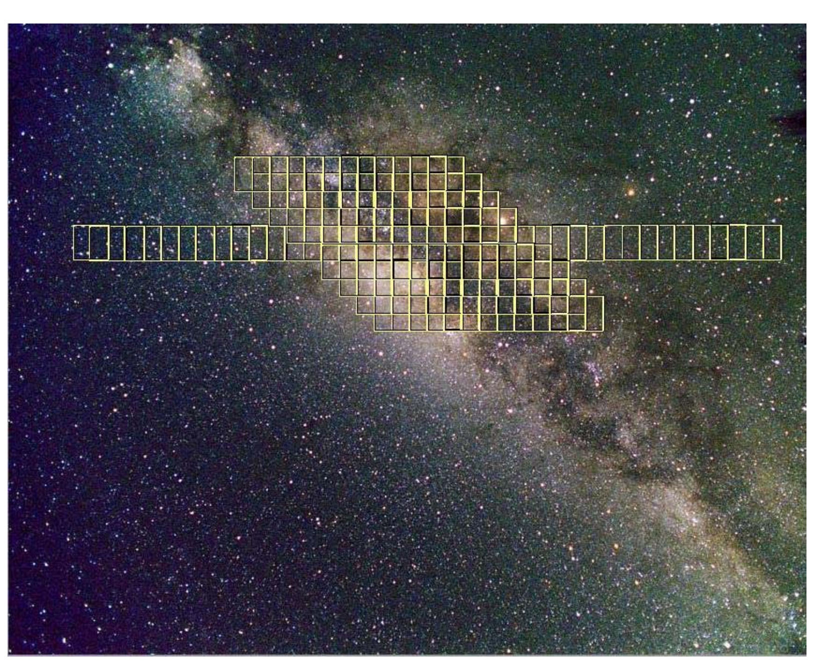
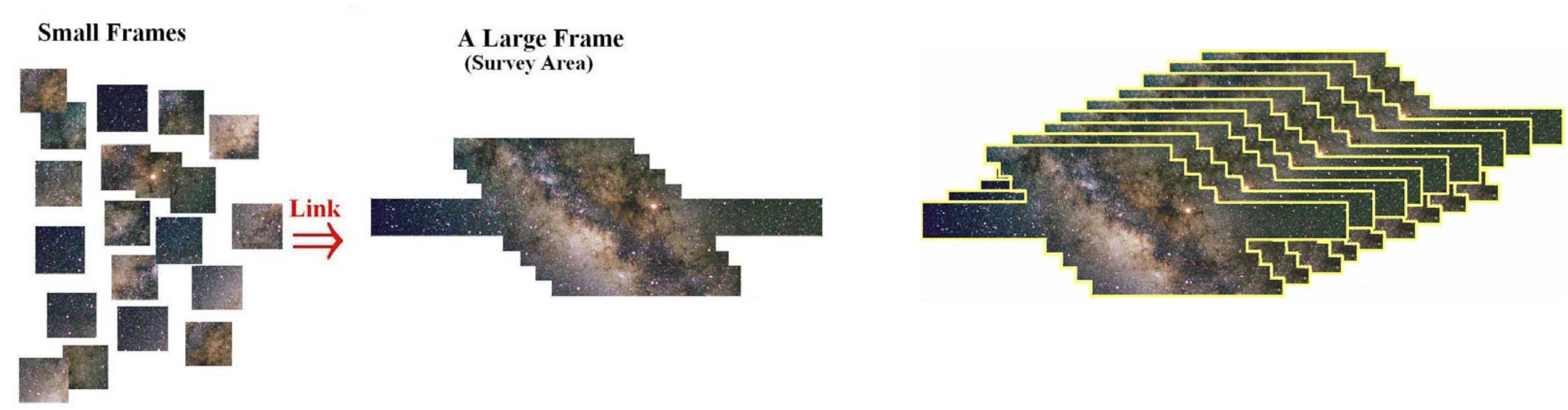


Fig 1



Summary of the Procedures

The procedures of our method for measuring astrometric parameters of Galactic bulge stars can be summarize in three steps.

1. Centroiding of stars
The centroids of stars in a field of view are determined using a photon weighted means of stars (Yano et al. 2004). Consequently positions of stars in a field of view (hereafter we call small frame) is obtained.

2. Construction of a large frame
JASMINE will take overlapping fields of view without any gaps to survey an area of about 20°×10°and a long and narrow region with the angle of about 60°shown in Figure 1.
During this time (about 14h) variations of the optical equipments are measured using a laser interferometric monitor to correct them. Then we connect all small frames to make positional relations of stars in a large region shown in Figure 1(hereafter large frame). Accordingly a large frame is obtained.

3. Estimations of the parallaxes of stars
We continue the above procedure about 3000 times during the mission life. We derive the astrometric parameters such as parallaxes of stars using these large frames.

About procedure2

-Correction of the distortion of an image-

It takes about 14 hours to overlap fields of view without any gaps to survey an area of about 20°×10°. During the time scale of the 14 hours, optical equipments have the variation in size. The variation will be measured using the laser interferometric monitor with high precision. We equip two monitors measuring the length of the focal plane, and the other, the length between the primary and secondary mirrors. Accordingly we model all of the small frames in a large frame in the following way,

$$X=x+a_0 + \{a_1(1+ k_1 dL_1/L_1+dL/L) + dL/dL\}x + a_2 (1+k_2\, dL_1/L_1+2dL/dL)x^2 + a_3(1+k_3\, dL_1/L_1+3dL/dL)\, x^3$$

where L, dL are the length of the focal plane and its variation, respectively, and L_1, dL_1 are the length between the primary and secondary mirrors and its variation, respectively.

