Stochastic法を用いたクォーコニウムスペクトル関数の解析

大野浩史[1,2]
in collaboration with
H.-T. Ding[3], O. Kaczmarek[4], Swagato Mukherjee[2] and H.-T. Shu[3]
[1]CCS, University of Tsukuba, [2]Brookhaven National Laboratory,
[3]Central China Normal University, [4]Bielefeld University

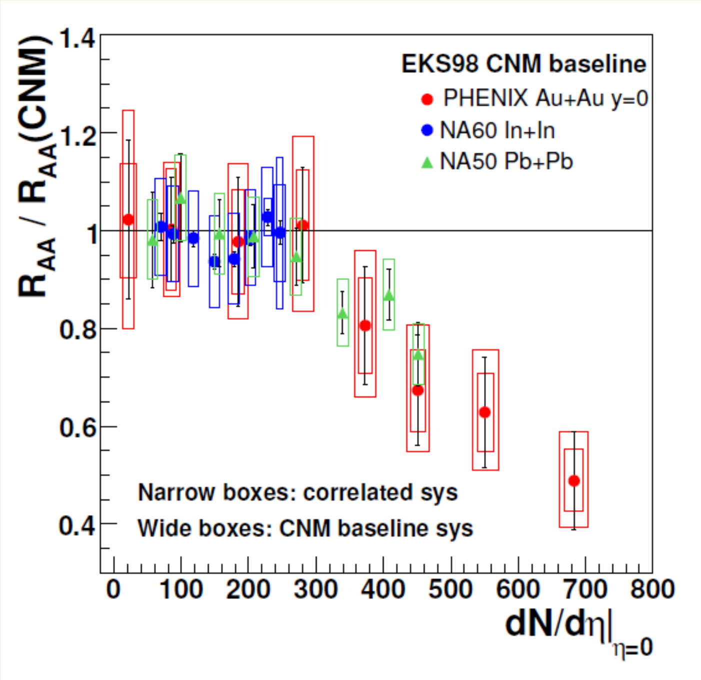
熱場の量子論とその応用 2016
理化学研究所, 和光市, 2016年8月23日

Motivation

- Quarkonium spectral function (SPF)
  - has all information about in-medium properties of quarkonia

Quarkonium dissociation temperature

→ Important to understand quarkonium suppression

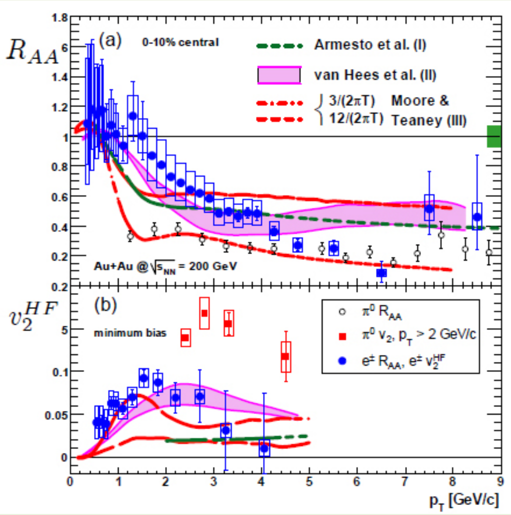


Heavy quark diffusion coefficient

$$D = \frac{1}{6\chi_{00}} \lim_{\omega \to 0} \sum_{i=1}^{3} \frac{\rho_{ii}^{V}(\omega, \mathbf{0})}{\omega}$$

$\rho_{ii}^{V}(\omega)$: vector SPF

→ Important input for hydro models



Reconstruction of SPF

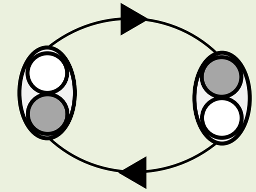
Euclidian (imaginary time) meson correlation function

$$G_H(\tau,\vec{p}) \equiv \int d^3x e^{-i\vec{p}\cdot\vec{x}} \langle J_H(\tau,\vec{x}) J_H(0,\vec{0})\rangle$$

$$= \int_0^\infty \frac{d\omega}{2\pi} \rho_H(\omega,\vec{p}) K(\omega,\tau)$$

Spectral function (SPF)

$$K(\omega,\tau) \equiv \frac{\cosh[\omega(\tau-1/2T)]}{\sinh(\omega/2T)} \qquad J_H(\tau,\vec{x}) \equiv \bar{\psi}(\tau,\vec{x})\Gamma_H\psi(\tau,\vec{x})$$



