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The axial coupling of the nucleon from Quantum Chromodynamics[1]

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The axial coupling of the nucleon, g_A, is a fundamental property of neutrons and protons. The long-range nuclear force between nucleons and the β-decay rate of a free neutron both depend on g_A^2. This coupling therefore underpins all of low-energy nuclear physics, controlling, for example, the primordial composition of the universe. While the value of g_A is, in principle, determined by the fundamental theory of nuclear strong interactions, Quantum Chromodynamics (QCD), it is daunting to compute, as QCD is non-perturbative and has evaded an analytic solution. Lattice QCD provides a rigorous, non-perturbative definition of the theory through a discretised formulation which can be numerically implemented. Using an innovative computational method, we resolve the two outstanding challenges identified by the lattice QCD community for determining g_A: we demonstrably control excited state lattice artefacts and are able to utilise exponentially more precise numerical data resulting in the determination $g_A^{QCD} = 1.275 \pm 0.012$, compatible with the experimentally measured value and with unprecedented precision of 0.95%. Prior to the work presented here, it was estimated, using standard methods of the field, that a 2% precision would only be achievable with the next-generation of leadership computing facilities by 2020. This calculation signals a new era of precision lattice QCD applications to high-impact experimental searches for physics beyond the Standard Model in nuclear environments.

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