Contribution ID: **183** Contribution code: **S06-CMPSP-003** Type: **Invited talk**

Transport in Strongly Correlated Systems: the Hubbard Model Perspective

Tuesday 30 August 2022 14:00 (30 minutes)

Understanding the behavior of strongly correlated electronic systems is one of the central challenges in condensed matter theory. In the focus of these efforts are the cuprate superconductors: They exhibit a highly universal strange metallic behavior, from the superconducting critical temperature, up to the highest accessible temperature. The nature of the strange metallic state, its universality and its apparent connection with superconductivity are not well understood. In this talk we will review some of the recent theoretical results, based on numerical simulations of the Hubbard model, that shed light on these matters. There are several universal behaviors that arise at high temperatures, and that seem to connect large classes of systems. In particular, a quantum critical scaling law of resistivity puts kappa-organics and the cuprates on the same phase diagram [1,2]. Also, doping-independent Brown-Zak magnetic quantum oscillations observed in moire lattices are now understood as a universal feature of incoherent regimes [3]. At the longest wavelengths and lowest frequencies, one finds that an emergent hydrodynamics underlies transport: the temperature dependence of dc resistivity is ruled by the effective diffusion constant; this is now supported by both the optical-lattice and numerical simulations of the Hubbard model [4]. In the end we will discuss recent developments [5] in quantum many-body methodology that are expected to allow further insights in the correlated-electron dynamics at low temperature.

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Session Classification: S06 Condensed Matter Physics and Statistical Physics

Track Classification: Scientific Sections: S06 Condensed Matter Physics and Statistical Physics