Charmonium and Upsilon States in Magnetized Hadronic Matter.

A. Jahan CS,* S. Reddy P, N. Dhale, S. Kesarwani, and A. Mishra
Department of Physics, Indian Institute of Technology Delhi,
Hauz Khas, New Delhi - 110016, INDIA

Introduction

Heavy flavour mesons consist of one or more quark (antiquark) belonging to the heavy flavors (charm or bottom). The properties of heavy quarkonia such as charmonium states (J/ψ, $\psi(3686)$, $\psi(3770)$, χ_{c0}, χ_{c2}) and upsilon states ($\gamma(1S)$, $\gamma(1D)$, $\gamma(2S)$, $\gamma(3S)$, $\gamma(4S)$) in strongly magnetized nuclear medium are investigated. Here we use a chiral effective Lagrangian model based on non-linearization of chiral symmetry and the broken scale invariance of QCD through the dilaton field. In Heavy Ion Collision experiments at Relativistic Heavy Ion Collider (RHIC) at BNL and at Large Hadron Collider (LHC) where strong magnetic fields are created, this study is necessary as they affect the experimental observables.

Mass Modifications of Charmonium and Upsilon states

To the chiral Lagrangian, we add a Lagrangian term incorporating the magnetic field, which can be assumed to be in z direction and uniform. The field term of the magnetic part of the Lagrangian has vectorial as well as tensorial interactions of baryons with the electromagnetic field. The tensorial interaction is related to the anomalous magnetic moment of the baryon. The number density and scalar density of the protons have contributions from the Landau energy levels in the presence of the magnetic field. The equations of motion are solved to obtain the values of scalar fields (the non- strange field σ, strange field ζ, isovector field δ and the dilaton field χ).

The mass modifications of charmonium and upsilon states are due to medium modifications of the dilaton field χ, which simulates the gluon condensates of QCD within the chiral effective model. If we assume the light quarks to be massless, then the energy momentum tensor, and hence the gluon condensate is in fact proportional to the fourth power of dilaton field χ. Hence, the mass shifts of the charmonium and upsilon states arise due to the difference in the medium value of the fourth power of the dilaton field from the fourth power of its vacuum value. The wave functions for these heavy quarkonium states are taken to be Gaussian. The excited heavy quarkonium states are observed to show significant modifications in their masses in presence of magnetic field, as compared to the ground states in the nuclear medium [1][2]. The mass shifts of charmonium and upsilon states are observed to increase with density and should show in observables in the Compressed Baryonic Matter (CBM) experiment at FAIR at the future facility at GSI, where baryonic matter at high densities and moderate temperatures will be produced.

References

[1] Amal Jahan C.S, Nikhil Dhale, Sushruth Reddy P, Shivam Kesarwani and Amruta Mishra, Phys. Rev. C 98, 065202 (2018).

[2] Amal Jahan C.S., Shivam Kesarwani, Sushruth Reddy P., Nikhil Dhale and Amruta Mishra, arXiv:1807.07572 [nucl-th].

*Electronic address: amaljahan@gmail.com