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Understanding the diffusion and melting of heavy flavor hadrons

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The substantial mass of charm quarks makes them an ideal tool for probing the de-confined medium of quarks and gluons. These charm quarks interact with the medium, thereby carrying vital information about it, before undergoing hadronization to form heavy flavor hadrons.
In this study, we make use of the color string percolation model (CSPM) and the van der Waals Hadron Resonance Gas (VDWHRG) model to examine the diffusion of charm quarks and the D^0 meson in the deconfined and the hadronic phase respectively. CSPM is a QCD-inspired model that assumes colored strings to be stretched between the partons of the colliding nuclei. This is a well-established model which has been used to estimate various thermodynamic and transport properties of the matter formed in ultra-relativistic hadronic and heavy-ion collisions. Conversely, the VDWHRG model is a modified hadron resonance gas model that takes both attractive and repulsive interactions between the hadrons into account. This model successfully explains the lattice QCD data up to temperature, $T \simeq 180$ MeV.
We calculate the drag coefficient (γ) and diffusion coefficients in both momentum (B_0) and coordinate space (D_s) within both CSPM and VDWHRG models. Our observations reveal a minima for the spatial diffusion coefficient around the deconfinement temperature, indicating a phase transition.
Additionally, we investigate the melting of the charmed hadrons by estimating the charm susceptibilities within the VDWHRG model. We found a smooth transition near the deconfinement region at a vanishing chemical potential, hinting at a crossover transition.
The net charm fluctuations can be estimated in experiments by taking the net number fluctuation of $D^{\pm}$ meson. It has not been done in experiments till now. However, with ALICE Run-3 going towards higher luminosity and better detection capabilities, one can perform this study experimentally.
This study offers significant insights into the behavior of charm quarks and open charm hadrons, thereby contributing to the broader understanding of the interaction of heavy flavor with the thermalized medium.

Auteurs principaux: GOSWAMI, Kangkan (Indian Institute of Technology Indore); Prof. SAHOO, Raghunath (IIT Indore, India)

Co-auteurs: M. SAHU, Dushmanta (Indian Institute of Technology Indore); M. PRADHAN, Kshitish Kumar (Indian Institute of Technology Indore)

Orateurs: GOSWAMI, Kangkan (Indian Institute of Technology Indore); Prof. SAHOO, Raghunath (IIT Indore, India)

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