Predicted rotational deceleration of asteroid Itokawa due to YORP

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An evaluation of the effect of solar radiation on the rotation state of asteroid Itokawa is given. The change in rotation rate due to this effect is known as "YORP" (Rubincam, 2000). For this evaluation we use the estimated Itokawa shape, spin pole, mass, and optical properties derived from the Hayabusa mission to that asteroid.

The current work only focuses on the predicted change in spin rate of Itokawa, and does not consider changes in its obliquity. Our specific interest is in making a prediction for when the YORP effect should be observable for Itokawa, an analysis which is still on-going. This has been studied earlier by Vokrouhlický et al. (2004) and Kaasalainen (2004) using pre-rendezvous models of the asteroid.

Based on the current shape model the rate of despin can be computed from the following formula: $\dot{\tilde{\omega}} = \alpha_1 + B\left[(1-s)\rho + \kappa(1-\rho)\right]\alpha_2 + \rho s \alpha_3$, where $\rho < 1$ is the albedo of the body, $s < 1$ is a specular reflection parameter, $\kappa < 1$ represents the reduction in emission due to finite thermal conductivity, and B is the Lambertian scattering coefficient. The constants α_i have units of radians per second squared and are directly computed from the asteroid shape, moments of inertia and current orientation relative to its orbital plane and equal: $\alpha_1 = -5.4 \times 10^{-18}$, $\alpha_2 = -1.352 \times 10^{-16}$, $\alpha_3 = -4.425 \times 10^{-16}$. These values are computed accounting for self-shadowing. If self-shadowing is ignored we find $\alpha_1 = 0$ but that α_2 and α_3 are relatively unchanged.

The albedo has been estimated to be $\rho \sim 0.2$ by Müller et al. (2005), however for simplicity for the abstract we assume $s = 0$, $\kappa = 1$, and $B = 2/3$, removing dependency on albedo. A more detailed discussion will be given at the conference. Thus, assuming that the main contribution is from α_2 the predicted deceleration in the spin rate for the current Itokawa state is 9.55×10^{-17} radians/s^2, or a rate of increase in rotation period of 2.5×10^{-4} hours/year, with an uncertainty to be determined. Given the current Itokawa rotation period of 12.13237 hours (Kaasalainen 2004), this corresponds to a halving of its spin rate, sometimes called the YORP timescale, in 7.5×10^{11} seconds, or a mere 24,000 years. This is an extremely rapid rotation rate evolution, and if verified would imply that YORP rotational acceleration is a dominating effect for small Near-Earth asteroids.