BRz' PHASE FUNCTION OF ASTEROID 4 VESTA DURING THE 2006 OPPOSITION. S. Hasegawa[1], S. Miyasaka[2], N. Tokimasa[3], A. Sogame[4], M. A. Ibrahimov[5], F. Yoshida[6], M. Abe[1], and D. Kuroda[7], [1]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Sagamihara-shi, Kanagawa, 229-8510 Japan (hasehase@isas.jaxa.jp, abe@planeta.sci.isas.jaxa.jp), [2]Tokyo Metropolitan Government, Tokyo, Japan (seidai@toybox.gr.jp), [3]Nishi-Harima Astronomical Observatory, Hyogo, Japan (tokimasa@nhao.go.jp), [4]Tokai Univ., Kanagawa, Japan (akito.sogame@nifty.ne.jp), [5]Ulugh Beg Astronomical Institute, Tashkent, Uzbekistan (mansur@astrin.uzsci.net), [6]National Astronomical Observatory of Japan, Tokyo, Japan (fumi.yoshida@nao.ac.jp), [7]Okayama Astrophysical Observatory, National Astronomical Observatory of Japan, Okayama, Japan (dai.kuroda@nao.ac.jp).

Introduction: Asteroid 4 Vesta which was discovered by H. W. Olbers on 1807 is known as the unique huge asteroid because it is the only differentiated asteroid with a basaltic crust, an ultramafic mantle, and a metal core in the main-belt. Fragments of 4 Vesta exist in the near-Earth and the main-belt regions and parts of them have been falling Earth. Therefore 4 Vesta has been done various observations using various methods. 4 Vesta is one of mission targets of the Dawn mission [1].

The phase function of 4 Vesta was investigated [2]-[12]. However, the slope parameter G for 4 Vesta including the smallest phase angle (<1.0°) are lacked due to opportunities of smallest phase angles are very rare. On January 5, 2006, the phase angle of 4 Vesta became 0.12°. Opportunities becoming the smallest phase angle (<1.0°) for 4 Vesta does not visit it until 2020. To obtain the phase function of 4 Vesta including the extremely low phase angle, we have obtained photometric data of 4 Vesta during the opposition from December 2005 to April 2006.

Observations: The photometric observations for asteroid 4 Vesta were made at the phase angle ranging from 0.12° to 23.79°. 4 Vesta was observed through B and R bands of the Johnson-Cousins system and z' band of the SDSS system.

Telescopes. The observations were performed at four different telescopes in Japan and Uzbekistan. The data of asteroids are obtained with the 0.064-m telescope, yielding the field of view of 278.8' x 191.1', on ISAS/JAXA at Kanagawa, Japan, the 0.36-m telescope, giving the field of view of 29.4' x 29.4', of the Miyasaka Observatory at Yamanashi, Japan, the 0.076-m telescope, giving the field of view of 59.6' x 59.6', of the Nishi-Harima Astronomical Observatory at Hyogo, Japan, and the 0.60-m telescope, yielding the field of view of 11.7' x 11.7', of the Maidanak Observatory, Uzbekistan.

Data analysis. Obtained image reduction including dark subtraction and flat field correction was carried out by the APPOT task of the Image Reduction and Analysis Facility (IRAF) software. Measurements of 4 Vesta and the standard star, the comparison stars were done thorough a cycle aperture.

The heliocentric and the geocentric distance, the phase angle, apparent sub-solar and sub-Earth planetographic longitude and latitude for 4 Vesta were obtained by the JPL Ephemeris Generator.

Lightcurve correction. To obtain the phase curve for 4 Vesta eliminated influence of rotational variation, we obtained composite lightcurves of 4 Vesta using data in phase angle >9° (Figure 1). The lightcurves in B, R, z' bands are not contradictory to those of previous works [13]-[16]. Based on fitting curves as a function of PAB longitude, corrections were carried out.

