Nucleon Structure Functions, their Medium Modification and the Polarized EMC effect

Ian C. Cloët

Supervisors: Prof. A. W. Thomas and A/Prof. D. B. Leinweber

Special Research Centre for the
Subatomic Structure of Matter
and
Department of Physics,
University of Adelaide,
Australia

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Abstract

The central theme of this thesis is an investigation of the in-medium modifications to nucleon structure. We focus on the medium modifications to the three twist-two quark lightcone momentum distributions and associated structure functions. To achieve this we utilize the Nambu–Jona-Lasinio model, with the proper-time regularization scheme, in which confinement is simulated by eliminating unphysical thresholds for nucleon decay into quarks. The nucleon bound state is obtained by solving the relativistic Faddeev equation in the quark-diquark approximation, where both scalar and axial-vector diquark channels are included.

In this framework we obtain excellent results for the free spin-independent and spin-dependent quark distributions. The transversity distributions satisfy the Soffer inequality and are similar to the spin-dependent distributions. With the introduction of mean scalar and vector fields that couple to the quarks in the nucleon, we obtain a good description of many nuclear matter properties, including saturation at the correct energy and density.

The medium modifications to the nucleon structure functions are investigated in both infinite nuclear matter and for the nuclei ^{7}Li, ^{11}B, ^{15}N, ^{27}Al and the closed shell neighbours ^{12}C, ^{16}O and ^{28}Si. In each case the in-medium quark degrees of freedom are accessed via the convolution formalism. For finite nuclei we use a relativistic shell model including mean scalar and vector fields. We derive, for the first time, relativistic expressions for the nucleon distributions in a nucleus, that retain the phenomenologically important lower components of the nucleon wavefunction. We find that we are readily able to reproduce the experimental F_{2A}/F_{2N} ratio, that is, the EMC effect. However, the main focus of this thesis is on a new ratio – the nuclear structure function, g_{1A}, divided by the naive free result – which we refer to as the polarized EMC effect. We find that the medium modifications of the spin structure functions are remarkably large, up to twice the usual EMC effect. This result has important experimental implications, and may provide the impetus for future polarized deep inelastic experiments on nuclei.

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