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Quantum oscillations in vortex-liquids[1] SUMILAN BANERJEE, SHIZHONG ZHANG, MOHIT RANDERIA, Department of Physics, The Ohio State University, Columbus, OH 43210 — Motivated by observations of quantum oscillations in underdoped cuprates [1], we examine the electronic density of states (DOS) in a *vortex-liquid* state, where long-range phase coherence is destroyed by an external magnetic field H but the local pairing amplitude survives. We note that this regime is distinct from that studied in most of the recent theories, which have focused on either a Fermi liquid with a competing order parameter or on a d-wave vortex lattice. The cuprate experiments are very likely in a resistive vortex-liquid state. We generalize the s-wave analysis of Maki and Stephen [2] to d-wave pairing and examine various regimes of the chemical potential, gap and field. We find that the $(1/H)$ oscillations of the DOS at the chemical potential in a d-wave vortex-liquid are much more robust, i.e., have a reduced damping, compared to the s-wave case. We critically investigate the conventional wisdom relating the observed frequency to the area of an underlying Fermi surface. We also show that the oscillations in the DOS cross over to a $\sqrt{H}$ behavior in the low field limit, in agreement with the recent specific heat measurements. [1] L. Taillefer, J. Phys. Cond. Mat. **21**, 164212 (2009). [2] M. J. Stephen, Phys. Rev. B **45**, 5481 (1992).

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