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Evidence for intrinsic charm quarks in the proton

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The theory of the strong force, Quantum Chromodynamics, describes the proton in terms of quarks and gluons. The proton is a bound state of two up and one down quark, but quantum theory predicts that in addition there is an infinite number of quark-antiquark pairs. Both light and heavy quarks, whose mass is respectively smaller or bigger than the proton's, are revealed inside the proton in high-energy collisions. However, it is unclear whether heavy quarks also exist as a part of the static nucleon wave-function: so-called intrinsic heavy quarks. It has been argued for long that the proton could have a sizable intrinsic component of the lightest heavy quark, the charm quark. Innumerable efforts to establish intrinsic charm in the proton have remained inconclusive. We provide first evidence for intrinsic charm by exploiting a high- precision determination of the quark-gluon content of the nucleon based on machine learning and a large experimental dataset. We disentangle the intrinsic charm component from charm-anticharm pairs arising from high-energy radiation. We establish the existence of intrinsic charm at the 3σ level, with a momentum distribution in remarkable agreement with model predictions. We confirm these findings by comparing to very recent data on Z production with charm jets from the LHCb experiment.

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