2-color QCD phase diagram

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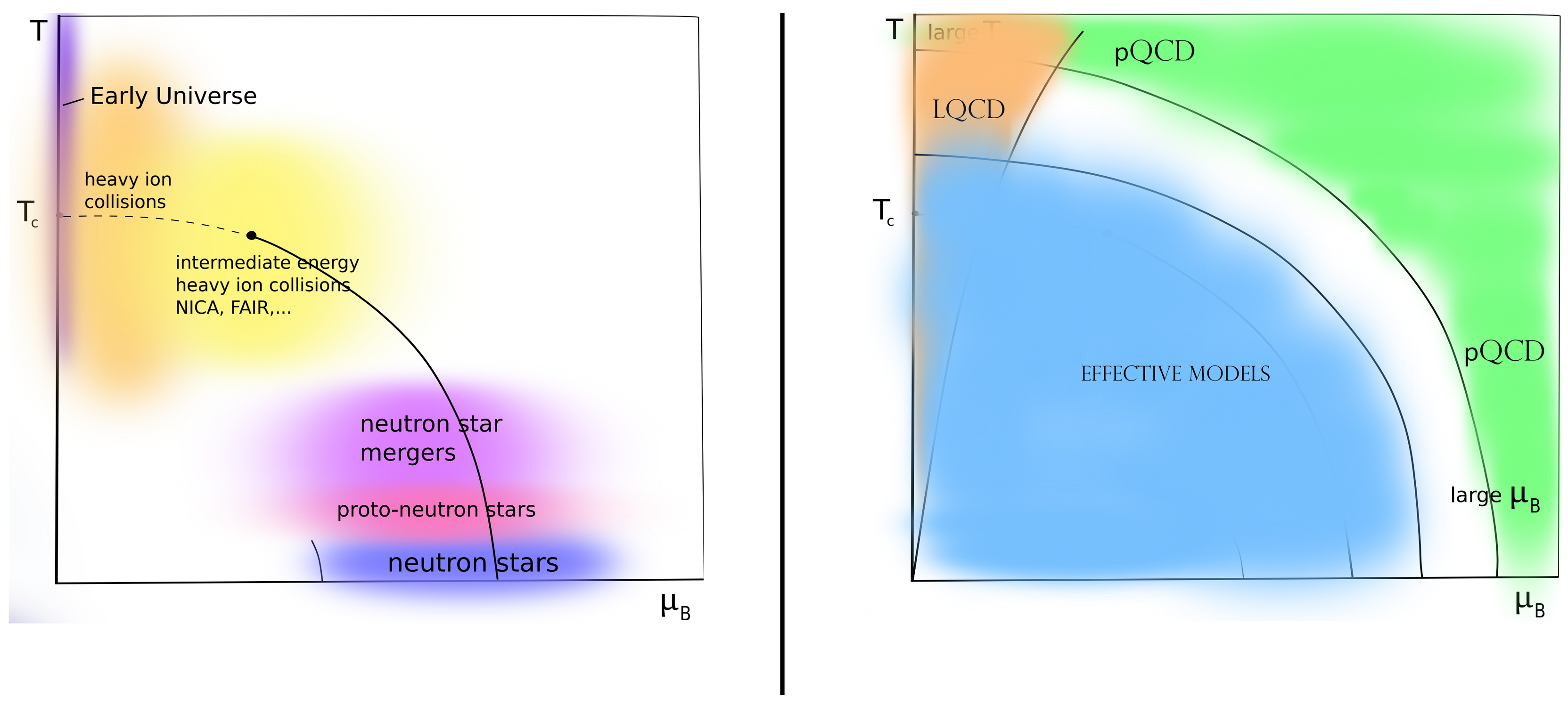
QCD phase diagram



2-color QCD

There are a lot similarities between QCD and 2-color QCD

- similar phase transitions:
  confinement/deconfinement, chiral symmetry breaking/restoration at large T and μ
- A lot of physical quantities coincide up to few dozens percent
  Critical temperature $T_c/\sqrt{\sigma}$, topological susceptibility $\chi^{\frac{1}{4}}/\sqrt{\sigma}$ shear viscosity η/s
- There are no sign problem in SU(2) case
  and lattice simulations at non-zero baryon density are possible