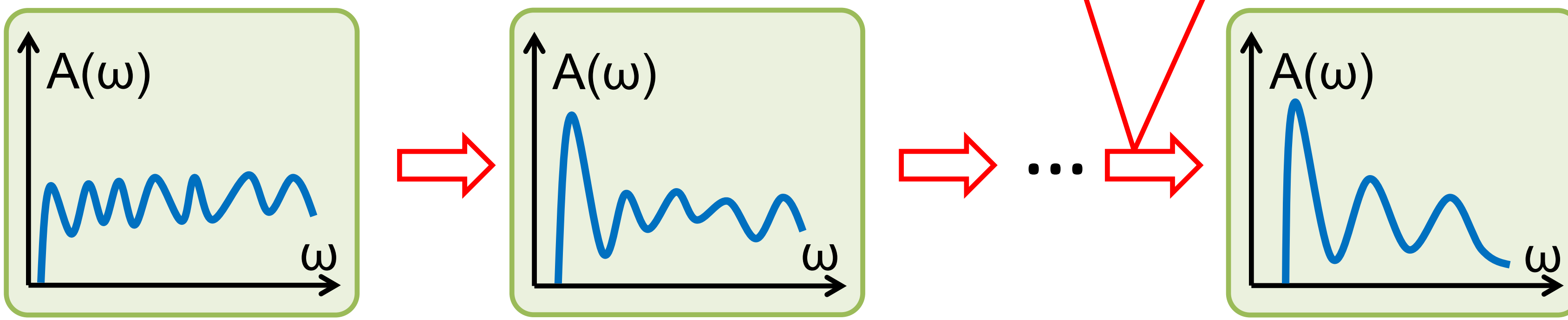
- Computing SPF → **Ill-posed problem**
  - # of data points of a correlator is *O*(10) while a SPF needs O(1000) data points.
  - In general, simple χ^2 fitting does not work!
- Several ways to reconstruct SPF
  - MEM — M. Asakawa, T. Hatsuda and Y. Nakahara, Prog.Part.Nucl.Phys. 46 (2001) 459-508
  - A new Bayesian method — Y. Burnier and A. Rothkopf, PRL 111 (2013) 18, 182003
  - Stochastic methods → **our approach**

Stochastic method: basic idea

For given α (fictitious temperature, regularization parameter),

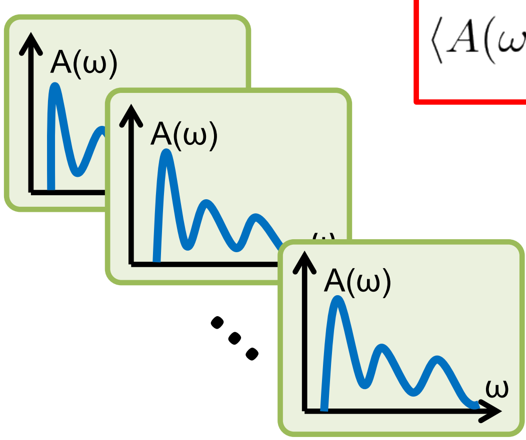
1. generate SPFs stochastically

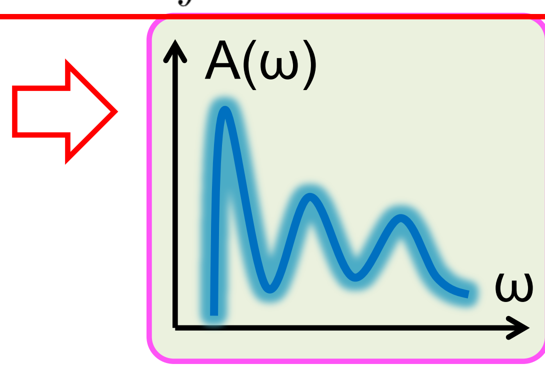
$$P = \min\{1, e^{-\chi^2/2\alpha}\}$$



2. average over all possible spectra

$$\langle A(\omega)\rangle_\alpha \equiv \frac{1}{Z}\int \mathcal{D}A\ A(\omega)e^{-\chi^2/2\alpha} \quad Z \equiv \int \mathcal{D}A\ e^{-\chi^2/2\alpha}$$





