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Theory of Strange Metals and high Temperature superconductors

CHANDRA VARMA, Univ of California - Riverside

The discovery of high temperature superconductivity almost thirty years ago opened a rich vein of unsuspected and beautiful quantum phenomena. The vast experimental effort that followed has led to many different illustrations of new principles at work. This has been matched by intense theoretical effort, sometimes with deep ideas. I will describe a direction in which the central organizing principle is quantum-critical fluctuations, in some metals of antiferromagnetic order, and in cuprates of a new class of order. The statistical mechanical model for both is the dissipative quantum XY model. The quantum-criticality of this model is driven by topological excitations and not renormalized spin-waves as in the usual theory. The correlation functions are products of functions of frequency with ω/T scaling and functions of momenta with spatial correlation length proportional to the logarithm of the temporal correlation length. A thorough examination of a variety of experimental results in the normal and superconducting state suggests that this form of critical fluctuations with the associated coupling to fermions is uniquely responsible for the phenomena.