It is a great playground for studying dense matter

2-color NJL model and its thermodynamical potential

$$L = \bar{q}\left[\gamma^\nu i\partial_\nu\right] + \mathcal{M} + H\left[(\bar{q}q)^2 + (\bar{q}i\gamma^5\vec{\tau}q)^2 + \left(\bar{q}i\gamma^5\sigma_2\tau_2 q^c\right)\left(\overline{q^c}i\gamma^5\sigma_2\tau_2 q\right)\right]$$

$$\mathcal{M} = \frac{\mu_B}{3}\gamma^0 + \frac{\mu_I}{2}\tau_3\gamma^0 + \frac{\mu_{I5}}{2}\tau_3\gamma^0\gamma^5 + \mu_5\gamma^0\gamma^5$$

- μ_B is baryon chemical potential,
- μ_I is taken into account to introduce the non-zero imbalance between u and d quarks,
- μ_{I5} and μ_5 accounts for chiral isospin and chiral imbalances.

From here we use notations $\mu \equiv \mu_B/3$, $\nu = \mu_I/2$ and $\nu_5 = \mu_{I5}/2$.

If you use Habbard-Stratanovich technique and auxiliary fileds

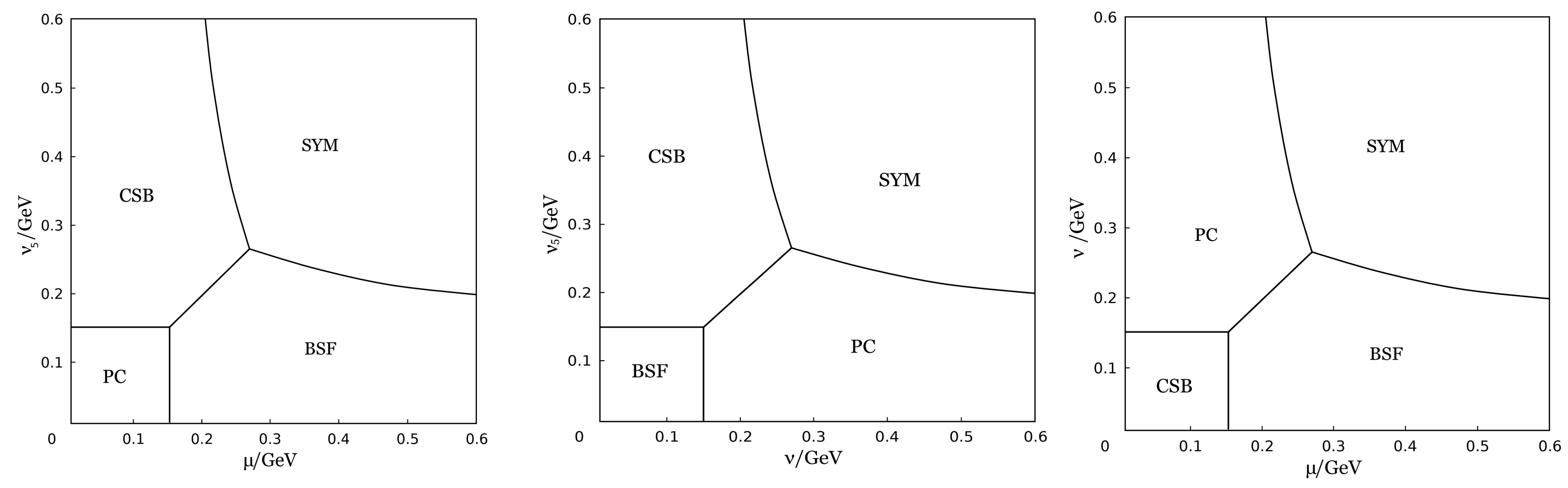
$$\sigma(x) = -2H(\bar{q}q),\ \vec{\pi}(x) = -2H(\bar{q}i\gamma^5\vec{\tau}q)$$
$$\Delta(x) = -2H\left[q^T Ci\gamma^5\sigma_2\tau_2 q\right], \quad \Delta^*(x) = -2H\left[\bar{q}i\gamma^5\sigma_2\tau_2 C\bar{q}^T\right]$$

