Energy and momentum relaxation of heavy fermion in dense and warm plasma

Content :

Recent years have witnessed significant progress in understanding the properties of hot and/or dense relativistic plasma specifically the study of partonic energy loss and momentum diffusion coefficient in this medium. We here first calculate the drag (\eta) and the momentum diffusion coefficients (B) in the extreme case of zero temperature and then incorporate finite temperature corrections to our result in the limit T<<\mu which is the region of interest of the upcoming experiments on compressed baryonic matter (CBM) to be performed at FAIR/GSI and also in the astrophysical situations. We also determine the relationship between \eta and B i.e Einstein relation (ER) at zero temperature, which shows some interesting behavior due to finite density plasma effect.

In case of hard photon exchange, the expressions for both drag and diffusion coefficients are infrared divergent and unlike the finite temperature here higher powers of q appear in the denominator. To deal with this problem, we can use Braaten and Yuaan's prescription (BY) to separate the integration into two domains: one involving the exchange of hard photons and the other involving soft photons. In the later the term containing intermediate scale (q*) appear only at higher order in coupling and the leading order terms are finite and independent of q*. The hard contribution also fails to contribute at the leading order. This is a distinctive feature of degenerate plasma not encountered at finite temperature (\mu = 0). There both the hard and the soft part contribute to the same order in coupling and the divergence is only logarithmic. Hence, the whole contribution to leading order comes from the soft sector alone in case of dense plasma. So, BY prescription is not required in this case. It is seen that in degenerate matter drag coefficient at the leading order mediated by transverse photon is proportional to (E-\mu)^2 while for the longitudinal exchange this goes as (E-\mu)^3 i.e the electric and the the magnetic modes behave differently. Similar differences for B is also seen where one more extra power of (E – \mu) involved in each case. The dominant contribution to both \eta and B comes from the magnetic sector in the ultrarelativistic case(v_f ⟶ 1) and the electric sector when v_f<<1. In hot plasma, from the expressions of \eta and B it is known that B=2ET\eta. At zero temperature, we find, B=3E(E –μ)/4 when we do not take the plasma effects into account. However, we can see that this common scale behavior is lost for soft photon exchange where the plasma effects are included and both the magnetic and electric contributions are retained. But as ER is

formulated in the region where v_f<<1, in this nonrelativistic region exchange of the magnetic photons are suppressed in comparison with the electric one. Hence, considering only the electric part we get the same ER, $B=3E(E-\mu)/4$ as in the case of bare perturbation theory. The zero temperature, finite density results can easily be extended to the case of a hot and dense (T<<\mu) plasma. One can find here that with the thermal correction the ER cannot be established even for the electric sector alone.

The importance of the present work resides in the fact that the T or \mu dependent expressions of \eta or B which we derive can directly be employed to study the equilibration of heavy fermions in dense and warm plasma. This might be very important for conditions under which QCD matter can be produced in CBM like experiments.

Reference:
Sreemoyee Sarkar and Abhee K. Dutt-Mazumder Phys. Rev. D 82, 056003 (2010).

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