EPSC Abstracts
Vol. 10, EPSC2015-165, 2015
European Planetary Science Congress 2015

The Application of Chang'e-3 Moon-based Extreme Ultraviolet Camera Geometric Positioning

W. Yan, J.J. Liu, W.R. Wang, F.F. Wang, X.G. Zeng, X.Y. Gao
Key Laboratory of Lunar and Deep Space Exploration, National Astronomical Observatories, Chinese Academy of Sciences, Beijing, China. (yanw@nao.cas.cn/ Tel: +86 01064880607-8012)

Abstract

The moon-based extreme ultraviolet camera (EUVC) mounted on the Chang'e-3 (CE-3) lander is used to observe Earth's plasmasphere. Geometric positioning is critical for the EUVC observations to determine Earth center in each image. In this paper, calculation accuracy of Earth center's Solar Magnetic System (SM) coordinates is analyzed by comparing the results obtained by geometric positioning and image recognition respectively. The conclusion is geometric positioning results are more accurate so that the original images should be modified to ensure its accuracy for further scientific researches.

1. Introduction

The CE-3 lunar probe successfully landed in the northwestern part of Mare Imbrium at 13:11 on 2013 December 14 (UTC), making China the third country to achieve a soft landing on the Moon. The EUVC is one of four payloads on the CE-3 lander. It has taken photos of Earth's plasmasphere from a perspective on the side during about one year (Ip et al. 2014).

1.1 Scientific Goals

The scientific goals of the EUVC are as follows. (1) Image Earth's plasmasphere at 30.4 nm from the perspective of the side at different positions along the orbit of the Moon to investigate three-dimensional structures in the plasmasphere. (2) Continuously image the plasmasphere over a relatively long duration to monitor evolution of the plasmaspheric density and structure with geomagnetic activity.

1.2 Technical Requirements

The specifications for the EUVC are listed in Table 1 (Chen et al. 2014).

Table 1: Specifications for the EUVC

Parameter	Value
Central wavelength (nm)	30.4 ± 0.5
Spectral bandwidth (nm)	⩽5.0
Field of view (◦)	15.00 ± 0.75
Angular resolution (◦)	⩽0.10
Exposure time (min)	2, 10 or 20
Dynamic range (Rayleigh)	0.1_10.0
Sensitivity (count s^{-1} $Rayleigh^{-1}$)	⩾0.10
Sensitivity ratio at 30.4 nm and 58.4 nm	⩾70.0

1.3 Geometric Positioning

The EUVC images (Figure 1) can be obtained after image processing such as geometric calibration, photometric calibration, and so on. The plasmasphere, plasmapause, airglow and the Earth's shadow can be seen clearly in the image. In Figure 1, the red cross is the center of the image, which is corresponding to the optical axis pointing of the EUVC, and the black cross indicates Earth's center, which is corresponding to the geocentric pointing of the image and can be calculated by image recognition as mentioned in (He et al. 2011).

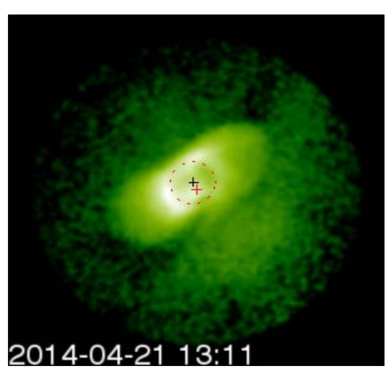

Figure 1: The EUVC image

The purpose of geometric positioning is determining the optical axis pointing, the geocentric pointing and any other pointing of the EUVC images at SM system. Its process is transforming the initial pointing vector which obtained by image coordinates to SM system through a series of coordinate conversion. The coordinate systems involved in this process are instrument coordinate system, the CE-3 lander body coordinate system, moon-fixed coordinate system, geocentric mean equator coordinate system for epoch J2000.0, SM system, and so on. Conversion equation is as follows in which $\vec{V}_{SM}$,$\vec{V}_{O}$ and $T_{SM\leftarrow O}$ denotes pointing vector in SM system, in the initial system, and the conversion matrix respectively.

$$\vec{V}_{SM} = T_{SM\leftarrow O}\vec{V}_{O} \qquad (1)$$

2. Experiment and Results

The angle formed by the optical axis pointing and the geocentric pointing (noted as AOG) can be obtained by geometric positioning and image recognition respectively. In theory, the two results should be equal to each other. However, we found there are differences between them, which are even larger than 1° sometimes. To analyze the reason of this phenomenon, the change trend of AOG with time by the two methods is calculated as Figure 2.

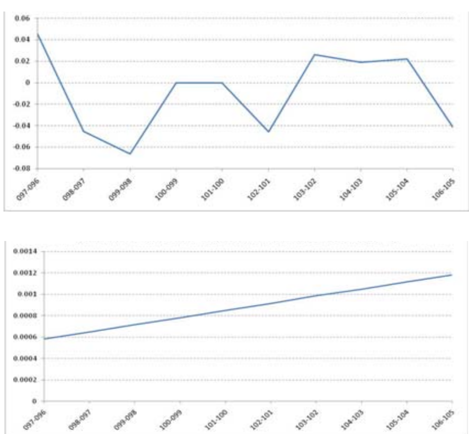

Figure 2: The change trend of AOG with time(°)

Because the optical axis pointing of the EUVC is fixed during the experimental period while the geocentric pointing is changed regularly according to the rotation of Earth and Moon, it can be seen from Figure 2 that the change trend of AOG obtained by geometric positioning is more reasonable. Geometric positioning results can be used to modify the original EUVC images.

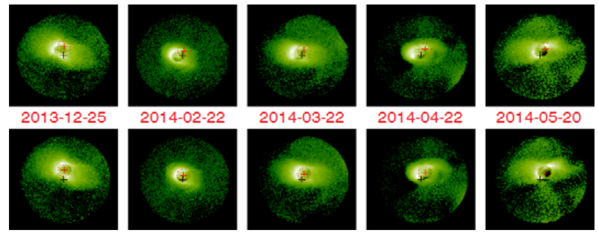

Figure 3: The original EUVC image modification

Figure 3 illustrated the effect of the original EUVC image modification using geometric positioning results. The top and bottom parts show images before and after modification respectively. The red cross denotes Earth center determined by geometric positioning. It can be seen that bright spot center which is the principle of Earth center chosen by image recognition is overlapped with red cross after image modification.

3. Summary and Conclusions

Geometric positioning is one of key technical steps for the EUVC images processing. It can provide accurate geocentric pointing to determine Earth center and to achieve scientific goals of the EUVC. Calculation of measured data shows that geometric positioning results can also be used to modify the original EUVC images. So geometric positioning can ensure the reliability of the EUVC observation data.

References

[1] Ip,W.-H., Yan, J., Li, C.-L.,& Ouyang, Z.-Y.: Preface: The Chang'e-3 lander and rover mission to the Moon, RAA(Research in Astronomy and Astrophysics), Vol. 14, No. 12, 1511-1514, 2014.

[2] Chen B., Song K.-F., Li Z.-H., et al.: Development and calibration of the Moon-based EUV camera for Chang'e-3, RAA, Vol. 14, No. 12, 1654–1663, 2014.

[3] He F., Zhang X.-X.,2 Chen B., et al.: Reconstruction of the plasmasphere from Moon-based EUV images, JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, A11203, 2011