

**30th Inter-Agency
Space Debris Coordination
Committee (IADC) Meeting**

***Light curve observation of LEO
objects at the innovative technology
research center of JAXA***

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Abstract

- We succeeded in determining the shape and motion of one LEO object using light curve data taken by an optical telescope.
- The axial ratio of the LEO object is 100:18:18. The coordinates of the rotational axis' direction in the celestial sphere are R.A.=305.8° and Dec=2.6° .

The rotation period is 41 seconds.

- These results show light curve observations with optical telescopes are sufficient to determine the shape and the motion of LEO debris.

Lightcurve Observation of LEO target

Site: JAXA/Chofu, Tokyo

Date: 2004/1/6, 8, 2/16, 17, 19, 23

Equipments: The 35cm telescope mounted on the 3-axial equatorial mount, The fast read-out CCD camera

Target: cosmos 2082 rocket body

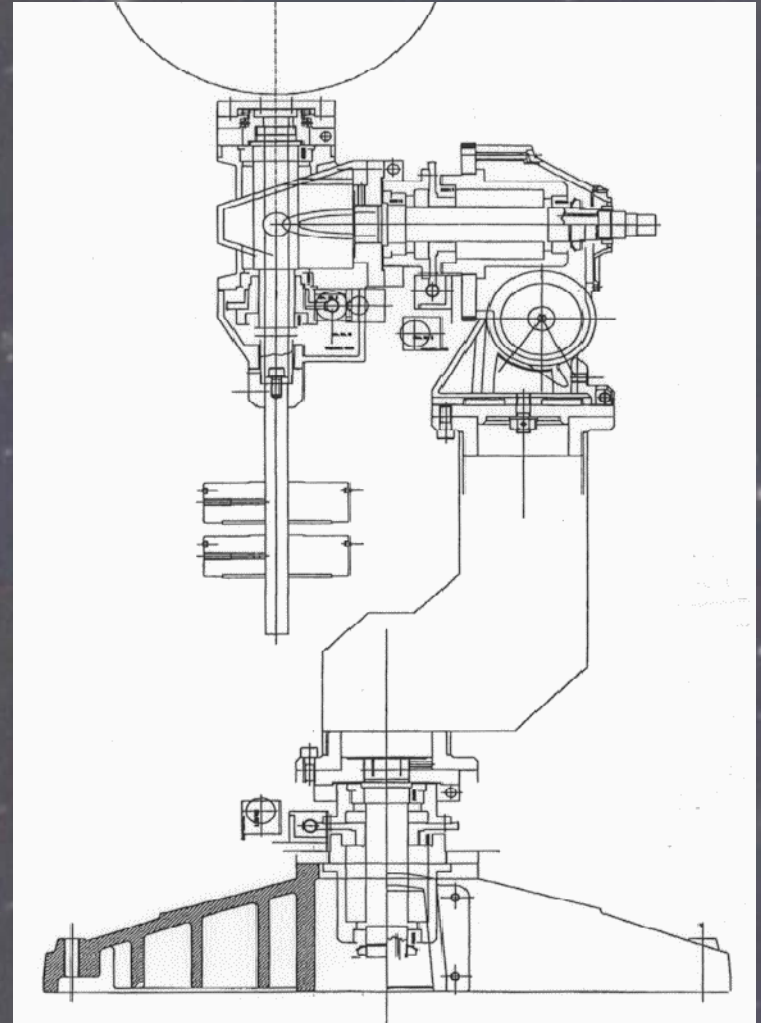
Exposure time : 10ms-100ms

Number of images: 1000-1600 frames



Observation Equipment

- *3-axial equatorial mount*
- No singular point in the celestial sphere
- 5-phase stepping motor for each axis
- Auto tracking controlled by PC
- Auto adjustment by the chaotic algorithm or the hand set.
- Manufactured by A.E.S.



Observation Equipment

- *Main telescope and Fast read-out CCD camera*

- Main telescope: Vixen SC355L

Diameter 350mm, Focal length 3910mm

- Fast read-out CCD camera:

N.I.L. ICC-130M

Chip: SONY ICX085AL

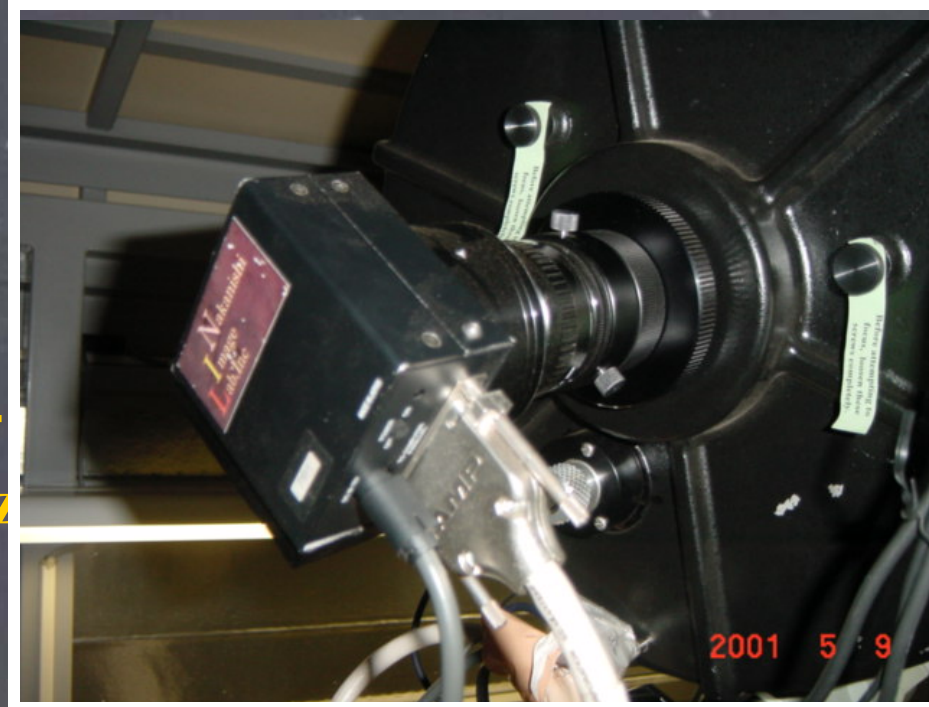
Pixel size: $6.7 \mu\text{m} \times 6.7 \mu\text{m}$

