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Solving relativistic bound-state problems in QCD with a fault-tolerant quantum computer

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We show how to use a fault-tolerant quantum computer to solve relativistic bound-state problems in *ab initio* (3+1)D quantum chromodynamics (QCD) non-perturbatively. We use a formulation of QCD in a frame of reference moving at the speed of light (the "light front frame") to simplify the relevant calculations. To showcase our approach, we work out detailed resource estimates for the T-count complexity for the problem of predicting the mass of a specified hadron. We apply our estimates to a variety of hadronic particles, including the color-flavor-spin singlet sexaquark (udsuds), a particle that could be the source of dark matter if its mass is in the range of 1870 to 1890 MeV/c^2, as argued by Farrar, Wang, and Xu. Computing the mass of this particle, whose size is predicted to be an extremely compact 0.1 fm because of all the symmetries it possesses, is beyond the reach of the best classical computers today using lattice gauge theory methods.

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