

## Baryon electric charge correlation as a magnetometer of QCD

Monday, 27 October 2025 11:50 (20 minutes)

We present the first lattice QCD results of quadratic fluctuations and correlations of conserved charges in (2+1)-flavor lattice QCD in the presence of a background magnetic field. The simulations were performed using the Highly Improved Staggered Quarks with physical pion mass  $m_\pi = 135$  MeV on  $N_\tau = 8$  and 12 lattices. We find that the correlation between net baryon number and electric charge, denoted as  $\chi_{11}^{\text{BQ}}$ , can serve as a magnetometer of QCD. At pseudocritical temperatures the  $\chi_{11}^{\text{BQ}}$  starts to increase rapidly with magnetic field strength  $eB > 2M_\pi^2$  and by a factor 2 at  $eB \simeq 8M_\pi^2$ .

By comparing with the hadron resonance gas model, we find that the  $eB$  dependence of  $\chi_{11}^{\text{BQ}}$  is mainly due to the doubly charged  $\Delta(1232)$  baryon. Although the doubly charged  $\Delta(1232)$  could not be detected experimentally, the proxy constructed from its decay products, protons and pions, retain the  $eB$  dependence of  $\Delta(1232)$ 's contribution to  $\chi_{11}^{\text{BQ}}$ . Additionally, under the same kinematic cuts as in the ALICE experiment, the proxy for  $\chi_{11}^{\text{BQ}}$  still exhibits a strong dependence on the magnetic field.

Furthermore, the ratio of electric charge chemical potential to baryon chemical potential,  $\mu_Q/\mu_B$ , shows significant dependence on the magnetic field strength and varies with the ratio of electric charge to baryon number in the colliding nuclei in heavy ion collisions. These results provide baselines for effective theory and model studies, and both  $\chi_{11}^{\text{BQ}}$  and  $\mu_Q/\mu_B$  could be useful probes for the detection of magnetic fields in relativistic heavy ion collision experiments as compared with corresponding results from the hadron resonance gas model.

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**Session Classification:** Parallel I

**Track Classification:** QCD 相变与状态方程 (QCD phase transition and equation of state)