Logarithmic flux-flow resistivity across the cuprate phase diagram

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The microwave response of vortices in high quality $YBa_2Cu_3O_{6+x}$ and $Tl_2Ba_2CuO_{6+x}$ samples has been studied using high resolution microwave spectroscopy in an applied magnetic field. Measurements of the flux flow resistivity and vortex viscosity probe dissipation from electronic states near the vortex cores. These quantities have been accurately measured for $T \ll T_c$ and $B \ll B_{c2}$, at a number of dopings that span the entire superconducting region of the cuprate phase diagram. Here we report the observation of a universal logarithmic temperature dependence of the flux-flow resistivity, in the highest quality samples, across the cuprate phase diagram. The behaviour bears a strong resemblance to the normal-state resistivity of the underdoped cuprates first observed by Ando and Boebinger. Our measurements shows that the effect persists to the highly overdoped side, where the resistivity is metallic and the normal state is a Fermi liquid. The resistivity upturns appear to be an intrinsic property of vortices in a d-wave superconductor. We discuss the implications of the result for the normal state of the underdoped cuprates.