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Noether's Theorem and Holographic Gravitational Anomaly

In this work, we present a systematic study of asymptotic symmetries and conserved charges in Topological Massive Gravity(TMG) within asymptotically Anti-de Sitter(AdS_3) spacetimes. By rigorously applying Noether's theorem to the holographically renormalized action, we establish a robust framework that resolves long-standing ambiguities regarding boundary effects in the covariant phase space formalism. First, we demonstrate that the asymptotic diffeomorphisms are indeed physical symmetries of the theory in the strict Noether sense, as they preserve the action up to well-defined boundary terms. Second, we develop a unified holographic method to derive the central charges and anomalies; specifically, we explicitly calculate the holographic Weyl anomaly and the gravitational anomaly, as well as the mixed anomaly between them. Finally, we establish the equivalence between the derived Noether charges and the results obtained from the boundary stress tensor method. A distinguishing feature of our approach is its ability to naturally capture configuration-independent anomaly terms, which are often obscure in the conventional covariant phase space formalism, thereby offering a precise Noether's theorem resolution to the problem of holographic gravitational anomalies .

Presenter: FENG, Zhe (Institute of Theoretical Physics, Chinese Academy of Sciences)