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A Tower Weak Gravity Conjecture from Infrared Consistency

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We analyze infrared consistency conditions of 3D and 4D effective field theories with massive scalars or fermions charged under multiple U(1) gauge fields. At low energies, one can integrate out the massive particles and thus obtain a one-loop effective action for the gauge fields. In the regime where charge-independent contributions to higher-derivative terms in the action are sufficiently small, it is then possible to derive constraints on the charge-to-mass ratios of the massive particles from requiring that photons propagate causally and have an analytic S-matrix. We thus find that the theories need to contain bifundamentals other than satisfying the convex-hull condition. Demanding self-consistency of the constraints under Kaluza-Klein compactification, we show that, for scalars, they imply a stronger version of the weak gravity conjecture in which the charge-to-mass ratios of an infinite tower of particles are bounded from below. We find that the tower must again include bifundamentals but does not necessarily have to occupy a charge (sub-)lattice.

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