Constraining the distribution of regolith deposits from the gravitational potential field on small asteroids

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The relationship between the global distribution of regolith deposits and the gravitational potential fields on small asteroids is investigated in this paper. It is expected that the global distribution of regolith deposits is controlled by the gravitational potential fields on small asteroids, because they are formed on low potential regions on a small asteroid by gravitational migration [1].

Regolith deposits would be formed on the polar regions of an oblate body with slow rotation, because gravitational potential is low on the polar regions. Smooth terrains found on the polar regions of asteroid Itokawa are representatives of this case [2, 3]. Oppositely, regolith deposits would be found on the equatorial region of a spherical body with fast rotation, where the latitudinal gradient of the centrifugal potential from the pole to the equator overcome the gravitational potential gradient. Equatorial bulges found on fast-rotating near-Earth asteroids with oblate shapes may have this kind of regolith deposit [4,5]. When two gradients are canceled by each other, an equipotential state over the whole surface of the body is achieved. The equilibrium rotation period is defined as the period at which the equipotential state is accomplished. In this case, local topographic features would affect the distribution of regolith deposits.

We modeled the gravity potential on the spheroidal surface by considering a balance between the gravitational attraction and the centrifugal force. The figure represents equilibrium rotation periods for given axial ratios of spheroidal bodies and densities. Itokawa (density: 1950 kg/m^3, axial ratio: 2.5 for a/c and 1.2 for a/c) [3] is located above the equilibrium line of its rotation period 12.132 h, indicating that low potential regions and smooth terrains are formed on the polar region, whereas Bennu (density 1260 kg/m^3, axial ratio: 1.1) [6,7] is far below of its equilibrium line (P: 4.3 h), suggesting that its equatorial region has regolith deposits. Even though only limited constraints on shape and density are obtained on asteroid 1999 JU$_3$ (P: 7.63 h) [8], the target of the Japanese Hayabusa2 mission, we will discuss the expected distribution of regolith deposits on this asteroid, because smooth regolith deposits are strong candidates of landing sites for the mission.

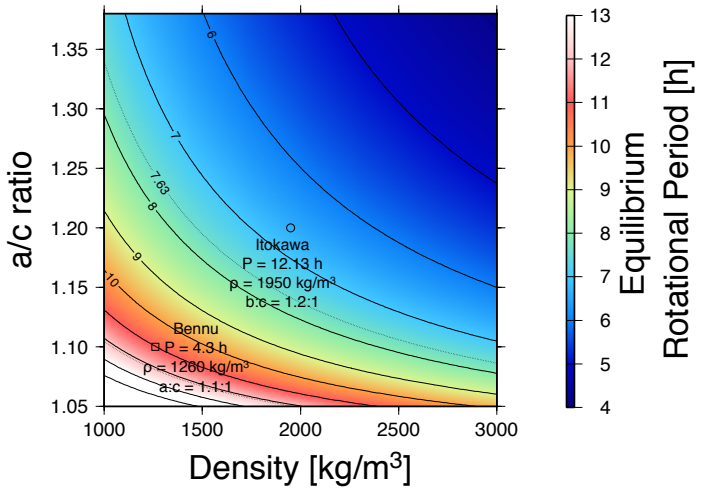

Figure: Equilibrium rotation periods for given axial ratios of spheroidal bodies and densities. Known axial ratios and densities of asteroids Itokawa (open circle) and Bennu (open square) are plotted. Also, known rotational periods of Itokawa, Bennu, and 1999 JU$_3$ are indicated as thin dashed lines.

References: [1] Richardson, Bowling (2014) Icarus 234, 53. [2] Miyamoto et al. (2007) Science 316, 1011. [3] Fujiwara et al. (2006) Science 312, 1330. [4] Scheeres (2014) LPSC 45, #1930. [5] Busch et al. (2011) Icarus 212, 649. [6] Chesley et al. (2014) Icarus (accepted), arXiv:1402.5573. [7] Nolan et al. (2013) Icarus 226, 629. [8] Müller et al. (2011) A&A 525.