Number of pixel: 1280×1024

A/D conversion: 12bit/18MHz

Cooling: Perche

Field of view: $7.6' \times 6.1'$



Observation of cosmos 2082 rocket body

SSC N: 20625

International N: 1990-046B

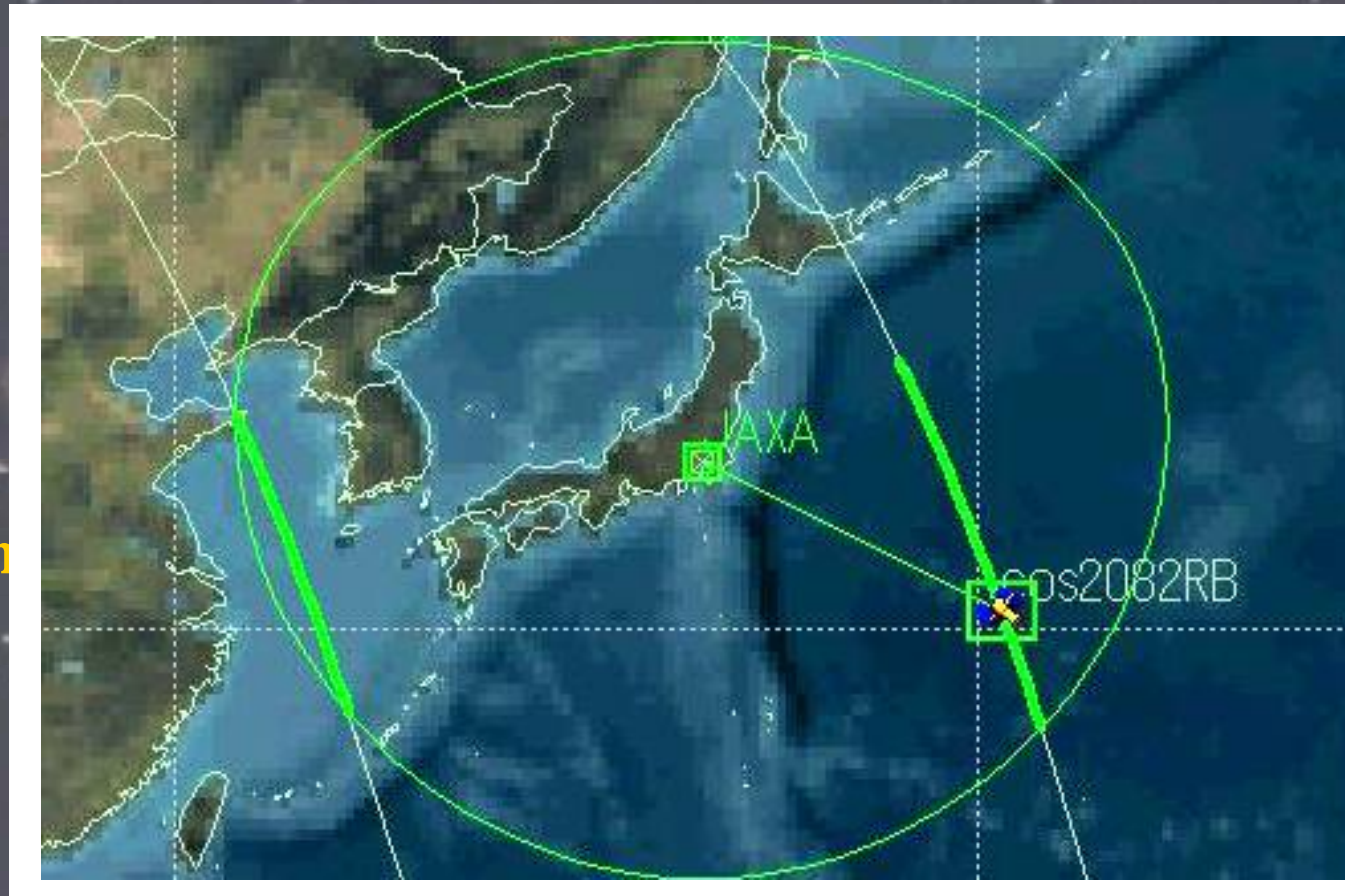
Owner: USSR

Apogee: 855km

Perigee: 834km

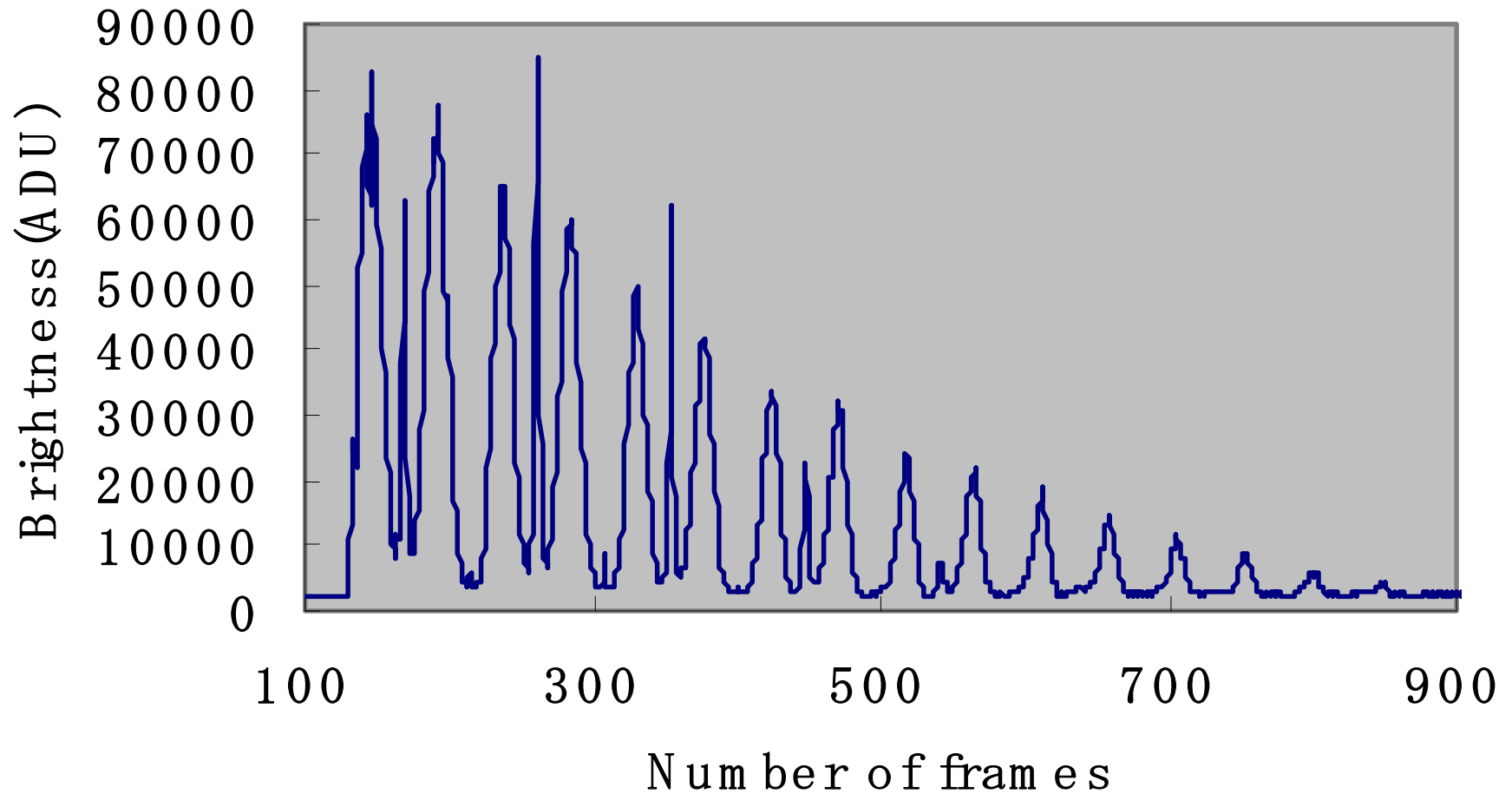
Inclination: 71.0°

Period: 101.8 min



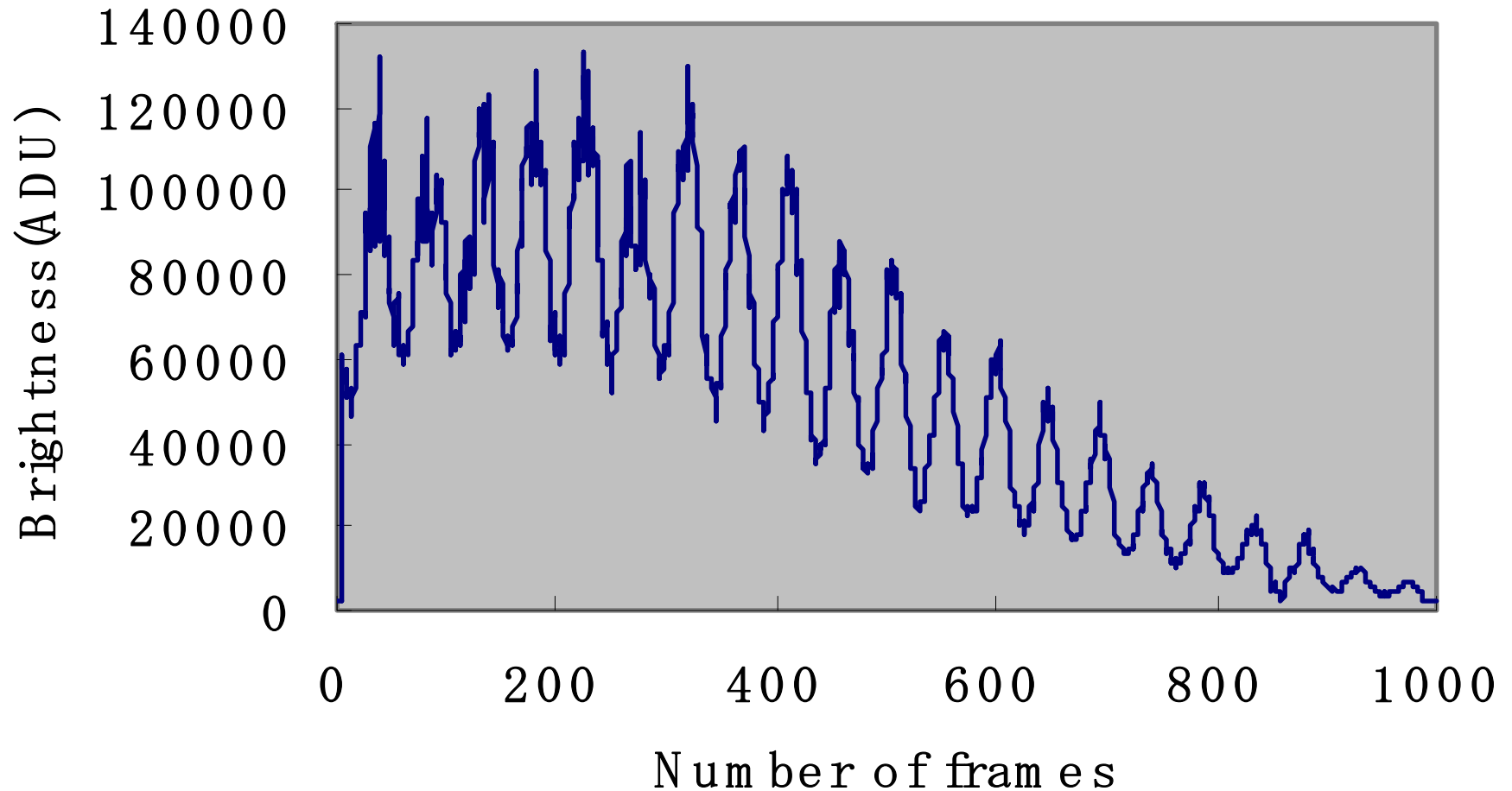
Two passes of cosmos 2082 rocket body on January 6

Observed light curve 1



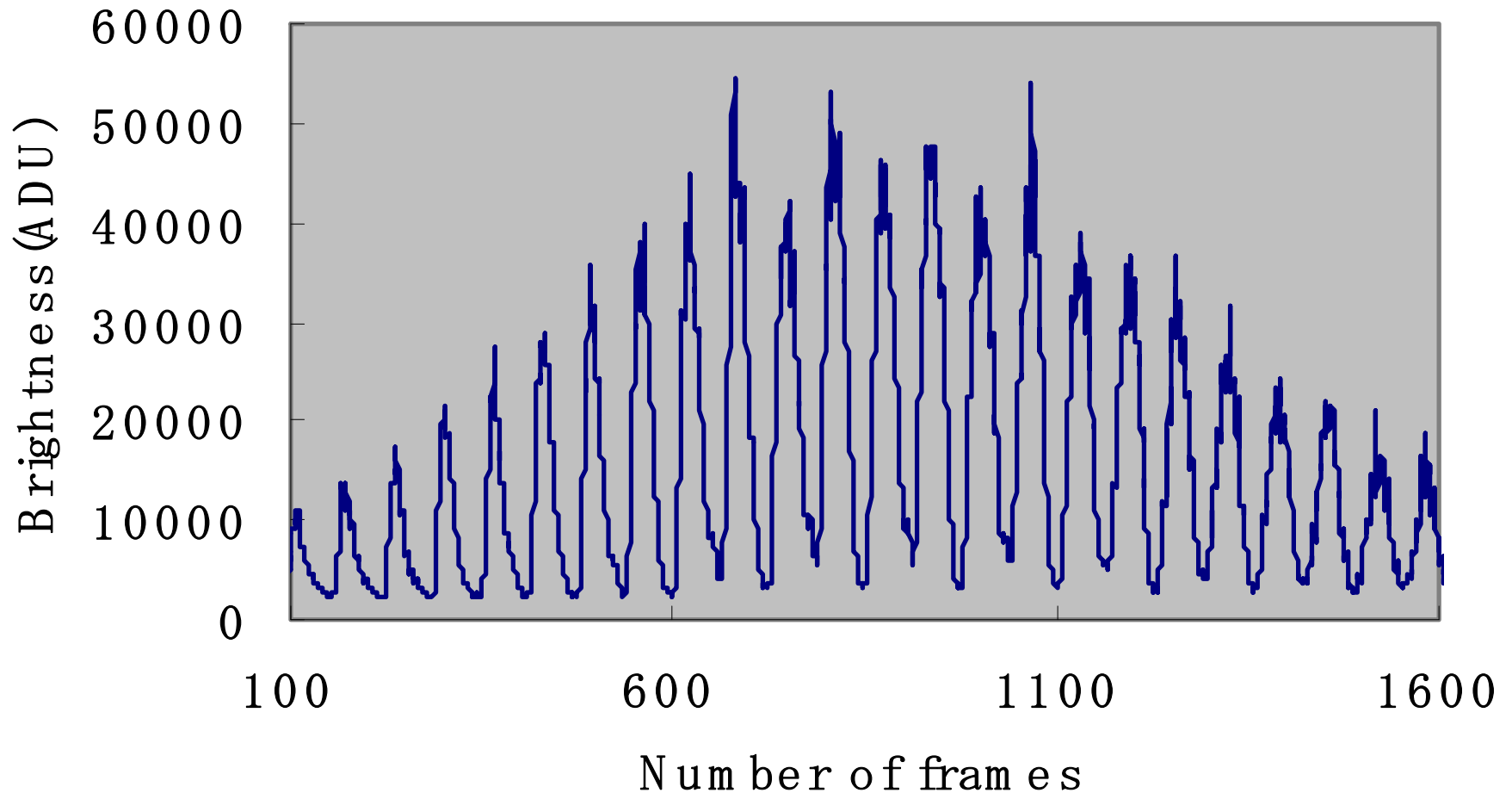
Light curve of the first pass on January 6.

Observed light curve 2



Light curve of the second pass on January 6.

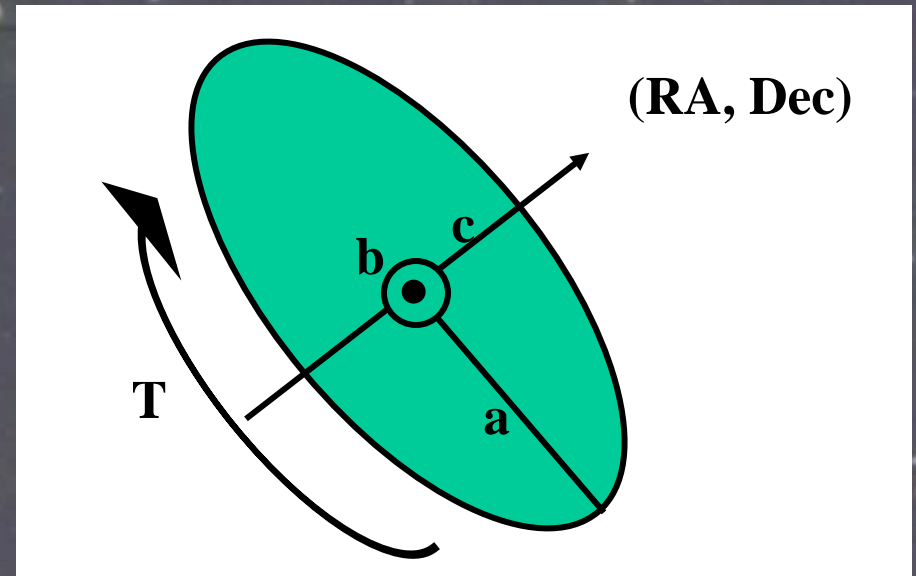
Observed light curve 3



Light curve of cosmos 2082 on January 8.

