MAR05-2004-006541

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

**Jammed Ellipsoids Beat Jammed Spheres: Experiments with Candies and Colloids**[1]

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Packing problems, how densely objects can fill a volume, are among the most ancient and persistent problems in mathematics and science. For equal spheres, it has only recently been proved that the face-centered cubic lattice has the highest possible packing fraction $\phi \sim 0.74$. It is also well-known that the corresponding random (amorphous) jammed packings have $\phi \sim 0.64$. The density of packings in lattice and amorphous forms is intimately related to the existence of liquid and crystal phases and is responsible for the melting transition. Geometrical aspects of packing different shapes and the thermodynamic consequences are most readily observed in colloidal systems. Colloids are also useful for building micromachines and there is much more flexibility in colloidal architecture if the building blocks are non-spherical particles. A first step is to understand how such systems densely pack. Here we show experimentally and with a new simulation algorithm that ellipsoids can randomly pack more densely; up to $\phi \sim 0.68$ - 0.71 for spheroids with an aspect ratio close to that of M&M's®Candies, and even approach $\phi \sim 0.75$ for general ellipsoids. The higher density relates directly to the higher number of degrees of freedom per particle, d, and then to the number of contacts per particle Z. We find Z $\sim$10 for our spheroids as compared to Z $\sim$ 6 for spheres, confirming the isostatic conjecture Z=2d. Our results lead to the question as to ellipsoids, or any shaped particle will pack denser randomly than crystalline. In our studies we have found the crystal packings of ellipsoids to a density, $\phi \sim .7707$ which exceeds the highest previous packing.

[1]with Aleksander Donev, Weining Man, Frank Stillinger, Salvatore Torquato