

Bootstrapping the Chiral-Gravitational Anomaly

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We analyze causality and unitarity constraints in graviton scattering amplitudes, aiming to establish new bounds on theories with $U(1)$ -gravitational anomalies, such as axion models or strongly-coupled gauge theories. For this purpose, we show the necessity of coupling these theories to gravity. We obtain a universal scale Λ_{caus} at which states with $J \geq 4$ must appear in the theory. We show that this scale can lie below the quantum gravity scale. For axion models, we get $\Lambda_{\text{caus}} \sim \sqrt{M_P f_a}$ where f_a is the axion decay constant. In strongly-coupled gauge theories in the large- N_c limit, the presence of glueballs allows to evade these bounds, provided the number of fermions $N_F \ll N_c$ and the 'tHooft coupling is not large. Nevertheless, for models that have a holographic 5D dual (large 'tHooft coupling), Λ_{caus} emerges as a new cutoff scale, unless certain conditions on the parameters of the 5D models are satisfied.

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