The effect of YORP on the NEO spin rate distribution.

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The overall change of the NEO spin rate due to planetary encounters and YORP is evaluated computing the steady state spin distribution of a large sample of test objects. Our model distribution, once artificially biased, shows an excellent match to the observational data.

The Monte Carlo numerical model: Each simulation is performed with a population of 2×10^4 fictitious NEOs modelled as triaxial ellipsoids. For each body a starting rotation rate is computed from a Maxwellian distribution typical of Main Belt objects.

The dynamical behavior of NEOs is modeled in a statistical way, accounting for the NEO limited lifetime. The time evolution of the most important orbital elements of the NEOs, i.e., a and e, are followed in broad terms, simulating a random walk leading to a progressively decreasing perihelion distance.

The change $\Delta\omega$ in the rotational frequency is computed during each timestep dt taking into account gravitational and non-gravitational interactions. The variation due to close encounters is treated according to [1]. The spin evolution due to YORP is computed for each body by assigning a YORP coefficent C_Y drawn randomly at the beginning of the simulation accordingly to a simplified model based on [2].

The rotation rate has boundaries within which it evolves because of YORP and encounters. The continuous spin up for positive values of C_Y would lead a body to a very high rotation rate. For rubble–piles we set an upper threshold $\omega = \omega_M$ given by the rotational disruption limit. NEOs smaller than a given diameter D are instead considered monolithic bodies and are not allowed to breakup. When a rubble pile asteroid reaches the disruption limit we assume that reshaping takes place, eventually leading to the asteroid taking on a negative YORP acceleration coefficient [4]. In the numerical code we model this by changing the sign of C_y (keeping the same absolute value). Therefore, the direction of the YORP evolution is reversed, the body despins and a new YORP cycle starts. For a despinning body we assume that the rotation, after reaching $\omega = 0$, smoothly restarts in the opposite sense. Following this strategy, each fictitious NEO may have many YORP cycles before exiting the population. We currently do not model the creation and evolution of binary asteroids, but will add this in future versions.

Note that even we do not model YORP disruption, we allow close encounters to disrupt a body. A flyby relatively close to a planet can produce an abrupt spin up to a rate where self–gravity cannot hold it together, in particular if the body is a rubble pile.

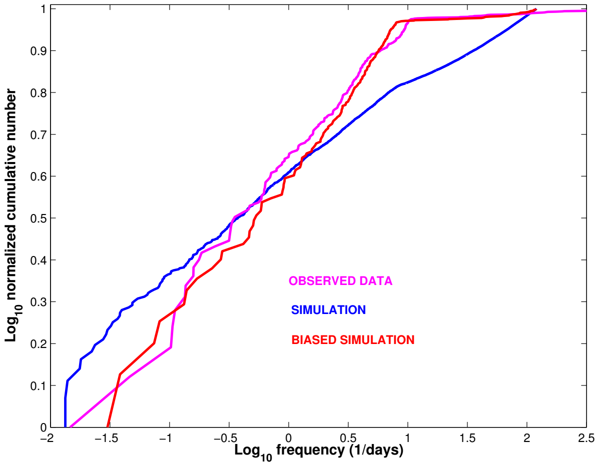

Figure 1: Observed vs simulated vs biased simulated cumulative frequency distribution

Results: Fig.1 shows (blue line) the cumulative steady state spin distribution. However, our distribution is an un–biased sample of NEOs, complete down to small diameters. To compare it with the dataset of NEO spin rates from [3] (magenta line) we have to bias our population to reproduce the size distribution of the observational dataset. This can be performed by dividing the diameter range in size bins and matching the number of objects in the model population to that of the observed population. The red curve shows the biased population. The excess of slow rotators with spin rates $\omega < 1$ day^{-1} in the observed distribution is very well reproduced by our biased distribution.

The results shown in Fig. 1 suggests that YORP is responsible for the concentration of spin at low rotation rates. In absence of YORP, the steady state population significantly deviates from that with YORP. The YORP evolution is also so fast among NEOs that the initial rotation rate distribution of the source population is quickly relaxed to that of the observed population. This has profound consequences on the study of NEO origin since we cannot trace the sources of NEOs from the rotation rate only.

References: [1] Scheeres D.J. et al. (2004), *Icarus, 170, 312*. [2] Scheeres D.J. (2007), *Icarus, 188, 430*. [3] Pravec et al. (2008), *Icarus, submitted*. [4] Scheeres et al. (2007), *Icarus, 188, 425*.