Study of Charmonia States in Vacuum and High density medium

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Introduction:

Heavy quarks (charm and bottom) provide a probe for the Quark Gluon Plasma (QGP) because of their heavy masses which are much larger than $T_s\approx 200$ MeV, the critical temperature for the QGP to form. We study bound states these quarks form, in particular Charmonium, a charm-anticharm bound state. Charmonium and its excited states ($J/Psi$, $Psi'$, ... ) are studied both in vacuum and in medium (the QGP).

The Quark Gluon Plasma:

Quantum Chromodynamics (QCD) predicts an exotic state of quark matter at temperatures of about $2\times 10^{12}$ K (170 MeV), the Quark Gluon Plasma (QGP). Experiments performed at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, where two Au nuclei are sent to collide at relativistic energies provide evidence for such a medium to occur.

The kinetic energy of the colliding Au Nuclei is converted into compression and thermal energy which allow different matter types to be produced. After collisions and other hadrons containing u, d, s, quarks, are observed. It is believed tough that the life time of the QGP is just $10^{-22}$ s after the collision. Nevertheless this interval of time is enough for this “fireball” to reach equilibrium. Hadrons containing heavy quarks (charm and bottom) have been identified as possible probes for the QGP. We say deconfinement occurs from vacuum potentials. These are the Energies of the presented states above:

For each potential a different charm rest mass was used, this to match the ground states to about 3.096 GeV, the rest mass of charmonium. The energies obtained are the following: (Format: charm mass, System mass, Eigen System (Energy in GeV’s))

<table>
<thead>
<tr>
<th>Rest mass</th>
<th>System mass</th>
<th>Eigen System</th>
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</thead>
<tbody>
<tr>
<td>1.190</td>
<td>2.182</td>
<td>0.212</td>
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<tr>
<td>1.190</td>
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<td>0.212</td>
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<tr>
<td>1.190</td>
<td>1.918</td>
<td>0.424</td>
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</tbody>
</table>

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References: