“Strange Metals and Anomalous Dimensions for Conserved Currents from Noether's Second Theorem”

The unsaturating resistivity exceeding the Ioffe-Regel-Mott bound in the strange metal phase of the cuprates implies that electrons are not the propagating degrees of freedom. The search for new degrees of freedom has led some to conclude that not only does the relevant gauge field that describes the interactions with electromagnetic radiation have an anomalous dimension but so does the current. This conclusion flies in the face of the well known result in quantum field theory that conserved quantities do not acquire anomalous dimensions under any amount of renormalization. My talk will focus on demistifying the claim of anomalous dimensions of conserved quantities. I will show that N"other's Second Theorem allows for electromagnetisms in which the conserved current and gauge field can actually have arbitrary dimensions. However, I will show that the only quantum theories to date which exhibit such behaviour are holographic models that are derived from a gravity theory that lives in an extra dimension. Such theories can exhibit a volume-to-area law transition in their entanglement spectra. The existence of currents having anomalous dimensions, a direct probe of the existence of extra dimensions, can be tested with the Aharonov-Bohm effect. I will describe this effect and its potential impact for unlocking the physics of the strange metal in the cuprates.
