Glassy and plastic vortex creep regimes in superconductors

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Vortex matter in oxide and Fe-based HTS is strongly affected by thermal and quantum fluctuations, which give rise to a variety of vortex liquid phases that occupy substantial portions of the phase diagram as well as fast dynamics of the metastable states (flux creep). The strong thermal fluctuations in HTS are due to the small coherence length, the large anisotropy and high transition temperatures in these materials, as quantified by the Ginzburg number (Gi) that measures the ratio of the thermal energy to the condensation energy in an elemental superconducting volume. We had previously found that, for strong pinning superconductors in the Anderson-Kim (A-K) creep regime at $T<<T_c$, there is a universal minimum attainable creep rate $S_{min} \sim Gi^{1/2}(T/T_c)$. This lower limit has been achieved in a few materials including $YBa_2Cu_3O_7$, MgB_2 and our $BaFe_2(As_{0.67}P_{0.33})_2$ films and, to our knowledge, violated by none. On the other hand, many SC exhibit S values higher, sometimes orders of magnitude higher, than S_{min}.

Recently we focused our efforts on obtaining a general understanding of the lower achievable S outside the A-K regime, at higher T and H where collective effects and glassy dynamics are relevant. To that end we studied a broad spectrum of systems, including conventional $NbSe_2$ single crystals with columnar defects created by heavy ion irradiation, clean HTS such as single crystals of YBCO and Hg1201, ReBCO films and coated conductors with the strongest pinning in any known superconductor, and single crystals of the magnetic superconductor $RbEuFe_4As_4$. We categorize several glassy and plastic regimes, the boundaries among which are determined either by intrinsic vortex properties or by thickness effects. In the strong pinning systems we find a “second A-K regime” at high T, and extend our previous result to identify the lowest $S(T,H)$ limit in thin samples.

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