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The new extremely correlated electron perspective of the normal state of high temperature superconductors

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In this talk, two recent angle resolved photoelectron spectroscopy (ARPES) studies on high temperature superconductors are discussed. These studies show the importance of the "extreme electron correlation" a la t-J model. First, we will discuss the normal state single particle spectral function, which has been considered both anomalous and crucial to understand. Here, we report [1] an unprecedented success of applying the new t-J model based "extremely correlated Fermi liquid theory" by Shastry, to describe both laser ARPES data and conventional synchrotron ARPES data on $Bi_2Sr_2CaCu_2O_{8+\delta}$ and synchrotron ARPES data on $La_{1.85}Sr_{0.15}CuO_4$. It fits all data sets with the same physical parameter values, satisfies the particle sum rule and successfully addresses two widely discussed kink anomalies in the dispersion. Second, new ARPES investigation [2] of the Fermi surface geometry of $Ca_{2-x}Na_xCuO_2Cl_2$ from underdoping to overdoping shows that the "weak correlation" Luttinger sum rule, based on Fermi surface only, clearly breaks down in the underdoped case. We note that a t-J model based theory by Yang, Rice and Zhang provides an alternative "extreme correlation" Luttinger sum rule, based on both Fermi surface and "Luttinger surface." This extreme correlation Luttinger sum rule offers much more natural explanation for the observed ARPES data. These two studies imply that the extreme correlation as embodied in the t-J model is essential for understanding high temperature superconductors over a wide doping range.

[1] Gweon, Shastry, and Gu, Phys. Rev. Lett. 107, 056404 (2011).
[2] Meng, Gweon et al., Phys. Rev. B 84, 060513(R) (2011).