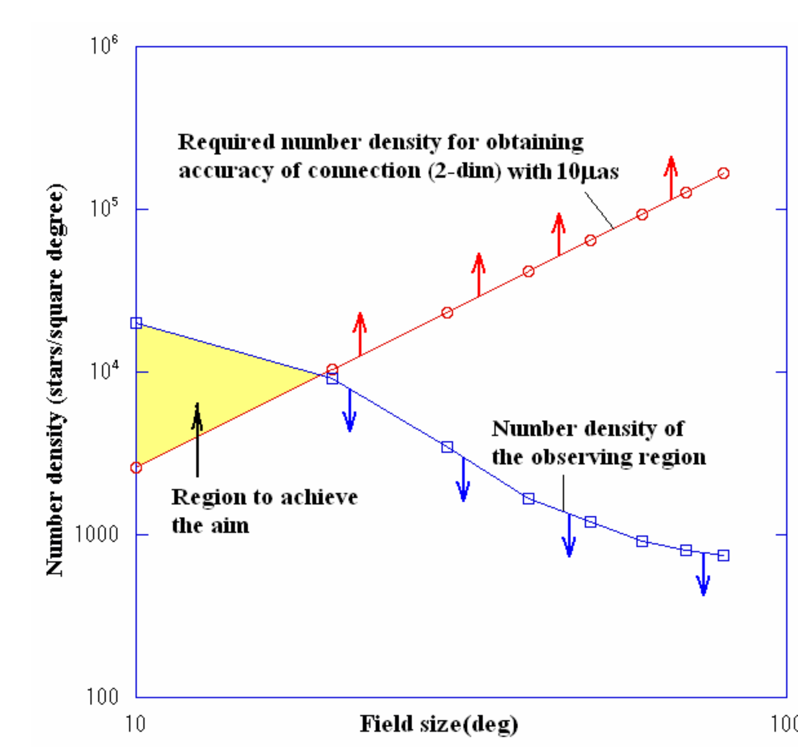


Fig 2 Reqired density for observing region

About procedure2 (Fig 2)

In order to acieve the accuracy of the aim, the required number density is obtained according to the length of the connection. From the figure 2, we can connect the small frames of about 20°×10°with the aimed accuracy.
⇒observing region becomes 20°×10°.

About procedure3 (Fig 3)

In order to derive the astrometric parameters such as parallaxes of stars, we use all the large frames obtained during the mission life. The sizes of all large frames are different from each other. In order to correct the variation, we need the long and narrow region (hereafter arm region) from the both side of the observing region shown in Figure1. In order to obtain the correction for the variation of the field size with the aimed accuracy, the required number density is shown in Figure 3. According to the length of the arm region, the required number density decrease. Therefore if we have the arm region with about 60deg, we can obtain the required density to achieve the aim. We also obtain the required density to connect the small frames with high accuracy.
⇒Length of the arm region becomes 60deg

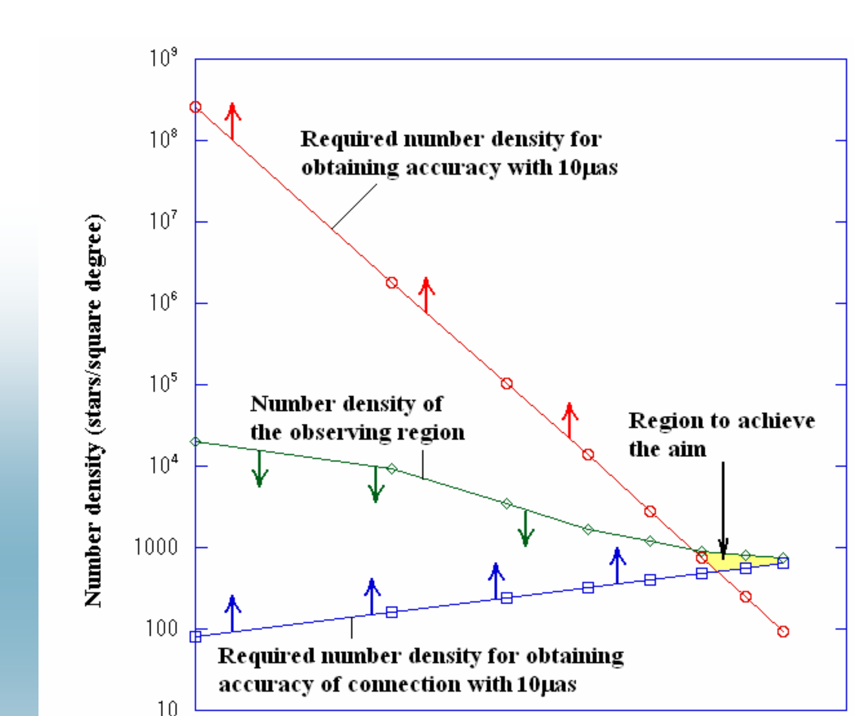


Fig 3 Required density for the arm region