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Two Sources of Mass in Nature

The Higgs boson (HB) is commonly regarded as the origin of mass within the Standard Model of particle physics (SM). The Higgs produces the electron mass, m_e=0.511 MeV, and the quark current masses, amongst them the light u (up) and d (down) quarks: m_u≈4m_e≈2.2 MeV, m_d≈2m_u. These particles combine to form the hydrogen atom, the most abundant element in the Universe, whose mass is 939 MeV. Somehow one electron, two u quarks and one d quark, with a total Higgs-generated mass of ~13m_e≈6.6 MeV, combine to form an object whose mass is 140-times greater. Plainly, Nature must have another, very effective mass generating mechanism, responsible for 99% of the visible mass in the Universe. Contemporary theory explains this emergent hadron mass (EHM) as the consequence of the dynamical generation of a gluon mass in quantum chromodynamics (QCD). The existence of such a mass ensures that the QCD running coupling has a stable infrared completion. Together, these phenomena explain the character of mass in the matter sector of strong interactions. Such extraordinary predictions require empirical verification. This presentation will sketch the EHM paradigm for the origin of almost all visible mass in the Universe and indicate how the study of semileptonic weak-interaction transitions between heavy and light hadrons may contribute toward its validation. Indeed, studying the evolution of hadron properties with quark current mass, i.e., the strength of HB couplings into QCD, provides a clear window onto constructive interference between Nature's two sources of mass. This is a new feature of flavour physics, which adds enormously to its role in searching for physics beyond the SM.

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