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Granular superconductivity in cuprate-manganite multilayers

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We have discovered a highly unusual proximity effect in cuprate/manganite multilayers in which a thin layer (7 nm) of the high Tc superconductor $YBa_2Cu_3O_7$ (YBCO) is sandwiched between two thicker layers (20 nm) made from the manganites $Pr_{0.5}La_{0.2}Ca_{0.3}MnO_3$ (PLCMO) or $Nd_{1-x}(Ca_{1-y}Sr_y)_xMnO_3$ (NCSMO). Contrary to common knowledge that a magnetic field supresses or destroys superconductivity, in these multilayers we find that the magnetic field restores a coherent superconducting response. In these kind of particular sandwiches at zero magnetic field these multilayers are in an insulator-like granular superconducting state with localised Cooper pairs that is induced by an interfacial coupling proximity with the charge and orbital order of the neighbouring manganite layers (Mn-CO/OO). As this Mn-CO/OO gets suppressed by a large magnetic field towards a ferromagnetic and metallic state, this unusual proximity effect also disappears and a coherent superconducting state is restored in the YBCO layer. There is an evidence that in particular the domain boundaries of this Mn-CO/OO states play an important role and may act as a template for corresponding grain boundaries of a copper charge density wave that is induced in the YBCO layer where it competes with superconductivity. This result suggests that these heterostructures can serve as a unique platform to control and study the competing interactions between this Cu-CDW and high Tc superconductivity in the cuprates.

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