Open Bottom Mesons in Hot Magnetized Strange Hadronic Matter

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Introduction

The influence of strong magnetic fields on the properties of QCD matter is relevant in non-central heavy-ion collision experiments. The strength of the magnetic field could reach up to $eB \sim 2{m_\pi}^2 \sim 6 \times 10^{18}$ Gauss in the Relativistic Heavy Ion Collider(RHIC) at Brookhaven National Laboratory (BNL) and eB $\sim 15{m_\pi}^2 \sim 10^{19}$ Gauss in the Large Hadron Collider(LHC) at CERN [1]. Since charm and bottom quarks are produced at the early stages of the heavy-ion collision where the strength of the magnetic field is sufficiently high, the heavy flavor mesons may experience the effect of magnetic fields [2]. The chiral condensates in QCD, which act as an order parameter for the amount of spontaneous chiral symmetry breaking, are altered through magnetic catalysis and inverse magnetic catalysis in the presence of magnetic fields. The gluon condensates, which play a role in scale symmetry breaking, are also modified by strong magnetic fields. As the hadrons produced in these heavy-ion collision experiments interact with these condensates, their properties also modify in the presence of the magnetic field at finite baryon density and temperature. Moreover, the effect of strange baryons on the medium properties at finite baryon densities is important to be investigated in heavy ion collision experiments.

Masses of open bottom mesons in the medium

We have investigated the masses of open bottom mesons (B(B^+,B^0), $\bar{B}$(B^-,$\bar{B^0}$), $B_s({B_s}^0,\ \bar{B_s}^0)$) in the isospin asymmetric magnetized strange hadronic medium at finite temperature using a chiral effective Lagrangian approach [3]. Here the chiral $SU(3)$ Lagrangian is generalized to include the bottom sector to incorporate the interactions of the open bottom mesons with the magnetized medium [3, 4]. At finite temperature, the number density and scalar density of baryons are expressed in terms of thermal distribution functions. For charged baryons, the magnetic field introduces contribution from Landau energy levels. The effects of anomalous magnetic moments (AMM) of baryons is also considered in this investigation. From the chiral effective Lagrangian, we solve the equations of motion of scalar fields as functions of baryon density at various values of temperature for different values of strangeness fraction and magnetic fields. The scalar meson fields (σ, ζ, and δ) mimic the light quark condensates in the medium, and the dilaton field (χ) simulates the gluon condensates in the medium.

The masses of the open bottom mesons get modified through their interactions with the baryons and the scalar mesons, which undergo modifications in a magnetized medium. The masses of the open bottom mesons are calculated by solving their in-medium dispersion relations. The charged B^+, B^- mesons have additional positive mass shifts due to Landau quantization in the presence of the magnetic field. The open bottom mesons states experience a mass drop in the magnetized medium. When hyperons are added to the medium, the intensity of this mass drop becomes more significant, and the mass degeneracy of B_s mesons is broken. The masses of these mesons initially increase with a temperature rise, and beyond a high-temperature value, their masses are observed to drop.

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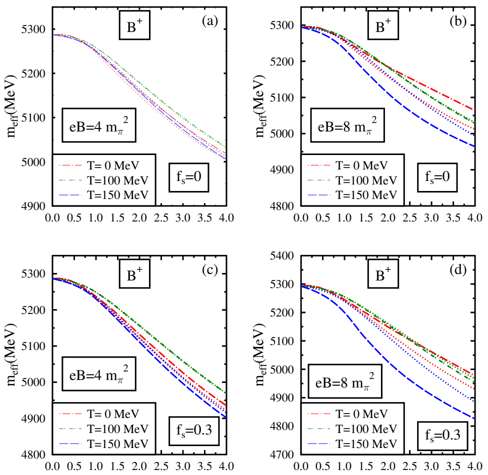

FIG. 1: The effective mass of B^+ meson in isospin asymmetric (η=0.5) hadronic matter plotted as a function of the baryon density ρ_B/ρ_0 for temperature T= 0, 100, and 150 MeV. These are plotted at magnetic fields $eB = 4m_\pi^2$ and $eB = 8m_\pi^2$, for strangeness fraction $f_s = 0, 0.3$. The effects of the AMM of baryons are incorporated (dashed lines) and compared to the case when these effects are not considered (dotted lines).

The value of this turnaround temperature at which this functional behavior reverses depends upon the strength of the magnetic field, baryon density, and the strangeness fraction. When the temperature is below 90 MeV, the in-medium masses of the mesons increase with an increase in the magnetic field. However, at high temperatures (T > 90 MeV), the masses drop with an increase in the magnetic field. These mass modifications can have observable effects in the B^+/B^0, $B^-/\bar{B}^0$, and ${B_s}^0/\bar{B_s}^0$ production ratios and the partial decay widths of upsilon states to $B\,\bar{B}$ in asymmetric heavy-ion collisions experiments.

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