Magnetic Properties of the Nucleon in a Uniform Background Field

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Abstract

We present a calculation of the magnetic moment and magnetic polarisability of the nucleon. The calculation is performed using the background field method of lattice QCD. Dynamical results are from $32^3 \times 64$ configurations with 2+1 flavours of quark provided by the PACS-CS group through the ILDG. These lattices use a clover fermion action and Iwasaki gauge action with $\beta = 1.9$ and physical lattice spacing $a = 0.0907(13)$ fm. Quenched results come from $32^3 \times 40$ lattices using a FLIC fermion action and Symanzik improved gauge action with $\beta = 3.2$ and $a = 0.127$ fm.

The Landau energy is a crucial effect in the calculation of magnetic polarisabilities for charged particles. We derive the Landau levels and show their effect using examples of proton energy shifts in a background field.

Next we investigate the effects of moving the origin of the background gauge potential. This procedure looks similar to the technique of twisted boundary conditions, but we explain how for a quantised background field there is no change in the physical states, and show evidence using tree level calculations.

We present magnetic moment calculations for the proton and neutron, with a comparison between quenched and dynamical background field results as well as three point function results. We use the variational method in order to isolate excited states so that we can present results for the magnetic moment of the lowest lying odd-parity proton and neutron states.

Finally we present a calculation of the magnetic polarisability of the neutron. We investigate ways of improving the plateau behaviour of the energy shift, including the use of a variational analysis with a variety of source and sink smearings. Results are compared with experimental values.

Statement of originality

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