Ab Initio Calculation of the Neutron-Proton Mass Difference

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Abstract: The existence and stability of atoms relies on the fact that neutrons are more massive than protons. The mass difference is only 0.14% of the average. This tiny mass splitting has significant astrophysical and cosmological implications. A slightly smaller or larger value would have led to a dramatically different universe. Here we show how this difference results from the competition between electromagnetic and mass isospin breaking effects. We compute the neutron-proton mass splitting and show that it is greater than zero by five standard deviations. Furthermore, splittings in the Sigma, Xi, D and Xi_cc isospin multiplets are determined providing also predictions. We perform lattice Quantum-Chromodynamics plus Quantum-Electrodynamics computations with four, non-degenerate Wilson fermion flavors. Four lattice spacings and pion masses down to 195 MeV are used.