Contribution ID: **13**

Type: **not specified**

Emergent holographic description for the Kondo effect: Comparison with Bethe ansatz

We propose one concrete realization of the holographic duality conjecture, implementing Wilsonian renormalization group transformations in a recursive way.
In other words, starting from an effective ultraviolet (UV) boundary quantum theory,we derive its corresponding infrared (IR) bulk classical field theory,
which appears naturally in one-dimensional higher spacetime.

It turns out that the emergent extra dimension can be identified with an energy scale of the renormalization group transformation. We find that an effective bulk equation of motion encodes all-loop quantum corrections through the extra dimension,organized in the 1/N expansion, where N represents the flavor number of strongly correlated quantum fields.

We implement this recursive Wilsonian renormalization group method to the Kondo problem. The perturbation approach in the vicinity of the decoupled local moment fixed point breaks down, approaching the Kondo temperature, where only three theoretical frameworks can access this crossover regime,including the strong coupling IR fixed point until now: Wilson's numerical renormalization group method, Bethe ansatz,and conserving t-matrix approximation. As a result, we succeed in describing the crossover regime from a weakly correlated local moment fixed point at high temperature to a strongly coupled local Fermi-liquid fixed point at low temperature in a nonperturbative way, where the characteristic energy scale is given by the Kondo temperature.

Impurity thermodynamics in our non-perturbative description is qualitatively well matched with the Bethe ansatz for the Kondo effect.

Previously, we applied essentially the same technology into an emergent geometric description for a topological phase transition in the Kitaev superconductor model, which allows us to extract out an emergent metric structure [Ki-Seok Kim, Miok Park, Jaeyoon Cho, and Chanyong Park, Phys. Rev. D 96, 086015 (2017)].

Based on the Ryu-Takayanagi Formula with our derived metric tensor, we calculated holographic entanglement entropy. Interestingly, it turns out that this entanglement entropy reproduced the Cardy's formula perfectly not only at but also near the quantum critical point.

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