The ground state expectation values of the composite bosonic fields are

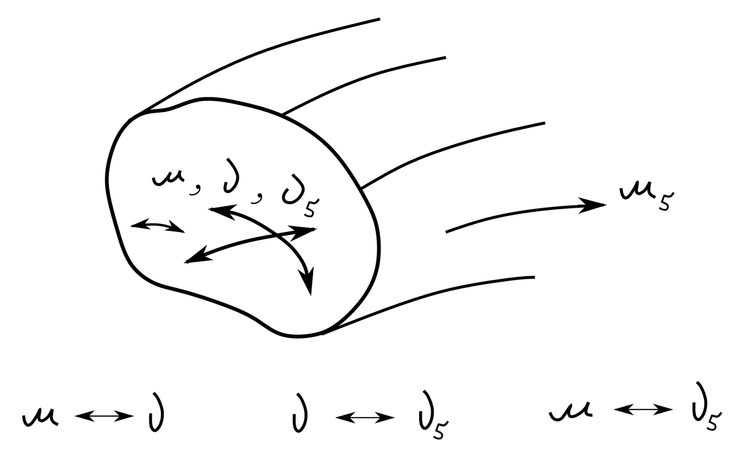
$$\langle\sigma(x)\rangle = M, \quad \langle\pi_1(x)\rangle = \pi_1, \quad \langle\Delta(x)\rangle = \Delta, \quad \langle\Delta^*(x)\rangle = \Delta^*$$

Phase diagram

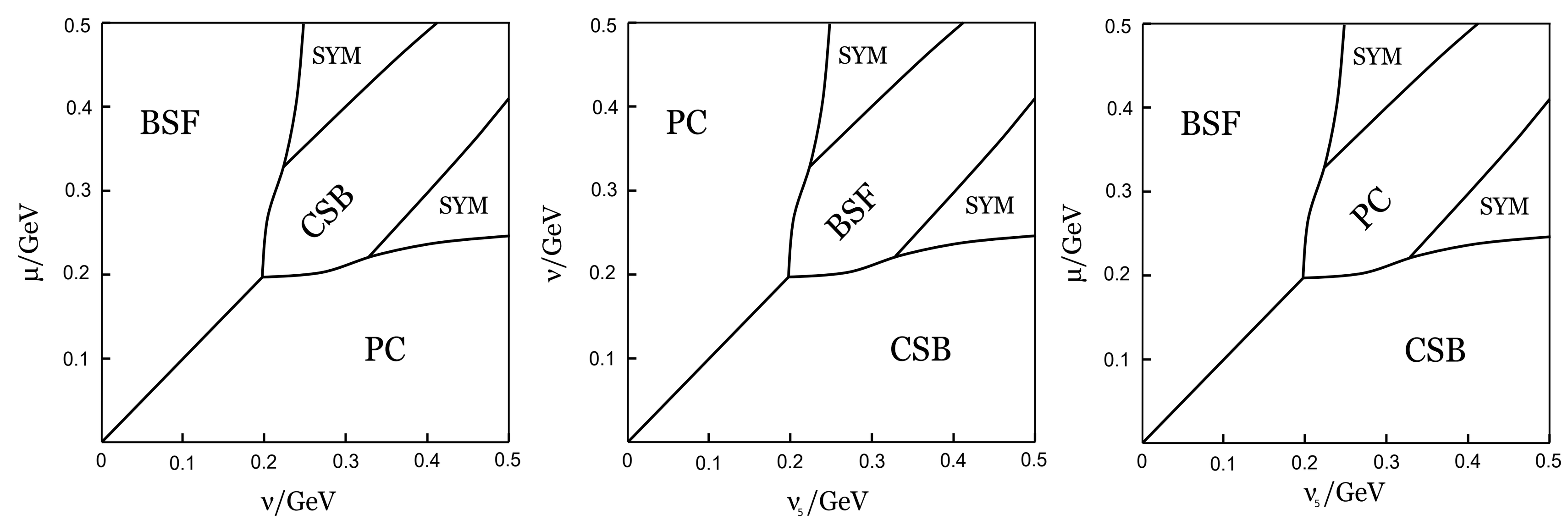
It is possible to demonstrate that the TDP is invariant with respect to the so-called duality transformation



$$\begin{array}{llll}
(a) & \mathcal{D}_1: & \mu \longleftrightarrow \nu, \quad \pi_1 \longleftrightarrow |\Delta|, & \text{PC} \longleftrightarrow \text{BSF} \\
(b) & \mathcal{D}_3: & \nu \longleftrightarrow \nu_5, \quad M \longleftrightarrow \pi_1, & \text{PC} \longleftrightarrow \text{CSB} \\
(c) & \mathcal{D}_2: & \mu \longleftrightarrow \nu_5, \quad M \longleftrightarrow |\Delta|, & \text{CSB} \longleftrightarrow \text{BSF}
\end{array}$$



- Universal catalysis effect of chiral imbalance
- Chiral imbalance mimics other chemical potentials



Conclusions

- There exist several dualities of the phase diagram
- Since dualities do not involve μ_5, it stands alone from other chemical potentials
- This leads to various interesting properties of μ_5