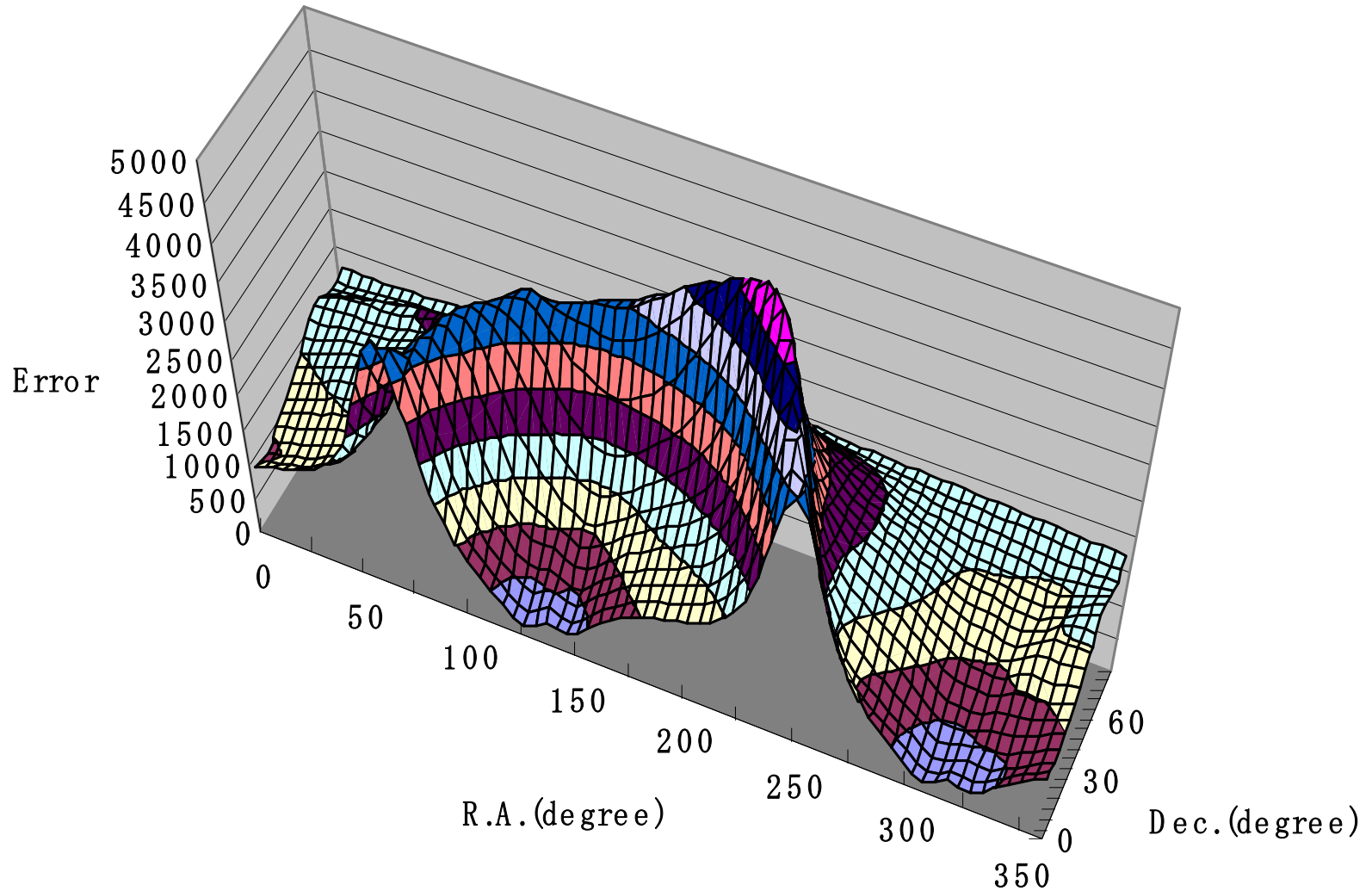
Analysis 1

- The motion and the shape of the target are estimated from these light curves.
- We assumed 1) the shape of target was a tri-axial ellipsoid, 2) it is rotating around the shortest axis and 3) the rotation axis is fixed in the celestial sphere.
- The axial ratio of the tri-axial ellipsoid, $a:b:c$, the celestial coordinates of the rotation axis' direction, (RA, Dec) , and rotation period, T are inferred using the method of least squares.



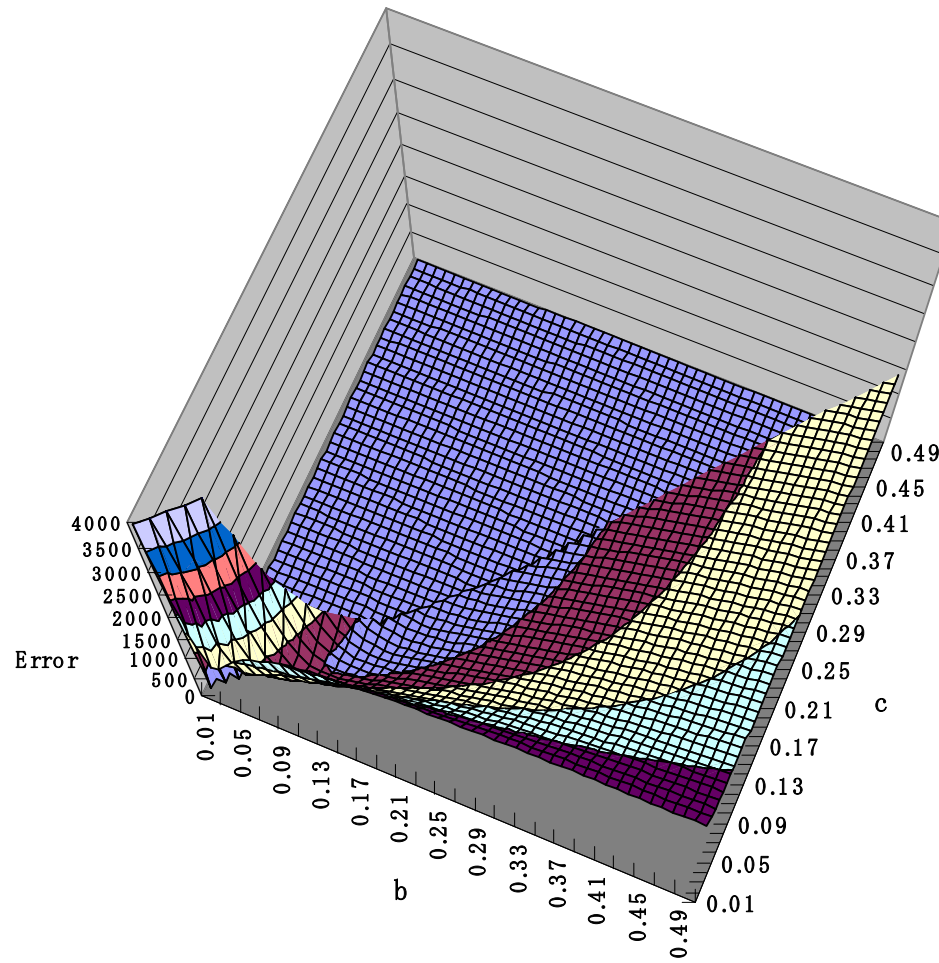
Result

Error distribution of rotation axis' direction in the celestial sphere.



