Comment on "Evidence from Mechanical Measurements for Flux-Lattice Melting in Single-Crystal $YBa_2Cu_3O_7$ and $Bi_{2.2}Sr_2Ca_{0.8}Cu_2O_8$"

In a recent Letter Gammel *et al.*[1] reported on nice measurements of frequency and dissipation of oscillating superconductors and concluded from these data the melting of the flux-line lattice (FLL) at a certain temperature. We argue about this conclusion.

First, if the magnetic field **B** and motion **V** were as depicted in Fig. 1 of Ref. 1 then there should be *no effect at all*: A superconductor moving without rotation in a homogeneous field B does not feel any force nor torque by this field. Thus, the curves called $\mathbf{B} \parallel \hat{c}$ in Ref. 1 should not be taken seriously. They reflect a spurious effect which might be due to a small misalignment or inhomogeneity of **B** but, more likely, is caused by a *torsional vibration* coupled to the linear vibration due to the off-axis epoxied sample. The resulting sample rotation, not mentioned in Ref. 1, periodically tilts the slightly pinned flux lines relative to **B** and has a similar effect as in the case $\mathbf{B} \perp \hat{c}$ explained in the next point. Therefore, the difference between the effects for $\mathbf{B} \parallel \hat{c}$ and $\mathbf{B} \perp \hat{c}$ *does not reflect crystal anisotropy but just the different geometries.*

Second, if the field is rotated, case $\mathbf{B} \perp \hat{c}$, a magnetic restoring force originates from the *tilt* (not motion) of the flux lines with respect to **B** when these are pinned to a periodically rotating material. This nontrivial effect was studied in amorphous[2] and ceramic[3] reeds. The resulting frequency enhancement is caused by two effects: (a) the tilt modulus of the FLL,[4] $c_{44} \approx B^2/\mu_0$ (this is a *volume* effect) and (b) the partial expulsion of field changes which are so small that they cannot unpin all flux lines (this differential Meissner effect depends on the sample *shape* and field orientation). For thin vibrating reeds it causes large enhancements of frequency and damping in *longitudinal* field,[2] but only weak (second order) effects in *transversal* fields. The geometries in Ref. 1 are difficult to treat quantitatively. In any case, the changes of frequency and damping *do not reflect the bulk modulus* of the FLL[4] ($c_{11} - c_{66} \approx B^2/\mu_0$) which, by the way, is nearly the same in a flux-line lattice and liquid. These changes might depend on the *shear modulus* of the FLL[4] ($c_{66} \ll c_{11}$) via the collective pinning strength which increases with decreasing c_{66}.[4]

Third, the peak observed in the attenuation near B_{c2} very likely does not reflect FLL melting but has the same origin as the peak observed near B_{c2} in superconducting vibrating reeds.[2,5] There, motion of the flux lines relative to the twin boundaries or other pins causes *hysteretic damping* due to elastic instabilities ("plucking" of flux lines). This damping mechanism exists even at extremely small vibrational amplitudes though, in principle, the viscous damping of moving flux lines should dominate at still smaller amplitudes. It would be helpful to measure the amplitude dependence before one dares a new interpretation.

Fourth, while two-dimensional FLL's are indeed interesting *dynamically*, three-dimensional FLL's are not uninteresting as claimed in Ref. 1. In fact, even *statically* these appear to be always entangled (contain screw dislocations[4]). This is suggested by an abrupt jump (by factors of 8 to 80) observed in the critical current of weak-pinning films when B is increased to a critical value B_{c0}.[6] This jump reflects a sharp transition from two- to three-dimensional pinning, i.e., from order to disorder along the flux lines, and occurs even at $T=0$. This transition should also occur in weak-pinning ceramics with sufficiently short flux lines.

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