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Magnetic-field Induced Pair Density Wave State in the Cuprate Vortex Halo

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When very high magnetic fields suppress the superconductivity in underdoped cuprates, an exceptional new electronic phase appears. It supports remarkable and unexplained quantum oscillations and exhibits an unidentified density wave (DW) state. Although generally referred to as a "charge" density wave (CDW) because of the observed charge density modulations, theory indicates that this could actually be the far more elusive electron-pair density wave state (PDW). To search for evidence of a field-induced PDW in cuprates, we visualize the modulations in the density of electronic states N(**r**) within the halo surrounding Bi2Sr2CaCu2O8 vortex cores. This reveals multiple signatures of a field-induced PDW, including two sets of N(**r**)modulations occurring at wavevectors $\mathbf{Q_P}$ and $2\mathbf{Q_P}$, both having predominantly s-symmetry form factors, the amplitude of the latter decaying twice as rapidly as the former, along with induced energy-gap modulations at $\mathbf{Q_P}$. Such a microscopic phenomenology is in detailed agreement with theory for a field-induced primary PDW that generates secondary CDWs within the vortex halo. These data indicate that the fundamental state generated by increasing magnetic fields from the underdoped cuprate superconducting phase is actually a PDW with approximately eight CuO_2 unit-cell periodicity (Î»=8a_0) and predominantly d-symmetry form factor.