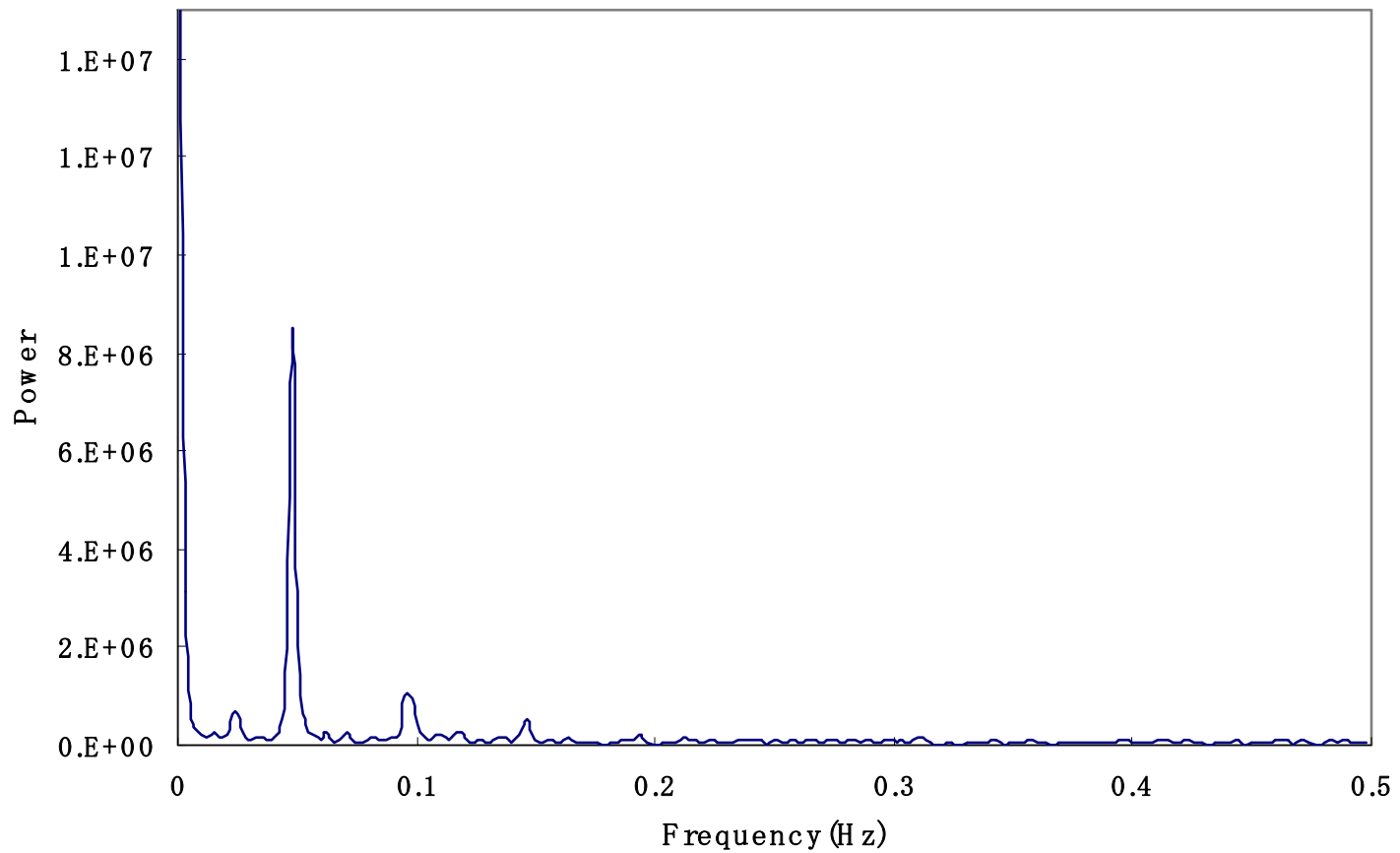
Result

Error distribution of b and c values (value of a is assumed to be 1.).



Result

Frequency vs power of Fourier transformation



Result

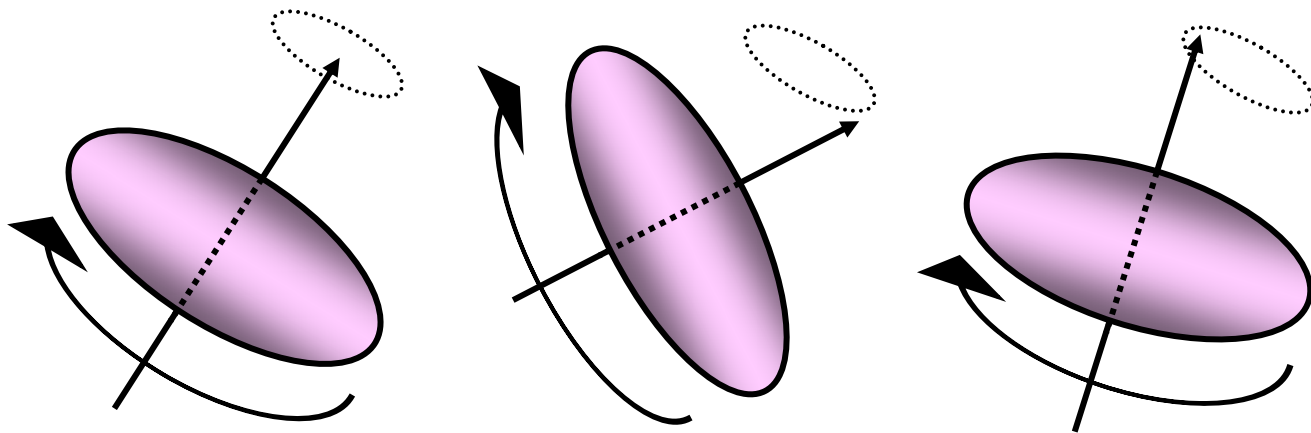
$$b = 0.18^{+0.61}_{-0.06} \quad c = 0.18^{+0.19}_{-0.14}$$

$$R.A. = 305.8^{+37.1}_{-37.1} \quad Dec. = 2.6^{+24.8}_{-24.1}$$

$$T_c = 41.0 \pm 0.68 \text{sec}$$

Analysis 2

The precession of the rotation axis is considered.



