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Multi-nucleon matrix elements on the lattice with e-graph optimised Wick contractions and the Feynman-Hellmann theorem

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The high-precision study of multi-nucleon matrix elements via lattice QCD requires numerical resources that increase dramatically with the number of nucleons, due to signal-to-noise degradation and a factorial number of Wick contraction terms. To address this, we present a particular variant of e-graphs (equality graphs) called tensor e-graphs which construct composite tensors that are 'maximally're-used within the numerical evaluation of a set of tensor expressions. By applying tensor e-graph optimisation to multi-nucleon matrix elements, we present speed-ups for a range of interpolating operators. We also show how an extension of Feynman-Hellmann theorem techniques developed for forward Compton virtual photon-nucleon scattering in concert with e-graph optimisation can enable a pathway to high-precision study of virtual photon-multi-nucleon scattering using lattice QCD.

Primary author: HUMPHREY, Nabil

Co-authors: Dr ZANOTTI, James (The University of Adelaide); Dr CAN, K. Utku (The University of Adelaide); YOUNG, Ross; DETMOLD, William

Presenter: HUMPHREY, Nabil

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