Phase structure of the Quark-Meson model

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I. INTRODUCTION

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II. 2 FLAVOR QUARK MESON MODEL

The effective action of the 2 flavor quark-meson model reads [1]

$$\Gamma_k[\Phi] = \int_x \{ Z_{q,k}\bar{q}(\gamma_\mu\partial_\mu - \gamma_0\mu)q + \frac{1}{2}Z_{\phi,k}(\partial_\mu\phi)^2 + h_k\bar{q}(T^0\sigma + i\gamma_5\vec{T}\cdot\vec{\pi})q + V_k(\rho) - c\sigma\} \tag{1}$$

with the integral $\int_x = \int_0^{1/T} d_{x_0}\int d^3x$. T and μ denote the temperature and quark chemical potential, respectively. The meson/quark wave function $Z_{\phi,k}/Z_{q,k}$ are scale and field dependent. Moreover, in this work we ignore the longitudinal and transversal splitting of Z_k, i.e., $Z_k^{\parallel}$ and $Z_k^{\perp}$, respectively, and an interesting discussion is presented in Ref. [2]. T^0 and $\vec{T}$ are generators of $SU(N_f = 2)$ with $\mathrm{Tr}(T^iT^j) = \frac{1}{2}\delta^{ij}$ and $T^0 = \frac{1}{\sqrt{N_f}}\mathbb{1}_{N_f\times N_f}$. Quark and meson interaction is encoded in Yukawa coupling h_k in Eq. (1). The effective potential $V_k(\rho)$ is scale and field dependent and chirally invariant with chirally invariant variable $\rho = \frac{1}{2}\phi^2$. The linear sigma term $-c\sigma$ explicitly breaks the chiral symmetry.

Then with the Wetterich equation

$$\partial_t\Gamma_k[\Phi] = \frac{1}{2}\mathrm{Tr}\, G_{\phi\phi}[\Phi]\partial_t R_k^\phi - \mathrm{Tr}\, G_{q\bar{q}}[\Phi]\partial_t R_k^q \tag{2}$$

with the regulators

The renormalized dimensionless meson and quark

$$\partial_t V_k(\rho) = \frac{k^4}{4\pi^2}\{(N_f^2-1)l_0^B(m_{\pi,k},\eta_{\phi,k};T) + l_0^B(m_{\sigma,k},\eta_{\phi,k};T) - 4N_cN_f l_0^F(m_{q,k},\eta_{q,k};T,\mu)\} \tag{6}$$

here $l_0^{B/F}$ are threshold functions which are defined as

$$l_0^B(\bar{m}_{\phi,k}^2,\eta_{\phi,k}) = \frac{2}{3}\frac{1}{\sqrt{1+\bar{m}_{\phi,k}^2}}\Big(1-\frac{\eta_{\phi,k}}{5}\Big)\Big(\frac{1}{2}+n_B(\bar{m}_{\phi,k}^2,T)\Big) \tag{7}$$

$$l_0^F(\bar{m}_{q,k}^2,\eta_{q,k}) = \frac{1}{3}\frac{1}{\sqrt{1+\bar{m}_{q,k}^2}}\Big(1-\frac{\eta_{q,k}}{4}\Big)\Big(1-n_F(E-\mu)-n_F(E+\mu)\Big) \tag{8}$$

$$\eta_{\phi,k} = \frac{1}{6\pi^2}\Big\{\frac{4}{k^2}\rho(V_k'(\rho))^2 \tag{9}$$

III. RESULTS

A. phase diagram at chiral limit

IV. SUMMARY AND DISCUSSIONS

In this work, we have studied

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[2] S. Yin, R. Wen, and W.-j. Fu, (2019), arXiv:1907.10262 [hep-ph].

masses are obtained by

$$\bar{m}_\pi = \frac{V_k'(\rho)}{k^2 Z_{\phi,k}} \tag{3}$$

$$\bar{m}_\sigma = \frac{V_k'(\rho) + 2\rho V_k''(\rho)}{k^2 Z_{\phi,k}} \tag{4}$$

$$\bar{m}_q = \frac{h_k^2 \rho}{2k^2 Z_{q,k}^2} \tag{5}$$

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