Result

$$b = 0.18^{+0.030}_{-0.027} \quad c = 0.18^{+0.153}_{-0.102}$$

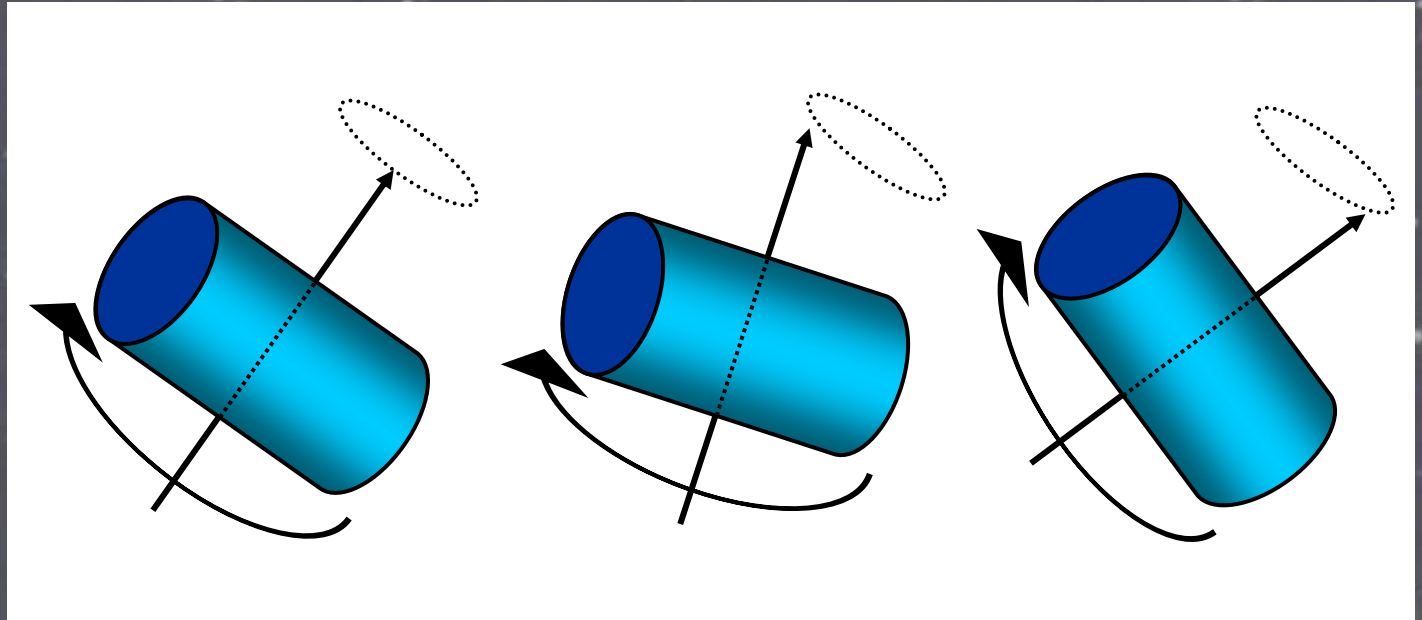
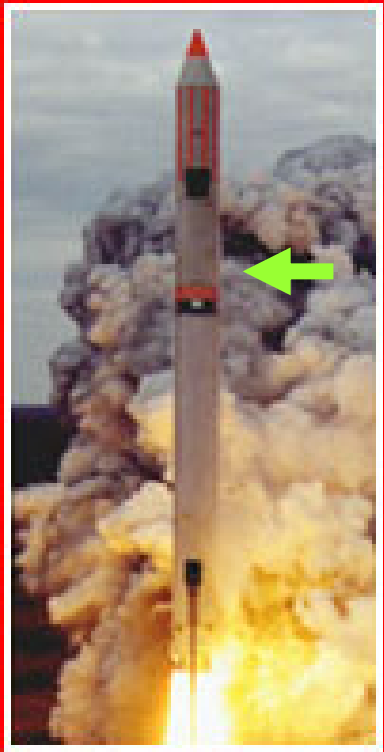
$$RA_0 = 302.9^{+8.46}_{-6.66} \quad Dec_0 = 5.4^{+6.00}_{-5.61}$$

$$D = 30.5^{+6.84}_{-7.08}$$

$$T_p = 1764.0 \pm 0.14 \text{ sec}$$

Analysis 3

More realistic model is considered.



2nd stage of Zenit2 rocket

D:3.9m L:10.4m

Result

$$R = 0.60^{+0.21}_{-0.18}$$

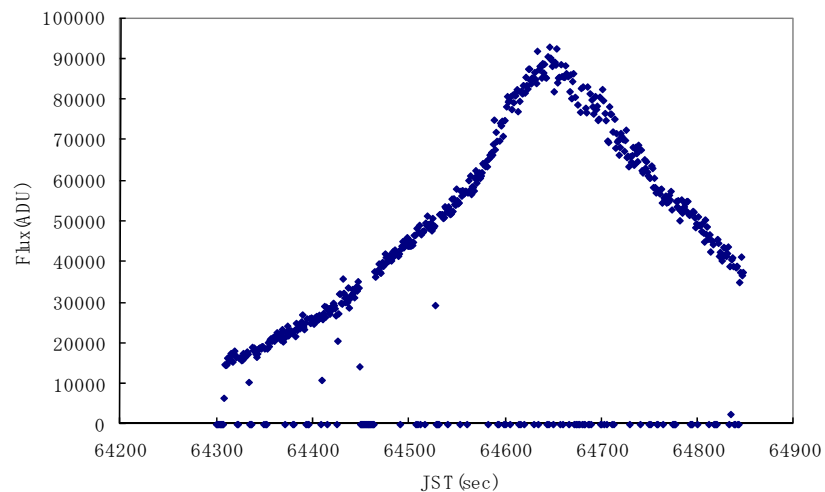
$$RA_0 = 301.6^{+5.16}_{-6.03} \quad Dec_0 = 7.3^{+3.75}_{-4.11}$$

