Detector tuned overlap Catastrophe in quantum dots

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Anderson overlap catastrophe (AOC) is a well-known many-body effect that arises when a local potential of a Fermi-sea is abruptly changed. The AOC physics is expected to play a key role in the prototypical experimental setup of a charge detector that is electrostatically coupled to a mesoscopic system, in the form of measurement back action (MBA). In quantum dot structures, that are highly tunable mesoscopic systems, AOC physics is yet not experimentally explored with the much desired tunability. Moreover, the MBA effects that are observed in experiments are often interpreted using approximate phenomenological theories, which fail to properly account for the non-perturbative aspects associated with AOC. We demonstrate that a standard quantum-dot detector can be employed as a highly tunable probe of the AOC. We show that, signatures of AOC are present in the MBA effects observed in existing experiments, and give explicit predictions allowing to tune and pinpoint their non-perturbative aspects. A key ingredient of our analysis is an exact numerical solution of the MBA, that we developed based on the techniques used to understand the famous X-ray edge problem. We also show that the popular phenomenological theory used to account for MBA, referred to as P(E) theory, is a perturbative limit of our exact theory. Our approach serves as an effective theoretical framework to study complex MBA effects in experiments.

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