Optical Spectroscopy of Highly Inclined Main-Belt Asteroids. Iwai, A.[1], Itoh, Y.[1], and Terai, T.[2], [1]Graduate School of Science, Kobe University, 1-1 Rokkodai-cho, Nada-ku, Kobe, Hyogo 657-8501, JAPAN, aya-i@stu.kobe-u.ac.jp, [2]National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, JAPAN, tsuyoshi.terai@nao.ac.jp

Introduction: A portion of asteroids are highly inclined. It is generally believed that such asteroids were born in the ecliptic plane, then were scattered by gravitational perturbation of protoplanets. Secular resonances [1] or gravitational scattering [2] are considered as the cause of the gravitational perturbation. The perturbation by the secular resonances increased the inclinations of the asteroids but did not change their semi-major axes. On the other hand, the perturbation due to the gravitational scattering increased the inclinations of the asteroids and decreased their semi-major axes.

Aims: In order to identify the cause of the perturbations, we searched for highly inclined D-type main-belt asteroids (MBAs). The main-belt is the region with the semi-major axis of 2.1 - 3.3AU. D-type asteroids are primordial asteroids and common in the region with the semi-major axis of 3.3 - 5.2AU [3][4][5]. If highly inclined D-type MBAs are frequent in the region between 2.1AU and 3.3AU, compared to the less inclined MBAs, we consider that the highly inclined MBAs were scattered due to the gravitational scattering. Else if the highly inclined D-type MBAs have same frequency with the less inclined MBAs, the highly inclined MBAs were scattered by the secular resonances. The spatial distribution of the D-type asteroids with highly inclination gives us the clue of origin and orbital evolution of MBAs.

Observations and Results: We obtained optical spectra of 41 highly inclined MBAs using the UH88 telescope with WFGS2 spectrograph and the IUCAA 2-meter telescope with IFOSC spectrogtaph. We used the low-dispersion grism, the 1.4” width slit, and the order sort filter for the UH88 run. For the IUCAA run, No.5 grism and the 1.5” width slit were used. Observation dates were 19-20 Oct. 2008 and 28-29 Dec. 2008. The wavelength range of the spectra is 440 – 920 nm. The spectral resolution was 0.8 nm and typical signal - to - noise ratio of the spectra is 25 with 300 – 600 seconds exposures. We determined spectral types of the asteroids by the overall shapes of the spectra between 440 nm and 830 nm. We compared them with the template spectra of C, S, X, D, and V-type asteroids[5]. We classified the spectral types of 23 asteroids. It is revealed that highly inclined D-type MBAs are more populated than the less inclined MBAs. This abundant population suggests that gravitation scattering events occurred during the formation process of the Solar system.

[1] Nagasawa, M., Tanaka, H., and Ida, S. (2000) *AJ*, 119, 1480-1497 [2]Ida, S., and Makino, J. (1993) *Icarus*, 106, 210-227 [3]Gradie, J. C., Chapman, C. R., and Tedesco, E. F. (1989) *Asteroids II*, 316-335 [4]Lazzaro, D. et al. (2004) *Icarus*, 172,179-220 [5]Bus, S. J., and Binzel, R. P. (2002), *Icarus*, 158,146-177

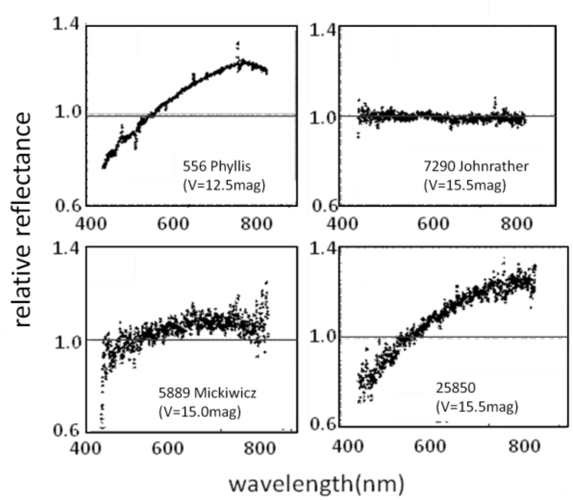

Fig.1 Obtained optical spectra using the UH88 telescope. Top left: S-type. Top right: C-type. Bottom left: X-type. Bottom right: D-type.