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Detailed Study of the ^{4}He Nuclei through Response Function Separations at High Momentum Transfers

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^{4}He is the simplest nuclear system in which all the basic ingredients of a complex nuclei exist. Its binding energy is similar to that of heavier nuclei and it is reasonable to expect that the behavior of nucleon pairs within this nucleus is similar to that inside heavier nuclei. It is a tightly bound system with strong correlations, providing a better environment for the study of short range effects and nucleon-nucleon correlations in nuclei. Moreover, its study provides an important connection between two- and three-body systems, where exact calculations are possible in both initial and final states of the (e,e'p) reaction, and heavier nuclei where microscopic many body calculations still remain intractable.

We propose a detailed study the electromagnetic structure of ^{4}He through (e,e'p) coincidence measurements at high momentum transfers. In perpendicular kinematics, this will be accomplished by measuring the quasi-elastic ^{4}He(e,e'p)^{3}H cross section at a fixed $\mathbf{q} = 1.50$ GeV/c and $\omega = 0.84$ GeV as a function of missing momentum up to 1.2 GeV/c. We shall also extract the response function R_{TL} and the left-right asymmetry A_{TL} up to $p_m = 0.5$ GeV/c, and extract R_T and R_{L+TT} for missing momenta around 0 GeV/c, 0.4 GeV/c, and 0.5 GeV/c. These measurements will provide detailed observables to test current and future theoretical models. In parallel kinematics, we shall study the Q^2 dependence of the reaction ^{4}He(e,e'p)^{3}H by performing a longitudinal/transverse R_L/R_T separation from protons emitted along $\mathbf{q}$ in the Q^2 range from 0.81 to 4.1 [GeV/c]^2 with missing momenta near zero. We shall also make R_L/R_T separations of the reaction ^{4}He(e,e'p)pnn for high missing momentum, $p_m = 0.4$ GeV/c, for a $\mathbf{q}$ of 1.5 GeV/c and $x_B = 1.86$ to investigate nucleon-nucleon correlations. These measurements will be performed in Hall A, using the two high resolution spectrometers and a cryogenic ^{4}He target. Hall A is the only facility in the world where such measurements can be performed.