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Microscopic Theory of the Phenomena in Cuprates

CHANDRA VARMA, University of California, Riverside

This work is based on two principles, (1) that the microscopic model for the Cuprates must reflect their unique properties, and (2) that there exists a quantum critical point in the superconducting region of the phase diagram of the Cuprates which marks the end of an unusual ordered phase and whose quantum fluctuations determine the "strange metal" or marginal fermi-liquid properties. A mean-field theory of such a microscopic model predicts the time-reversal breaking order parameter in the underdoped region which has now been observed experimentally in four different families of Cuprates. The quantum critical fluctuations of this order parameter are governed by topological excitations and are derived to have the ω/T scaling and spatial locality suggested long ago for the marginal fermi-liquid phase. The coupling of the topological excitations to the fermions is shown to be $\propto \nabla \times \mathbf{j}$, where $\mathbf{j}$ is the fermion current operator. Such a coupling produces an attractive pairing interaction in the d-wave channel. Experimental evidence for the applicability of the ideas and calculations to properties of cuprates and several predictions are provided.

Work in the past three years on this problem was done in collaboration with Vivek Aji, Arcadi Shehter and Lijun Zhu.