Results: The phase curves for asteroid 4 Vesta in B, R, z' band are shown in Figure 2-4. The phase function of 4 Vesta with parameters with H_B = 3.93±0.01 mag and G_B = 0.24±0.01, H_R = 2.77±0.01 mag and G_R = 0.21±0.01, and $H_{z'}$ = 2.95±0.02 mag and $G_{z'}$ = 0.20±0.01 were obtained.

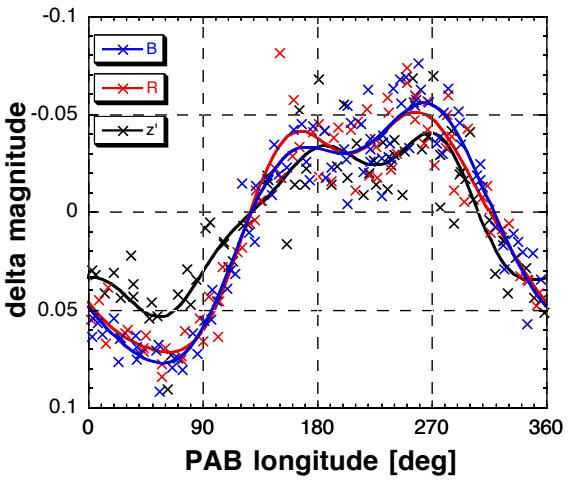

Figure 1. B, R, and z' lightcureves of asteroid 4 Vesta plotted as a function of PAB longitude. PAB is the mean between the geocentric and heliocentric position of the asteroid. The curves are made using the Fourier analysis.

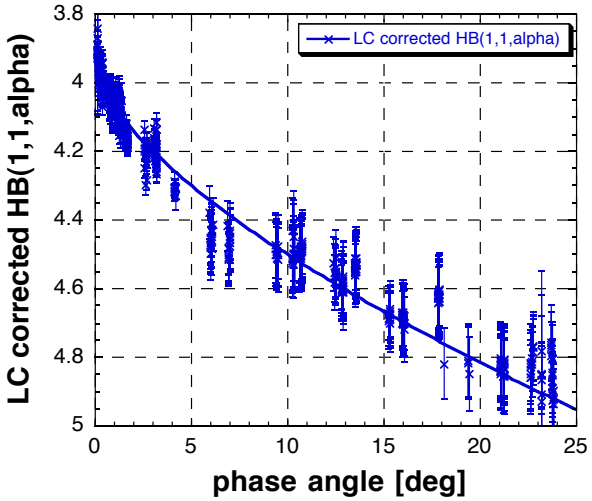

Figure 2. phase curve of asteroid 4 Vesta in the B band.

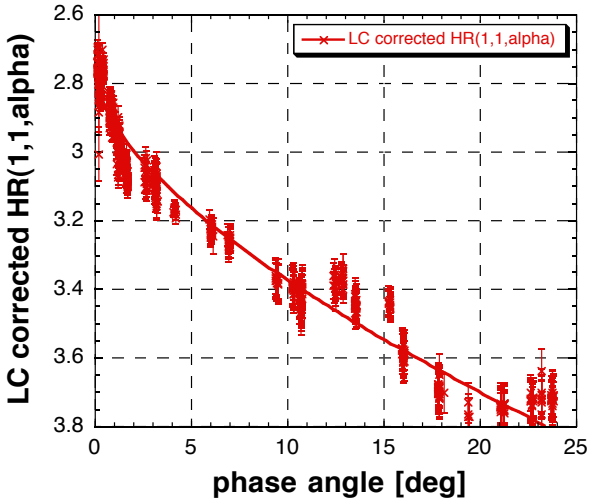

Figure 3. phase curve of asteroid 4 Vesta in the R band.

