Fermi Liquid Model for Hadrons in Medium

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I Introduction :

The Landau Fermi liquid theory is an phenomenological approach to strongly interacting normal fermi system at small excitation energies. It is a model which suggest a point to point correspondence between low energy excitation of non interacting Fermi gas [1]. We have estimated the effective mass of the hadrons in medium considering the fact that the hadrons behave like fermi excitation while in medium and have estimated the dressed mass considering a suitable potential.

II Formulation:

If a weak potential is assumed, the excitation spectrum remains same qualitatively similar as in free fermi gas with a shift of energy [2] So free fermi sphere is associated with another particle at momentum p with p > p_F and forms excited state of ideal gas with modified mass m^* which has been defined as effective mass. The modified density of states can be represented as:

$$g(\epsilon_F) = \frac{m^* p_F}{\pi^2 \hbar^3} \quad (1)$$

The energy can also be expressed as: [3]

$$\epsilon(p \simeq p_F) = \frac{p^2}{2m} + V(p) = \frac{p^2}{2m^*} + const. \quad (2)$$

Differentiating expression (2) with respect to p and setting p=p_F we obtain

$$\frac{1}{m^*} = \frac{1}{m} + \frac{1}{p_F}[\frac{dV(p)}{dp}]_{p=p_F} \quad (3)$$

We have used similar type of mechanism for hadron in nuclear medium. We assume that the mass of the hadron gets modified as it propagates through the medium due to interaction.'

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To describe the interaction we consider a momentum dependent potential [4] only $\upsilon(r)$ constant; we get

$$V(p^2) = V_0 e^{-\gamma(\frac{p^2}{m})} \tag{4}$$

and we came across the equation

$$\frac{1}{m^*} = \frac{1}{m} - \frac{2}{m} e^{-\gamma(\frac{p^2}{m})} | p = p_F \tag{5}$$

Table: $\frac{m^*}{m}$ for different hadrons.

Hadron	Radius in GeV^{-1}	(P_F) in GeV	$\frac{m^*}{m}$
λ^0	1.989	0.289	1.616
Σ^-	3.65	0.392	1.106
Ξ^-	3.3	0.398	1.146
Ω^-	2.9	0.396	1.217
λ_c^+	5.727	0.658	1.017
λ_b^0	1.481	0.493	2.393
Σ_c^+	3.386	0.506	1.135
Σ_b^0	1.253	0.453	3.382
Ξ_c^0	2.404	0.443	1.369
Ξ_b^0	1.12	0.436	4.682
Ω_c^0	2.5	0.468	1.332
Ω_b^-	2.012	0.595	1.597
Ξ_{cc}^{++}	4.549	0.724	1.048
Ξ_{cc}^+	1.443	0.408	2.506
Ξ_{bb}^0	3.917	1.069	1.083
Ξ_{bb}^-	3.039	0.942	1.189
Ξ_{cb}^+	4.402	0.947	1.053
Ξ_{cb}^0	1.989	0.637	1.615
Ω_{cc}^+	1.344	0.404	2.88
Ω_{cb}^0	1.054	0.47	5.916
Ω_{bb}^-	2.444	0.853	1.353
Ω_{ccc}	1.5	0.482	2.342
Ω_{bbb}	1.25	0.726	3.398
Ω_{ccb}	5	1.103	1.032
Ω_{bbc}	5	1.288	1.032

In the present work we have studied the properties of hadrons in medium in an analogy with the Fermi liquid model where the effect of the medium is incorporated via effective mass approximation. We have assumed that a baryon in medium behaves like a Fermi excitation incorporating the many body interaction in the system and behaves like a quasi particle with an effective mass different from constituent mass.

References:

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