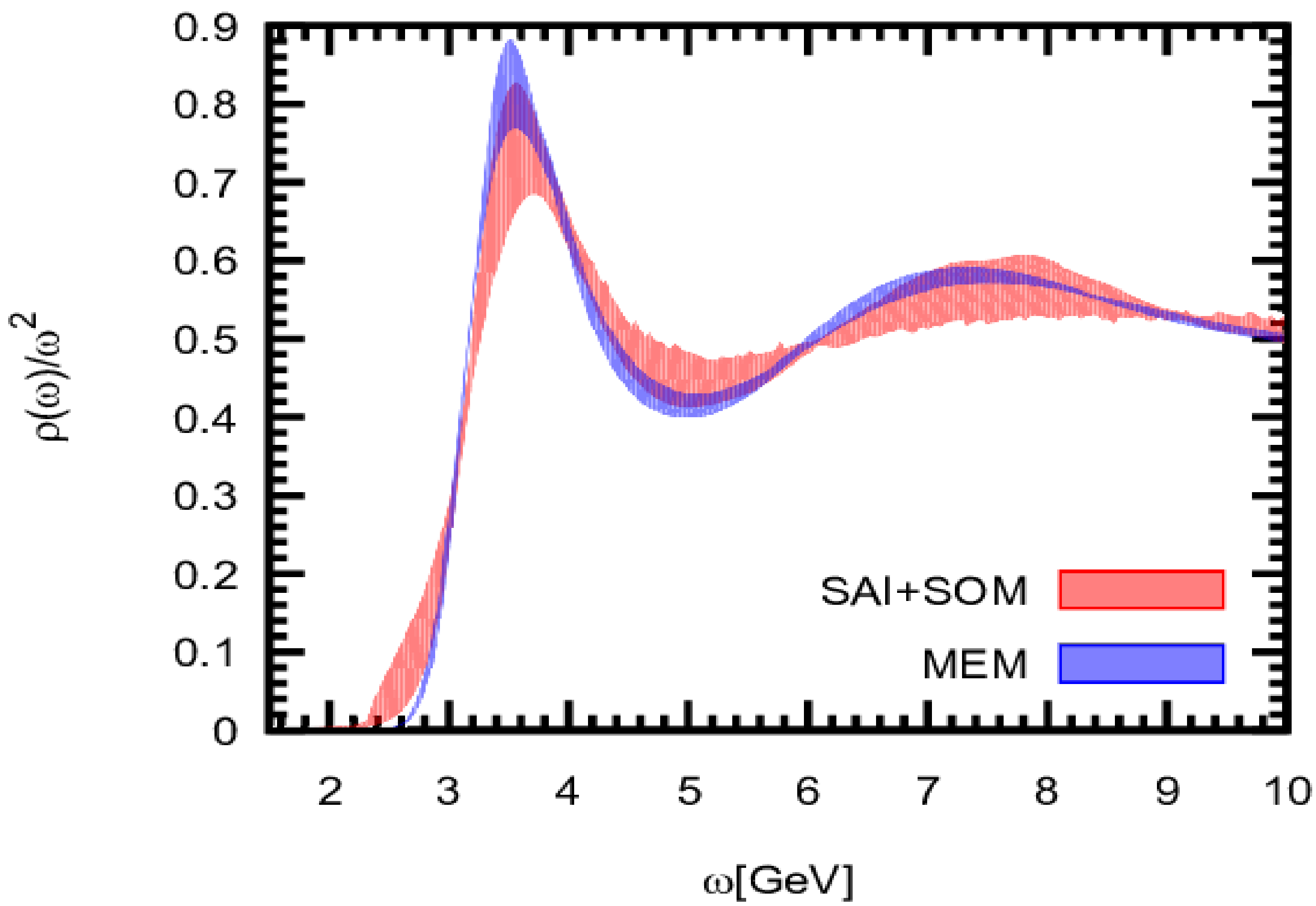
$$\chi^2 \equiv \sum_{\tau,\tau'} \Delta G(\tau) C^{-1}_{\tau,\tau'} \Delta G(\tau')$$

