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M2Or4B-02 [Invited]: Novel dynamics and critical currents in fast superconducting vortices at high pulsed magnetic fields

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High magnetic field studies are essential to understand high temperature superconductors. Because of their immense characteristic fields (>100 T) that cannot be reached using conventional DC magnets, measurements in pulsed fields are essential. The advent of hydrogen-based superconductors with critical temperatures in excess of 260 K heightens the need created by Cu- and Fe-based superconductors. Depending on the superconductor properties and the type and density of material disorder, the vortex solid phase changes drastically from crystalline to diverse glass phases or emergent phases like Fulde–Ferrell–Larkin–Ovchinnikov. The study of vortex pinning in commercially relevant superconductors at high fields is also essential for developing magnets and power applications such as the recent 32T record in an all-superconducting magnet. However, pulsed magnetic fields reaching 100T in milliseconds impose technical and fundamental challenges that have prevented the realization of these studies.
Here, we present a sub-microsecond smart I-V technique that enables determining the superconducting critical current in pulsed magnetic fields, beyond the reach of DC magnets. We demonstrate the excellent agreement of this technique with low DC field measurements on YGdBa₂Cu₃O_{7-x} coated conductors with and without BaHfO₃ nanoparticles. The I-V characteristics change with the magnetic field rate dH/dt, exhibiting an initial Ohmic dependence followed be the expected power-law dependence in current. We fully capture this unexplored vortex physics regimes through a model based on the asymmetry of the vortex velocity profile produced by the applied current in the presence of a changing magnetic field.

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