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Studying the structure of a bound proton through polarization-transfer measurements

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Knowledge of whether the proton's electromagnetic (EM) structure changes when it is bound inside an atomic nucleus is important for a better understanding of nuclear matter and its behavior. If such change is present it is expected to be relatively small and therefore difficult to experimentally determine.

The ratio of the transverse to longitudinal polarization-transfer components in the $\mathrm{A}(\vec{e}, e'\vec{p})$ reaction is proportional to the proton electromagnetic form factor (FF) ratio G_E/G_M. Experiments searching for in-medium modification of EM FF ratio were carried out on protons from different nuclei (^{2}H, ^{4}He, ^{12}C, and ^{16}O). Although the observed polarization transfer ratios deviated significantly (especially for those with higher Fermi momenta) from those of free proton, these differences could be accounted for with the inclusion of different nuclear effects. We observed that deviations in the measured polarization ratios from those of free-proton scattering have a similar dependence on virtuality (a measure of off-shellness) in all measured nuclei.

In our last experiment, instead of comparing results between different nuclei or comparing them against a free-proton scattering, we evaluated polarization transfer to protons extracted from s and p shell of ^{12}C nucleus and examined the differences. This was motivated by theoretical predictions that local nuclear densities experienced by protons in these two shells differ approximately by a factor of two, which could lead to significant changes in the proton EM FF ratio. Comparing protons from the same nucleus has also the advantage of reducing the influence of various experimental uncertainties. We will present these new data and the results in form of individual polarization components as well as their ratios that we obtained both as a function of the missing momentum (related to proton Fermi momentum) and proton's virtuality.

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