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COULOMB SUM RULE MEASUREMENT

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One of the important questions in nuclear physics is how nucleon properties are affected by the nuclear medium, since it might form a bridge between the strong interaction between nucleons and the underlying theory of Quantum ChromoDynamics (QCD). Since elastic scattering of electrons from a free nucleon has been well measured, quasi-elastic electron scattering off nuclei is a promising tool to investigate the properties of nucleons in nuclei. In particular, a Rosenbluth separation of the charge and magnetic responses of a nucleus can test a model-independent property known as the Coulomb Sum Rule (CSR).

This sum rule states that when integrating the charge response of a nucleus over the full range of energy loss ω at large enough three-momentum transfer $|\mathbf{q}|$, one should count the number of protons (Z) in a nucleus. This simple picture can be spoiled by the modification of the free nucleon electromagnetic properties by the nuclear medium and the presence of nucleon-nucleon short-range correlations. However it is expected that around the momentum transfer of 550 MeV/c, the CSR should not deviate more than a few percent due to $N-N$ correlations, and reach saturation at higher momentum trasfer, independent of the $N-N$ force chosen. Thus a deviation from the CSR might indicate a possible modification of the nucleon electric properties in the nuclear medium.

In the last twenty years, a large experimental program has been carried out at Bates, Saclay and SLAC aimed at the extraction of these two response functions for a variety of nuclei from ^{4}He to ^{208}Pb. Overall consistency of the data set between different laboratories has been observed except for ^{40}Ca. And in the case of medium-weight and heavy nuclei, conclusions reached by different experiments ranged from a full saturation of the CSR to its violation by 30%. Furthermore, a recent analysis argued that the "so-called quenching is mostly due to the limited significance of the data" and that including data at high energy loss ω leads to the result that "no A-dependent quenching is observed."

The approved experiment will make a precision measurement of inclusive electron scattering cross sections in the quasi-elastic region for a wide range of momentum transfers for ^{4}He, ^{12}C, ^{56}Fe and ^{208}Pb. We will extract the longitudinal and transverse response functions in the momentum transfer range $0.55\ \mathrm{GeV}/c \leq |\mathbf{q}| \leq 1.0\ \mathrm{GeV}/c$ with a precision of a few percent improving significantly on the precision of previous measurements in the overlap region. This should allow us to confirm/refute the presently controversial issue of the quenching of the longitudinal response function in medium weight nuclei and as importantly investigate the $|\mathbf{q}|$ evolution of the Coulomb Sum Rule as we probe significantly shorter distances.