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Quantum plasticity and supersolidity[1]

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We have discovered that, in the total absence of impurities, helium 4 crystals are anomalously soft [1]. In our opinion, this is a consequence of the quantum properties of their dislocation lines which are able to move macroscopic distances (typically a fraction of a millimeter) at high speed (several meters per second) as a response to very small applied stresses (one microbar). Moreover, this quantum plasticity appears to be closely related to another astonishing property of quantum crystals, namely their "supersolidity," that is the possible superflow of a fraction of the crystal mass through the rest which remains elastic, actually more rigid than in the normal state [2]. Very tiny traces of helium 3 impurities are sufficient to pin the dislocations below about 100 mK and destroy the quantum plasticity. By studying rotational and elastic properties of crystals with various qualities and variable helium 3 content, we are now checking that supersolidity is a consequence of matter flowing along dislocation lines but only if these dislocations are pinned by impurities.

[1] X. Rojas, A. Haziot, V. Bapst, H.J. Maris, and S. Balibar, Anomalous softening of helium 4 crystals, Phys. Rev. Lett. 105, 145302 (2010).
[2] S. Balibar, The enigma of supersolidity, Nature 464, 176 (2010).

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