Chiral Symmetry and Heavy Ion Collisions

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One QCD phase transition at finite temperature and baryon density that we can define theoretically is characterized by chiral symmetry which would be exact in the chiral limit (i.e. $m_q \to 0$). It might have nothing to do with another transition, that is, color deconfinement which would be well defined only in the absence of dynamical quarks (i.e. $m_q \to \infty$). It is most likely that the physical properties of hot and dense QCD matter created in the heavy ion collisions are sensitive to deconfinement rather than the chiral dynamics. The equation of state would significantly change in accord to the effective degrees of freedom which are given by the number of light mesons at low temperature and the number of quarks and gluons at high temperature, respectively. In contrast to that, the well-known QCD phase diagram in the temperature and density plane results from the theoretical analysis in chiral effective models.

Therefore, it is a non-trivial question how we can (or should) use the theoretically-drawn phase diagram to understand experimental indications appropriately. Fortunately the lattice QCD simulation has revealed that the chiral and deconfinement (pseudo) critical points are located nearly at the same temperature [1,2]. It seems that we do not have to distinguish them. Nevertheless, both of the chiral and deconfinement dynamics are indispensable to reach a correct understanding of the nature of the QCD phase transitions. In my talk I will give an overview and several remarks on this issue.

References

[1] Y. Hatta and K. Fukushima, *Phys. Rev. D*, **69**, (2004) 097502.
[2] K. Fukushima, *Phys. Lett. B*, **591**, (2004) 277.