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Understanding Properties of the Proton from Holographic Models

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Content

In this work we investigate some properties of the proton in the context of the Gauge/Gravity duality. Using holographic techniques, we study proton structure functions and its gravitational form factors. In particular, we develop a general framework that extends previous holographic calculations of F_1 and F_2 to the case where the bulk geometry stems from bottom-up Einstein-Dilaton models, which are commonly used in the literature to describe some properties of QCD in the strong coupling regime. We focus on a choice of the dilaton potential that leads to a holographic model able to reproduce known lattice QCD results for the glueball masses at zero temperature and pure Yang-Mills thermodynamics above deconfinement. Once the parameters of the background holographic model are fixed, we introduce probe fermionic and gauge fields in the bulk *a la* Polchinski and Strassler to determine the corresponding structure functions. This particular realization of the model can successfully describe the proton mass and provide results for F_2 at large x that are in qualitative agreement with experimental data.

We also explore the proton's gravitational form factors. In particular, we calculate the nucleon gravitational form factors by evaluating the interaction action between the graviton and fermionic probe fields in a five dimensional deformed anti- de Sitter background metric. This deformation acts a warp factor in the metric, and comprises a dilaton-like term in the metric, in contrast to soft-wall models which have a dilaton term in the action defining the probe fields. It is chosen to reproduce confinement in such models, and other QCD properties. In this context, we obtain the scalar terms inside the matrix elements of the nucleon Energy Momentum Tensor. These scalar terms correspond to the gravitational form factors $A(q^2)$ and $D(q^2)$, with q^2 the momentum squared transferred between the graviton and the probe fermionic fields. In this holographic scenario, we calculate numerically the gluonic contributions to each of them. $A(q^2)$ gives us information about the momentum distribution inside the proton. From this, we also obtain the momentum distribution radius due to gluons in the nucleon. On the other hand, the D form factor gives us information on stress forces inside the nucleon, as pressure and shear forces. By fitting our numerical results for D with a dipole parametrization, we are able to compute these forces and also the mechanical radius due to them. We also find that our results are in good agreement with Lattice-QCD results, as well as with another holographic model used in the context of nucleon form factors.

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