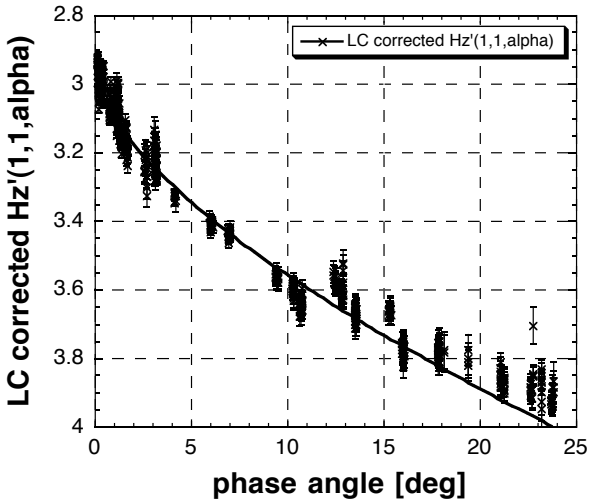

Figure 4. phase curve of asteroid 4 Vesta in the z' band.

The values of the slope parameters G are small in comparison with previous values reported by [3] (G =0.47, lowest phase angle =6°), [5] (G =0.47, lowest phase angle =5°), [6] (G =0.35, lowest phase angle =1.5°), [7] (G =0.33, lowest phase angle =1.5°), [8] (G =0.42, lowest phase angle =1.5°), [10] (G =0.35, lowest phase angle =1.0°), [11] (G =0.32, lowest phase angle =2.5°). Our values are rather similar to the values of S and M type asteroids [6], [17].

As a cause of a difference of the parameter G for 4 Vesta between our data and past data, a cause except the difference of observed filter band is also thought about. We obtained the slope parameter G using photometric data without the lowest phase angle <1.5°. The parameter G in B, R, z' band under elimination of the smallest phase angle are 0.34, 0.34, and 0.28, respectively. These values are consistent with reported values [3], [5]-[8], [10], [11]. It is thought that the difference was mainly caused by presence of observed data in the smallest phase angle.

This result indicates that photometric data in the smallest phase angle is important to obtain the phase function for asteroids.

References: [1] Russel C. T. et al. (2007) *Earth Moon Planet, 101,* 65-91. [2] Gehrels T. *Astron. J., 72,* 929-938. [3] Lagerkvist C.-I. and Williams I. P. (1987) *Astron. Astrophys. Sulppl. Ser., 68,* 295-315. [4] Hollis A. J. (1987) *J. Br. Astron. Assoc, 97,* 350-352. [5] Lagerkvist C.-I. et al. (1988) *Astron. Astrophys. Sulppl. Ser., 73,* 395-405. [6] Lagerkvist C.-I. et al. (1989) *Astron. Astrophys. Sulppl. Ser., 78,* 519-532. [7] Lagerkvist C.-I. and Magnusson P. (1990) *Astron. Astrophys. Sulppl. Ser., 86,* 119-165. [8] Rick J. W. and Hollis A. J. (1990) *J. Br. Astron. Assoc, 100,* 17-21. [9] M. P. C. 17257 (1990). [10] Lagerkvist C.-I. et al. (1992) *Astron. Astrophys. Sulppl. Ser., 94,* 43-71. [11] Piironen. et al. (1997) *Astron. Astrophys. Sulppl. Ser., 121,* 489-497. [12] McFadden L. A. (2008) *LPS XXXIX,* Abstract #2546. [13] Reynoldson G. et al. (1990) *Minor planet Bull., 20,* 11-13. [14] Jaumann A. et al. (1996) *Workshop on Evolution of Igneous Asteroids,* 13-15. [15] Nonaka H. et al. (2003) *Proc. 36th ISAS Lunar Planet Symp.,* 181-184, [16] Fulvio. et al. (2008) *Mem. S. A. It. Siuppl., 12,* 12-19. [17] Harris A. W. and Young J. (1988) *Bull. Am. Astron. Soc., 20,* 865.

Acknowledgements: This work was partially supported by the Japan Society for the Promotion of Science, under the Grant-in-Aid for Scientific Research (B) 17340133. S. Hasegawa was supported by Space Plasma Laboratory, ISAS, JAXA.