Commissioning and first data analysis of the Mainz Radius Experiment

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Abstract

The Mainz Radius Experiment (MREX) is an experimental campaign with the aim of determining fundamental properties of the equation of state (EOS) of nuclear matter. An important parameter, poorly-known, is the slope of the symmetry energy L, which quantifies the dependencies of the energy per nucleon associated with the changes in neutron-proton asymmetry. L is strongly correlated to the neutron-skin thickness δr_{np}, that is the difference between the mean square radius of the neutron and proton distributions. The MREX will measure δr_{np} for ^{208}Pb from parity-violating experiments (PV). The parity-violating experiments, where longitudinal polarized electrons scatter from a fixed target, consist in the determination of the cross section asymmetry $A_{pv} = \frac{\sigma^+ - \sigma^-}{\sigma^+ + \sigma^-}$ related to the different longitudinal beam polarization state. In this context, it is necessary to determine one of the possible background sources, the so-called transverse asymmetry A_n, that concerns transversely polarized electrons. A_n comes from the interference between two Feynman diagrams where one or two virtual photons are exchanged. The work of this thesis focuses on the measurement of A_n carried out at the MAMI accelerator on a ^{12}C target, particularly suited for testing the electronics systems that will be used to measure A_{PV}. A_n has been measured using two Cherenkov detectors (A and B) made of fused-silica materials coupled to 3 and 8 photo-multiplier tubes. The two detectors have been tested in the laboratory, together with the electronics that consist in the NINO-asic board with which the detector signals were acquired. The work consisted in a calibration phase, needed to measure the beam parameters, and in the analysis of the data. A_n has been measured for electron-carbon scattering at a two fixed angles ($\theta_B = -22.5°$, $\theta_A = 22.5°$) corresponding to a transfer momentum of $Q^2 = 0.04\,\mathrm{GeV}^2$. The measured values are: $A_B = -21 \pm 5\,(stat)\,ppm$ for detector B and $23.1 \pm 1.7\,(stat)\,ppm$ for detector A.