In-Medium Condensates

hadronic medium in thermal equilibrium

partition function:

$$\mathcal{Z}(V,T,\mu) = \mathrm{Tr}\left\{e^{-(\hat{H}-\mu\hat{N})/T}\right\}$$

thermal expectation values:

$$\langle\!\langle \mathcal{O} \rangle\!\rangle = \mathcal{Z}^{-1} \sum_n \langle n|\mathcal{O}|n\rangle e^{-(E_n-\mu)/T}$$

$$\langle\!\langle \bar{\psi}\psi \rangle\!\rangle = \mathcal{Z}^{-1} \sum_n \langle n|\bar{\psi}\psi|n\rangle e^{-(E_n-\mu)/T}$$

$$\langle\!\langle G^2 \rangle\!\rangle = \mathcal{Z}^{-1} \sum_n \langle n|G^2|n\rangle e^{-(E_n-\mu)/T}$$

EoS:

$$\Omega = -\frac{T}{V}\ln \mathcal{Z}$$

free energy dens.

$$p = T\left(\frac{\partial \ln \mathcal{Z}}{\partial V}\right)_{T,N}$$

pressure

$$\epsilon = \frac{T^2}{V}\left(\frac{\partial \ln \mathcal{Z}}{\partial T}\right)_{V,N} + \mu\frac{N}{V}$$

free energy dens.