$C^{-1}_{\tau,\tau'}$: covariance matrix

$$\Delta G(\tau) \equiv \bar{G}(\tau) - \int d\omega\ A(\omega)\tilde{K}(\omega,\tau)$$

Vector charmonium SPF at 0.75T_c

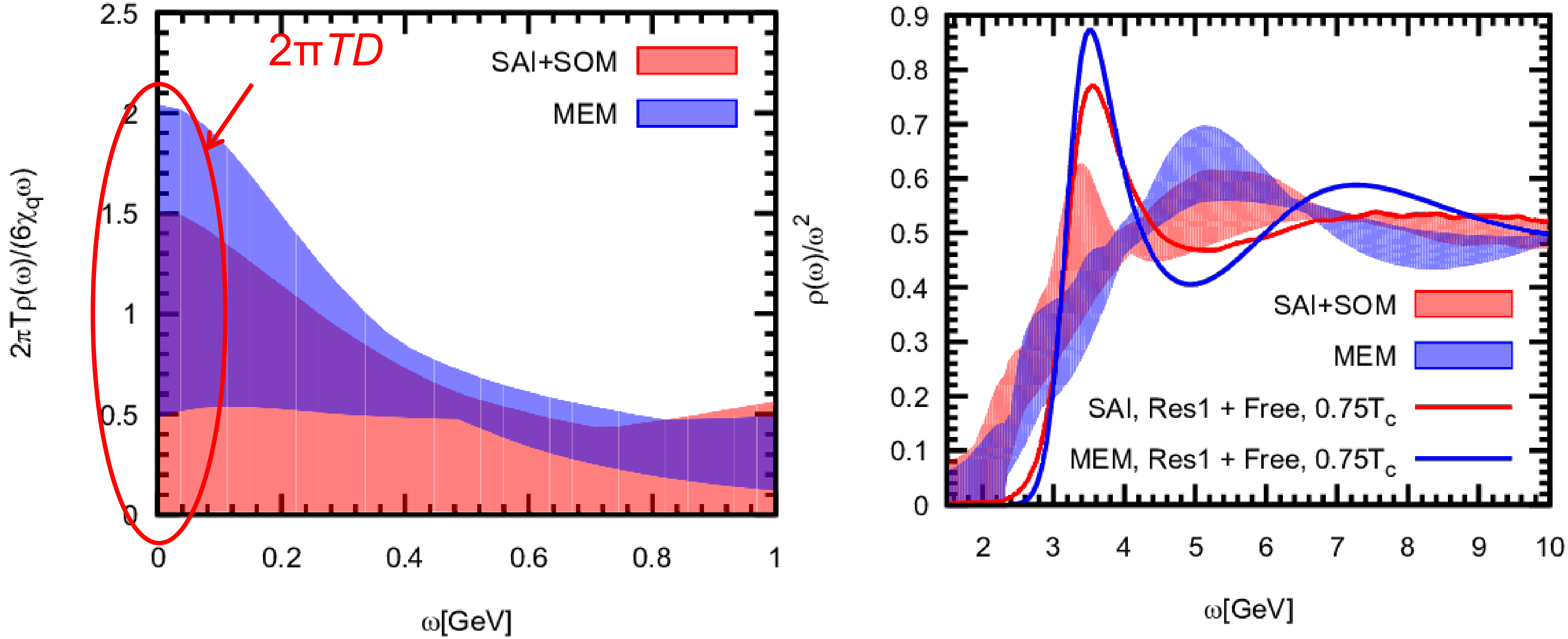
Band = Default model dependence



There is a stable J/Ψ peak.

Vector charmonium SPF at $1.5T_c$

Band = Default model dependence



Melting of J/Ψ is not conclusive so far, although most of the cases in our analysis suggests no clear J/Ψ peak.

There seems to be an upper bound of $2\pi TD$, which is 1.5—2 in this study, while a lower bound is not clear.