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Lattice simulations of vector mesons in strong magnetic field

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We have explored ground state energies of the light vector mesons on the base of the $SU(3)$ lattice gauge theory. This study was performed without dynamical quarks. We have observed the energies splitting depending on the value of the spin projections on an external magnetic field. The ground state energy of neutral mesons with the $s_z = 0$ diminishes with the increase of the field, while the energy of charged one increases according to the theoretical expectation. The neutral mesons energies with non-zero spins $s_z = -1$ and $+1$ increase with the value of the magnetic field.

The Landau level describes the energy of a charged point-like particle in a magnetic field, while in our calculations we took into account the quark structure of a particle and introduced the term with magnetic polarizability:

$$\begin{equation} E^2 = p_z^2 + m^2 + |qH| - g s_z H - 4\pi m \beta_m H^2, \quad H = eB, \end{equation}$$

where E is the ground state energy of a particle, g is the magnetic dipole moment of the particle in $\frac{e}{2m\rho}$ units, q is its charge, $m = E(H = 0)$ is the mass of the particle, s_z is the spin projection on the external magnetic field, β is the magnetic polarizability. We have observed the agreement of the Landau level picture with our data for the magnetic field values below 0.6 GeV^2 .

The background magnetic field enables to calculate the magnetic polarizabilities and the magnetic dipole moments of the hadrons. We measured the energy of a meson as a function of the uniform abelian field.

In our calculations external magnetic field is constant and its values vary from 0 up to 2.5 GeV^2 . The magnetic dipole moment of the charged ρ meson has been defined for various quark masses more precisely than in our previous work. This value is in good agreement with the experimentally obtained value. We have also estimated the magnetic dipole moment of the K^* meson.

The study of the internal structure of hadrons in external fields is important and relevant in connection with ongoing experiments at JLAB, CERN(COMPASS), SLAC. Currently there exist significant discrepancies between the theoretical predictions, different phenomenological models and experimentally obtained data. For most mesons the magnetic polarizability and g -factor has not been found experimentally yet. There still exist large uncertainties in determination of the electric and magnetic polarizabilities. According to the chiral perturbation theory magnetic and electric polarizabilities are interrelated, what stresses the importance of calculating magnetic polarizability.

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