PR12-23-011

Precision Deuteron Charge Radius Measurement...

David Richards, Christian Weiss

This proposal will extract the deuteron charge radius from elastic electron-deuteron scattering with the aim of "resolving" the *deuterium radius puzzle* where the highly precise muonic-deuterium determination is signfiicantly different from other determinations, notably those from electron scattering. The proposed experiment capitalizes on the PRad experiment, and in particular will imprevious experiments in three significant ways. First, the experiment will access far lower values of Q^2 than that of earlier determinations, thereby improving the reliability of the radius extraction that is related to the slope of the form factor at small Q^2. Second, by normalizing the cross section to the precisely known Moller cross section rather than that of the electron-proton scattering, thereby decoupling the deuterium charge radius from that of the proton. Third, by the use of a recoil detector to filter the elastic from the inelastic cross sections, and a precise measurement of the elasticity, a significant factor given the low binding energy of deuterium.

The proposal clearly describes the proposed analysis procedure for the high-precision demands of the experiment. The group has made considerable efforts modeling the inelastic background processes for extracting the elastic signal in the kinematics of the proposed experiment.

Regarding the deuteron radius extraction procedure, it is worth pointing out some similarities and differences to the proton case. Complex analyticity plays an essential role in the extraction of the charge radius and should be incorporated into the analysis procedure for the deuteron. The analytic structure of the deuteron form factor is different from that of the proton – there is a low-lying anomalous threshold from the deuteron as a pn bound state. The proponents could work with theorists to develop appropriate analytic form factor parametrizations.

Experience with proton radius extraction has shown that the Q^2 dependence of the form factor over a range of low Q^2 is as important and interesting as the derivative at $Q^2 = 0$ (charge radius). The Q^2 dependence contains valuable information about the higher derivatives, which constrain the radius extractions, reveal the dynamical scales in the deuteron, and can be used for testing precision nuclear structure calculations.

The two-photon exchange (TPE) corrections in elastic electron-deuteron scattering at low Q^2 may be very different from those of electron-proton scattering due to the presence of the deuteron quasielastic breakup channel as an intermediate state in the TPE amplitude. This contribution needs to be computed including the distortion arising from the strong interactions in the pn intermediate state close to the deuteron threshold.

In summary, this is a fine and very thoroughly constructed proposal that is addressing a topic of extreme importance to our understanding of strong-interaction physics.