Medium modifications of light vector mesons in photoproduction reactions at JLab

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Theoretical calculations predict the modification of properties of vector mesons, such as a shift in their masses and/or broadening of their widths in dense nuclear matter. These effects can be related to partial restoration of chiral symmetry at high density or temperature. The light vector mesons (ρ, ω, and ϕ) were photo-produced on ^2H, C, Ti, Fe, and Pb targets at the Thomas Jefferson National Laboratory using the CEBAF Large Acceptance Spectrometer (CLAS). The data were taken with a beam of tagged photons with energies up to 4 GeV . The properties of the ρ vector meson at normal nuclear densities and zero temperature,were investigated via their rare leptonic decay to e^+e^-. This decay channel is preferred over hadronic modes in order to eliminate final state interactions in the nuclear matter. A combinatorial background was subtracted from the invariant mass spectra using a well-established event-mixing technique. The ρ meson mass spectrum was extracted after the ω and ϕ signals were removed in a nearly model-independent way. The rho meson mass distributions were extracted for each of the targets. Comparisons were made between the ρ mass spectra from the heavy targets ($A > 2$) with the mass spectrum extracted from the deuterium target. With respect to the ρ-meson mass, we obtain a small shift compatible with zero. Also, we measure widths consistent with standard nuclear many-body effects such as collisional broadening and Fermi motion.

In this experiment, due to the long lifetimes and momenta greater than 0.8 GeV, the ω and ϕ mesons have a high probability of decaying outside the nucleus in their vacuum state. However, their in-medium widths can be accessed through their absorption inside the nucleus. Preliminary results on the ratios of the nuclear transparencies of the ω and ϕ mesons as a function of the number of target nucleons A, have been obtained and indicate a substantial widening in the medium.

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