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Duality and normal modes in a Cooper pair Wigner crystal

TAMAR PEREG-BARNEA, University of Texas, MARCEL FRANZ, University of British Columbia — A duality transformation from a phase fluctuating d-wave superconductor to a condensed state of vortices shows that Cooper pairs may form a Wigner crystal once the phase fluctuations destroy the superconducting long range order [1]. The lattice constant and the basis of this crystal are consistent with the charge modulations seen by the STM experiments in strongly underdoped cuprates [2]. Based on this vortex-boson duality we suggest a theoretical picture to relate the charge modulations seen by STM and the mysterious increase in the thermal conductivity [3] recently observed in the underdoped non-superconducting state. This addition to the thermal conductivity has bosonic temperature dependence and is attributed within our picture to the vibrational modes of the pair Wigner crystal. We analyze the spectrum of these modes and find it qualitatively consistent with the experimental observations.

1. Z. Tesanovic, Phys. Rev. Lett. 93, 217004 (2004).
2. J. E. Hoffman et al., Science 295, 466 (2002).
3. L. Taillefer (unpublished).

Tamar Pereg-Barnea
University of Texas

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