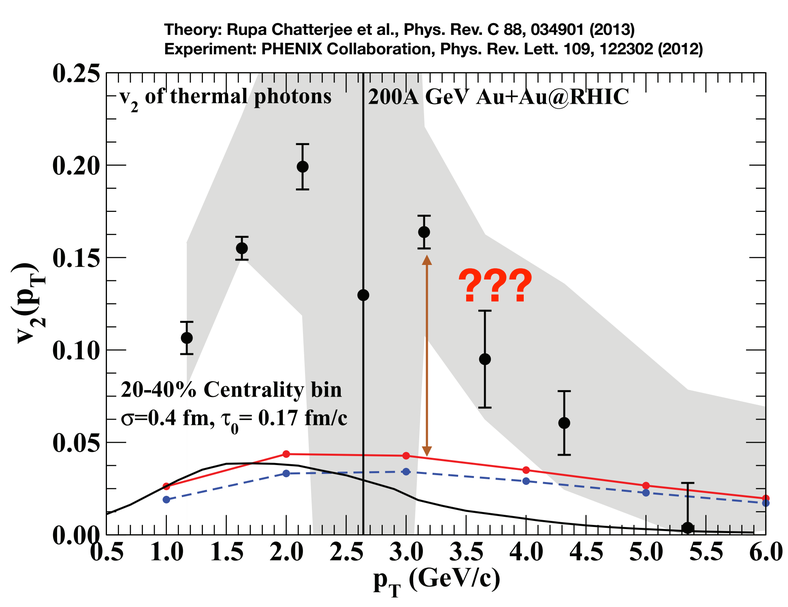
Dilepton and photon production in the semi-quark gluon plasma

Presenter/ Yoshimasa Hidaka Institution/ RIKEN Nishina Center
Collaborators/Lin Shu, Daisuke Satow, Robert D. Pisarski

Phys. Rev. D 92 (2015) 3, 034003, see also Gale, YH, Jeon, Lin, Paquet, Pisarski, Satow, Skokov, Vujanovic, Phys. Rev. Lett. 114, 072301

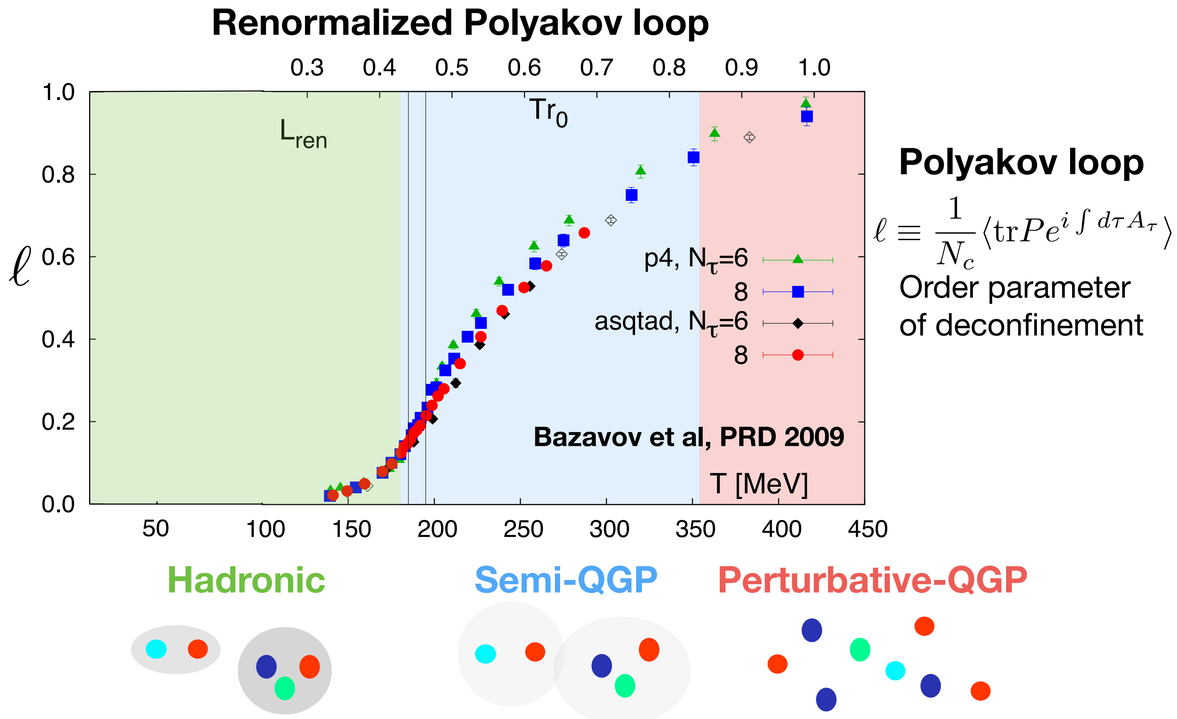
Motivation: Photon v2 puzzle



Theoretical prediction of v_2 is MUCH smaller than experimental data (factor 2~4).

Semi-quark gluon plasma

Partially deconfined quark-gluon plasma



Model of semi-QGP

Suppose the mean value of temporal gauge filed:

$$gA_\tau = \begin{pmatrix} Q_1 & 0 & 0 \\ 0 & Q_2 & 0 \\ 0 & 0 & Q_3 \end{pmatrix}$$

Q_a: Eigen value of the Polyakov loop operator. It plays a role of (imaginary) chemical potential.