$$D = 29.5^{+6.87}_{-5.73}$$

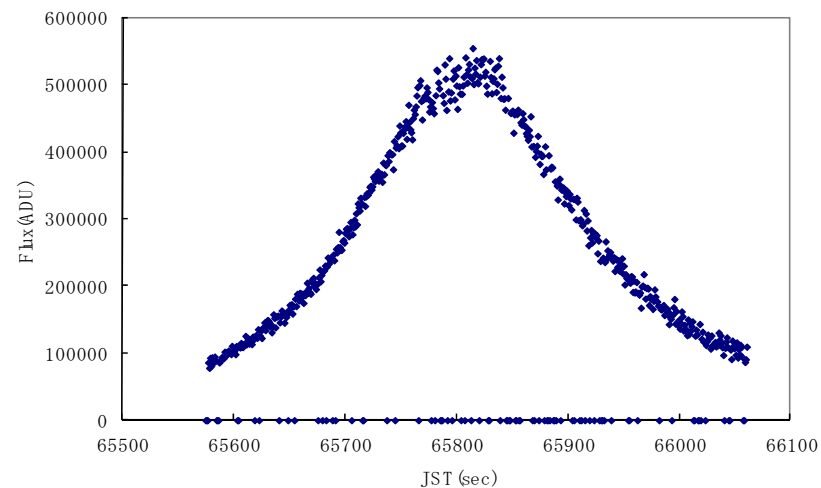
$$T_p = 1764.0 \pm 0.07 \text{ sec}$$

Rotational condition of removal target SL-8

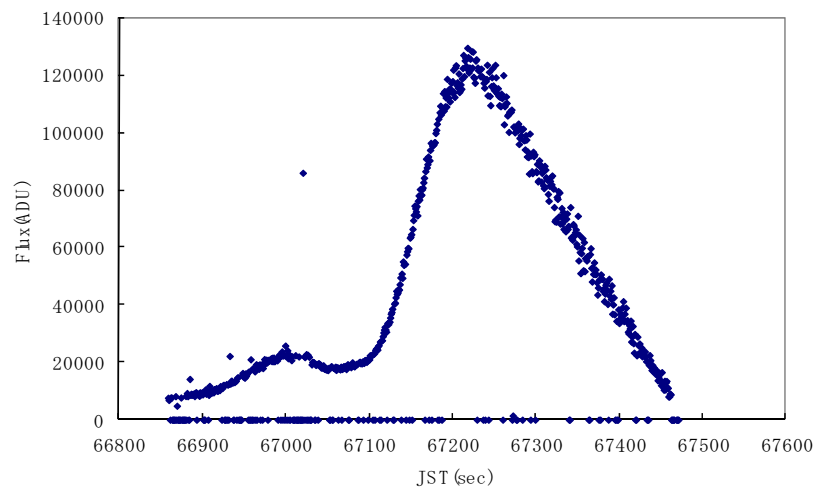
111215-07831



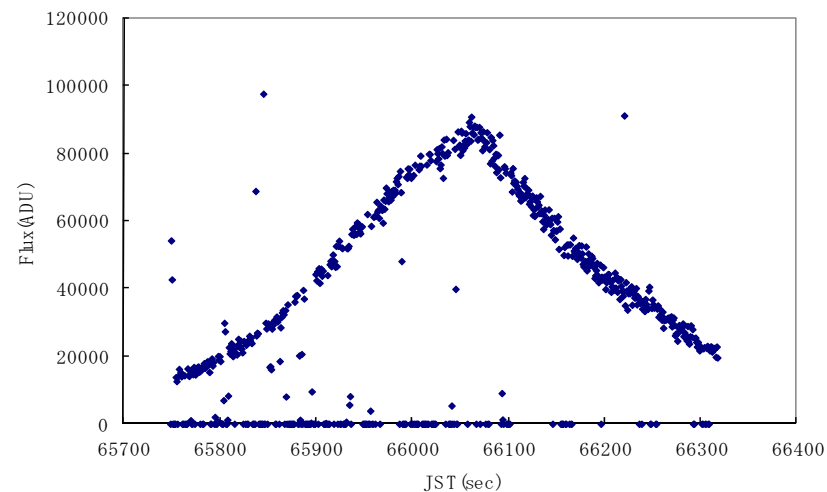
111215-22007



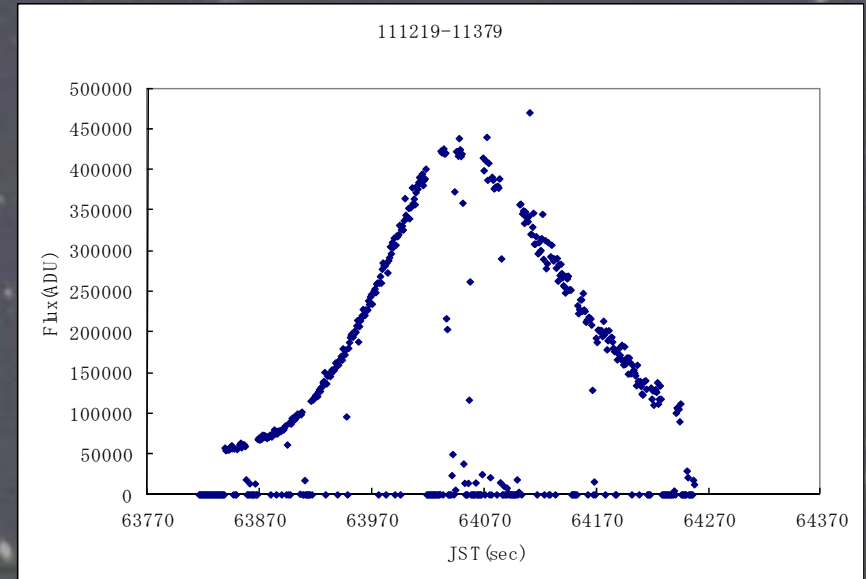
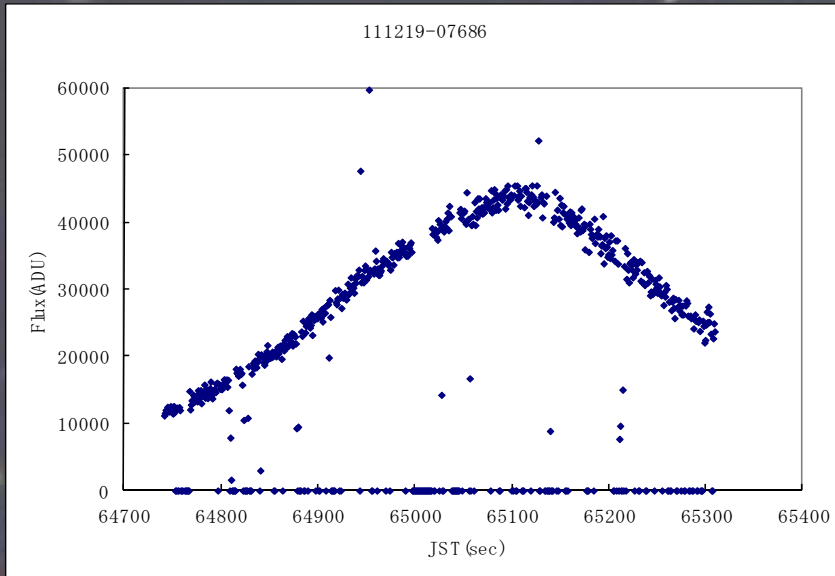
111219-06207



111219-07284



Rotational condition of removal target SL-8



The light curves of 6 SL-8 rocket bodies were observed. So far, rapid rotation that obstructs active removal is not detected in this type of rocket body.

Conclusions

- We succeeded in determining the shape and motion of one LEO object using a light curve data taken by an optical telescope.
- The axial ratio of the LEO object is 100:18:18. The coordinates of the rotational axis direction in the celestial sphere are R.A.= 305.8° and Dec= 2.6° .

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