STABILITY AND EVOLUTION OF ORBITS AROUND THE BINARY ASTEROID 175706 (1996 FG3) AND ASTERIOIDS 162173 (1999 JU3) AND 101955 (1999 RQ36): IMPLICATIONS FOR THE MARCO-POLO-R MISSION. H. Hussmann[1], J. Oberst[1], K. Wickhusen[1], X. Shi[1], F. Damme[2], F. Lüdicke[1], V. Lupovka[3], S. Bauer[1], [1]DLR Institute of Planetary Research, Rutherfordstr.2, 12489 Berlin, Germany; hauke.hussmann@dlr.de, [2]University of Halle-Wittenberg, Germany, [3]Moscow State University of Geodesy and Cartography (MIIGAiK), Russia.

Introduction: In support of the Marco-Polo-R mission [1], we have carried out numerical simulations of spacecraft trajectories about the binary asteroid 175706 (1996 FG3) under the influence of solar radiation pressure [2]. We study the effects of (1) the asteroid's mass, shape, and rotational parameters, (2) the secondary's mass, shape, and orbit parameters, (3) the spacecraft's mass, surface area, and reflectivity, and (4) the time of arrival, and therefore the relative position to the sun and planets. Simulations around asteroids 101955 (1999 RQ36) and 162173 (1999 JU3) are also shown.

Method: Based on ephemeris data generated with JPL's HORIZONS tool [3] we have constructed SPICE ephemeris kernels for the target asteroids. As a second order approximation we assume model tri-axial ellipsoids for the asteroids' shapes that are consistent with the mean radius, mass and reasonable density values.

Shapes, orientations of the rotational poles, rotation rates, and *GM*-values of the asteroids are implemented as SPICE kernels based on ground-based observations (e.g., [4]). We then perform a numerical integration of the spacecraft trajectory including the perturbations by the secondary asteroid, the sun, the other planets, the solar radiation pressure, and the multipole moments of the asteroid's gravitational field. We are searching for trajectories that are stable over a few months in a distance of about 5 to 20 km to the asteroid, representing the mapping phase of an NEA mission.

Results: With solar radiation pressure and gravity forces of the small asteroid competing, orbits are found to be unstable, in general. However, limited orbital stability can be found in so-called Self-Stabilized Terminator Orbits (SSTO), where orbits are circular, orbital planes are oriented approximately perpendicular to the solar radiation pressure, and where the mean orbital plane of the spacecraft is shifted slightly (between 0.2 and 1 km) from the asteroid in the direction away from the sun. Under the effect of radiation pressure, the vector perpendicular to the orbit plane is observed to follow the Sun direction (Fig.1).

Shape and rotation parameters of the asteroid as well as gravitational perturbations by the secondary (not to mention Sun and planets) were found not to significantly affect the orbital stability (see also Fig.2). However, we did restrict ourselves to distances greater than 5 km suitable for the mapping phase. It is expected that the higher moments of the gravity field and the secondary asteroid become much more important during the approach phase.

Simulations around the other targets show similar results. In case of 175706 the most stable region lies at a mean distance of 11 km from the body center. For 162173 this region can be found at around 10 km while for the significantly lower mass of 101955 the most stable region can be found at a distance of approximately 4 kilometers.

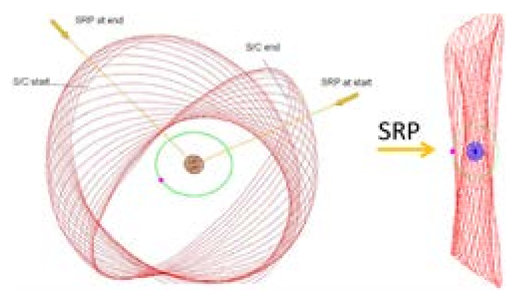

Fig.1: Example orbit of a quasi-stable solution for 1996 FG3 over approx. 180 days. The mean orbital plane of the terminator orbit is perpendicular to the direction of the solar radiation pressure. Right: Orbit in a rotating reference frame with fixed direction to the Sun (view from above).

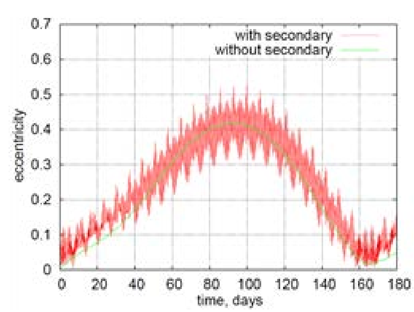

Fig.2: Influence of the secondary asteroid of 1996 FG3 (high-frequency oscillations in red) on the spacecraft orbit. The distance of the spacecraft to the center of mass of the binary system is always greater than 5km.

References:

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