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Superconductivity in Dilute Quantum Critical Polar Metals

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Superconductivity in low carrier density metals challenges the conventional electron-phonon theory. More specifically the traditional approach to overcoming Coulomb repulsion is not appropriate here. Here we show that superconducting pairing mediated by energy fluctuations, ubiquitously present close to continuous phase transitions, occurs in dilute quantum critical polar metals. It results in a dome-like dependence of the superconducting T_c on carrier density, characteristic of non-BCS superconductors. In quantum critical polar metals, the Coulomb repulsion is heavily screened, while the critical transverse optic phonons decouple from the electron charge. In the resulting vacuum, long-range attractive interactions emerge from the energy fluctuations of the critical phonons, resembling the gravitational interactions of a neutral dark matter universe. Our estimates show that this mechanism may explain the critical temperatures observed in doped $SrTiO_3$. We provide predictions for the enhancement of superconductivity near polar quantum criticality in two- and three-dimensional materials that can be used to test our theory. The presented material is based on work in the preprint P.A. Volkov, P. Chandra and P. Coleman, "Superconductivity from Energy Fluctuations in Dilute Quantum Critical Polar Metals," arXiv:2106.11295. P. A. V. is supported by a Rutgers Center for Materials Theory Fellowship, P. Chandra is supported by DOE Basic Energy Sciences grant DE-SC0020353 and P. Coleman is supported by NSF grant DMR-1830707.