DO 100 KM ASTEROIDS SPIN-FISSION INTO BINARIES? K. A. Holsapple[1], [1]University of Washington 352400, Seattle, WA 98195.
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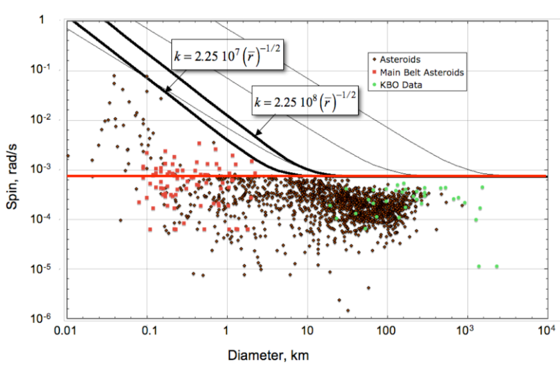
Introduction: The models of strength used for analyses of various processes of solar system bodies are becoming increasing sophisticated. The combination of advances in modeling and calculation is allowing us for the first time to relate diverse measures of "strength" used in the literature. However, often the values for the strength inferred by observations are distinctly below those expected from laboratory experiments. Perhaps the bodies are systematically weaker than we expect: an implication of that premise in regard to spin limits and spin fission as a mechanism to create binary bodies is pursued here.

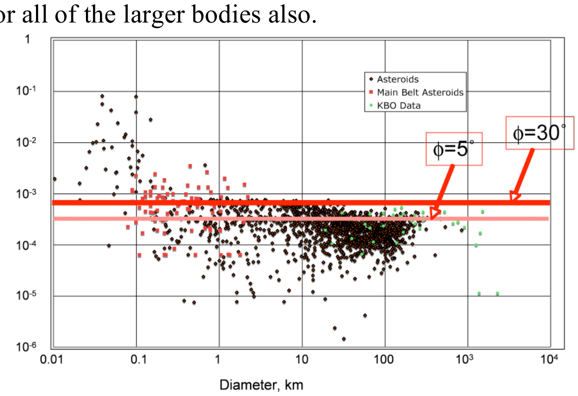
Asteroid Spin Limits: A recent example of the use of a complete strength theory used the Drucker-Prager strength theory for geological materials to derive spin limits for ellipsoidal bodies [1,2]. For smaller bodies (less than a few km diameter) the spin is limited by the cohesive (shear) strength of the material, which decreases with increasing body size. This is called the "strength regime". The downward sloping black lines in the Fig. 1 show these limits for two possible values for the cohesive strength (both decreasing with diameter $D^{-1/2}$). But for bodies 10km or larger, the cohesive strenth has no affect, and the gravity completely determines the spin limits. This defines a "gravity regime": shown as the red horizontal line. In this regime there is no dependence on body size.

But even in the gravity regime, there remains a dependence on a "strength" property: the angle of friction of the material. As the body size increases, the angle of friction gives a shear strength that increases with the confining pressure, which increases with size. Since both the actual stresses and the allowable stresses increase with the square of the body size, the size cancels out.



That theory can be made to match the observations of the spin distributions quite well, the leftmost line with $k=2.25\ 10^7\ r^{-1/2}$ in the Fig. 1 just upper-bounds all presently available data. However, the strength used in that line is about a factor of ten less than would be expected from laboratory tests. And note that the red points on this figure have been questioned in the literature, without those there are actually very few data supporting the strength limit curve. Whether that curve is indeed the limit, or faster spinning bodies will be found, will remain to be seen in the future.

The larger asteroids: An obvious feature of the distribution of spin limits shown on this plot is a characterisitic fall-off in the maximums of the spins for bodies about 20 km and larger. But there is a suppressed dependence on the angle of friction not shown in the Fig. 1: the angle of friction ϕ was assumed to be 30˚. Could the decrease in spins for the larger bodies be simply due to the angle of friction of the bodies being smaller? So I replot this figure, showing the limit spins in the gravity regime only, but also with a much lower angle of friction, ϕ=5˚, it gives the lower red line in Fig. 2. It is seen that this range of friction angles easily encompasses reasonable upper bounds for all of the larger bodies also.



If indeed the angle of friction falls off considerably for larger bodies, then there are, for some reason, bodies spinning at just under their spin limits at all sizes. Then a spin fission mechanism for binary formation would create systems with just about the same angular momentum as a single body at its spin limit, both for smaller and for larger systems, but the 100km ones would have about ½ as much angular momentum per unit mass. Such results have just been noted by Pravec and Harris [3].

References:

[1] Holsapple, K. A., (2001) *Icarus, 154,* 432-448.
[2] Holsapple, K. A., (2007) *Icarus, 187,* 500-509.
[3] Pravec, P. and Harris, A. W. (2007) *Icarus 190.* 250-259