Recent Results on Neutron Electromagnetic Form Factors

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Detailed information on the inner structure of the nucleon is provided by accurate data on the dependence of the nucleon form factors on momentum transfer Q^2. Particularly at low Q^2 accurate data allow for both a determination of the electromagnetic radii and accurate calculations of nuclear form factors.
Whereas the proton form factors are known with excellent precision over a large range of Q^2, data for the neutron are of much poorer quality due to the lack of a free neutron target. However, with today's high duty factor, high current electron beam facilities like Jefferson Laboratory (JLab) and the MAinz MIcrotron (MAMI), and the progress made in polarized beam and target technology, significant progress in this area has been made.
Precise data of the magnetic form factor G_{mn} have been extracted from measurements of the ratio $R = \sigma(e, e'n)/\sigma(e, e'p)$ on the deuteron in quasi–free kinematics at MAMI [1] for $Q^2 < 1$ $(\mathrm{GeV/c})^2$. The ratio is insensitive to the deuteron wave function and corrections due to FSI and MEC are small. The difficulty is shifted to the experiment: the precise determination of the *absolute* efficiency η of the neutron detector.
Together with G_{mn}–data measured at JLab via the asymmetry in ${}^3\vec{H}e(\vec{e}, e')$–scattering the new data have improved our knowledge of the neutron magnetic properties by a factor of 10 and reach the level of precision of the proton for $Q^2 < 1$ $(\mathrm{GeV/c})^2$.
Progress in the knowledge of the electric form factor, G_{en}, has been made by exploiting polarization observables. With experiments that involve the use of *both* polarized electrons and polarized target nuclei or polarization of the recoil neutron one can avoid the traditional uncertainties in G_{en} stemming mostly from the theoretical description of the 2N-system. The asymmetry in these measurements is directly proportional to an interference terms involving $G_{en} \cdot G_{mn}$.
By now several experiments have published results on G_{en} at low Q^2. In the present paper emphasis will be given to measurements performed at JLab at $Q^2 = 0.5, 1$ $(\mathrm{GeV/c})^2$ and at MAMI at $Q^2 = 0.67$ $(\mathrm{GeV/c})^2$. At JLab we completed experiment E93–026 in which G_{en} is extracted from the asymmetry of exclusive quasi–elastic $\vec{D}(\vec{e}, e'n)p$–scattering [2]. The additional data have improved considerably the accuracy at Q^2 of 0.5 $(\mathrm{GeV/c})^2$and provides new data at Q^2 of 1.0 $(\mathrm{GeV/c})^2$. At MAMI we determined G_{en} with a measurement of the asymmetry of ${}^3\vec{H}e(\vec{e}, e'n)$–scattering on top of the quasi–elastic peak at a Q^2-value of 0.67 $(\mathrm{GeV/c})^2$. In PWIA the polarized ${}^3\vec{H}e$ nucleus acts as a polarized neutron target and the measurement of the asymmetry in exclusive quasi–elastic scattering ${}^3\vec{H}e(\vec{e}, e'n)$ can provide G_{en}. In the second experiment we have improved the error bar of the pilot run by a factor of two [3]. Partly preliminary results of both experiments will be shown together with all other published data obtained via measurements of spin–observables.

References

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