Quark distribution function: $n_q = \dfrac{1}{e^{\beta(E-iQ_a)}+1}$

Gluon distribution function: $n_g = \dfrac{1}{e^{\beta(E-iQ_a+iQ_b)}-1}$

Polyakov loop characterizes statistical confinement

Expectation value

$$\langle n_q \rangle = \sum_n (-1)^n e^{-\beta n E} \ell^n \begin{cases} 0 & \ell^n = 0 \ \textbf{confinement} \\ \neq 0 & 0 < \ell^n < 1 \ \textbf{semi-QGP} \\ n_F(E) & \ell^n = 1 \ \textbf{perturbative QGP} \end{cases}$$

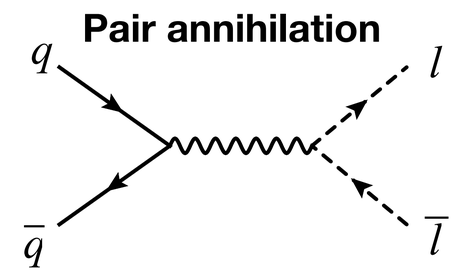
Colored excitation is suppressed in the Semi-QGP!

Dilepton production

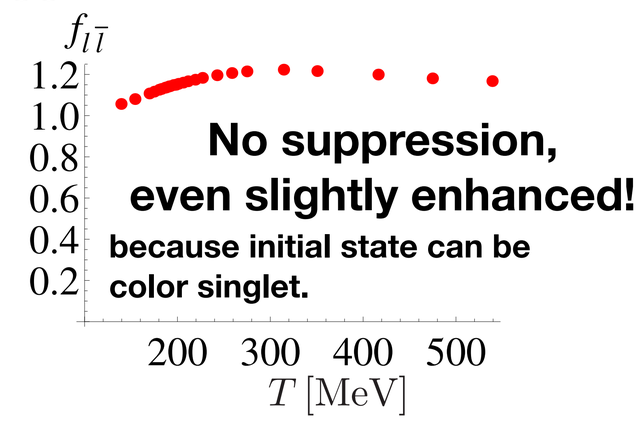
Production rate $\dfrac{d\Gamma}{d^4p} = f_{l\bar{l}}(Q) \dfrac{d\Gamma}{d^4p}\Big|_{Q=0}$

perturbative

Leading order process

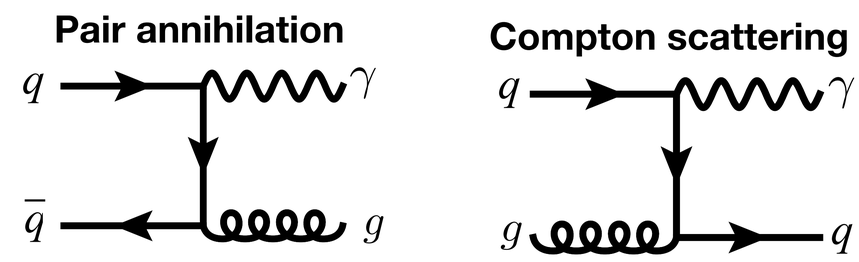


Modification function

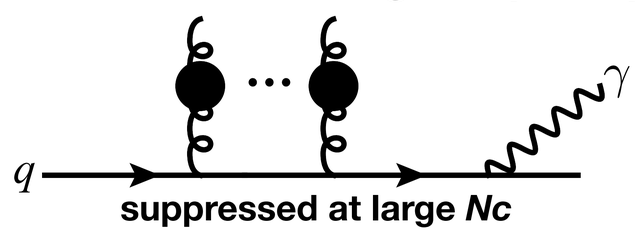


Photon production

Leading order processes



Landau-Pomeranchuk-Migdal (LPM) process

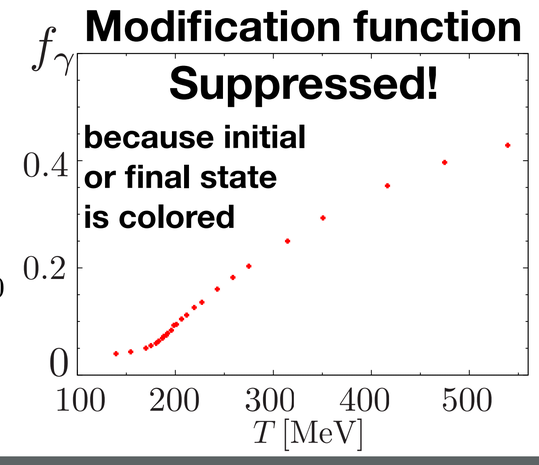


Production rate

$$E\frac{d\Gamma}{d^3p}\Big|_{Q\neq 0} = f_\gamma(Q)\, E\frac{d\Gamma}{d^3p}\Big|_{Q=0}$$

perturbative

Modification function



Dilepton and photon v2

$$v_2 = \frac{v_{2\mathrm{QGP}} N_{\mathrm{QGP}} + v_{2\mathrm{HM}} N_{\mathrm{HM}}}{N_{\mathrm{QGP}} + N_{\mathrm{HM}}} \qquad v_{2\mathrm{QGP}} < v_{2\mathrm{HM}}$$

Dilepton

Semi-QGP enhances N_{QGP} ➡ Suppression of v_2

Photon

Semi-QGP suppresses N_{QGP} ➡ Enhancement of v_2

Quantum Hadron physics Laboratory, Nishina Center, RIKEN, 2-1 Hirosawa, Wako, Saitama, 351-0198, Japan