HADRON RESONANCE GAS WITH REPULSIVE MEAN FIELD

P. Huovinen[1], P. Petreczky[2]

- We include repulsive baryon-baryon interactions in hadron resonance gas using repulsive mean field
- Huovinen & Petreczky, PLB777, 125 (2018)

We assume repulsive mean field of the form

$$u(n_g, \bar{n}_g, n_r, \bar{n}_r) = \frac{1}{2}K(n_g^2 + \bar{n}_g^2) + K(n_g n_r + \bar{n}_g \bar{n}_r)$$

where n_g is the density of members of baryon octet and decuplet, $\bar{n}$ density of corresponding antibaryons, and n_r and $\bar{n}_r$ densities of baryon and antibaryon resonances.

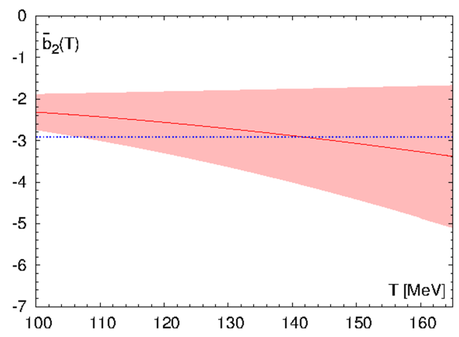
- Virial expansion:

$$P(T,\mu) = P_0(T)\left(\cosh(\beta\mu) - \bar{b}_2(T) K_2(\beta m)\cosh(2\beta\mu)\right)$$

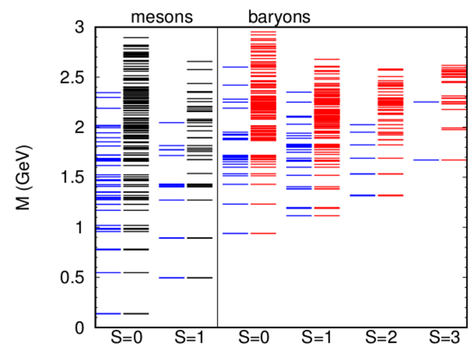
- $\bar{b}_2(T)$ from measured phase shifts
- Repulsive mean field:

$$P(T,\mu) = P_0(T)\left(\cosh(\beta\mu) - \frac{Km}{\pi^2} K_2(\beta m)\cosh(2\beta\mu)\right)$$

- set $Km^2/\pi^2 \approx \bar{b}_2(T)$
$\Rightarrow K = 250$ MeV fm^3

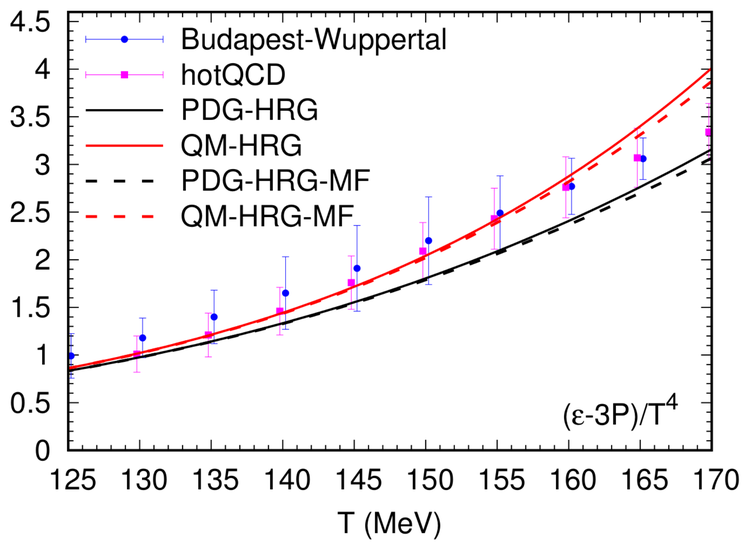


As particles in hadron resonance gas (HRG) we use either all strange and nonstrange particles and resonances in Particle Data Group's 2016 summary tables (PDG-HRG) or all states predicted by a quark model (QM-HRG):

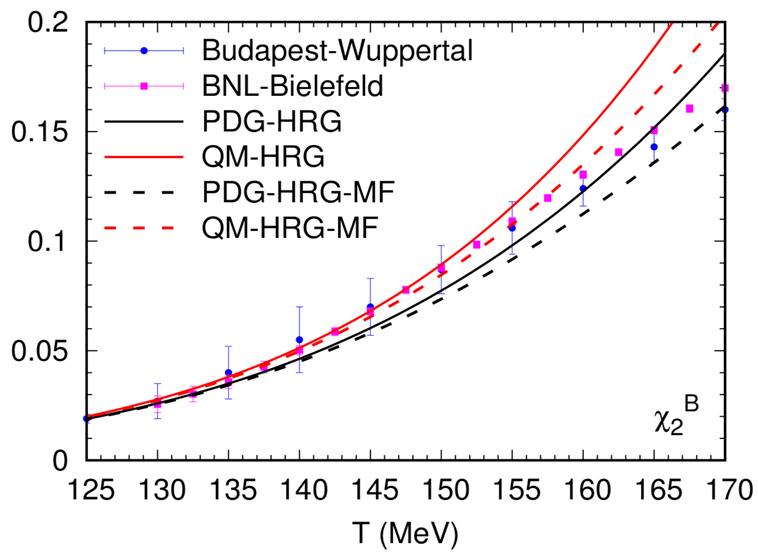


Blue: Particle Data Group 2016 summary tables
Red: PDG + Quark model for baryons: Löring et al., EPJA10, 395 (2001) & EPJA10, 447 (2001)
Black: PDG + Quark model for mesons: Ebert et al., PRD79, 114029 (2009)

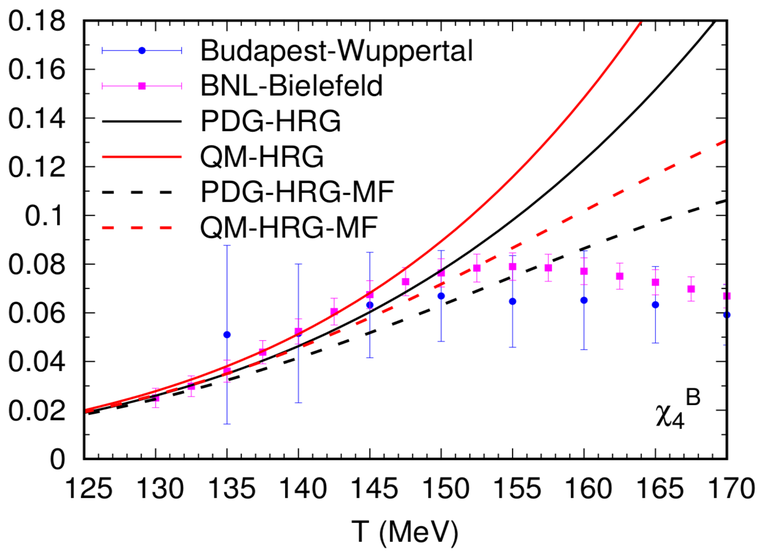
This work has been supported by the National Science Center, Poland under grant Polonez DEC-2015/19/P/ST2/03333 receiving funding from the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie grant agreement No 665778, and by U.S. Department of Energy under Contract No DE-SC0012704. Ripping off Piet Mondrian is respectfully admitted.



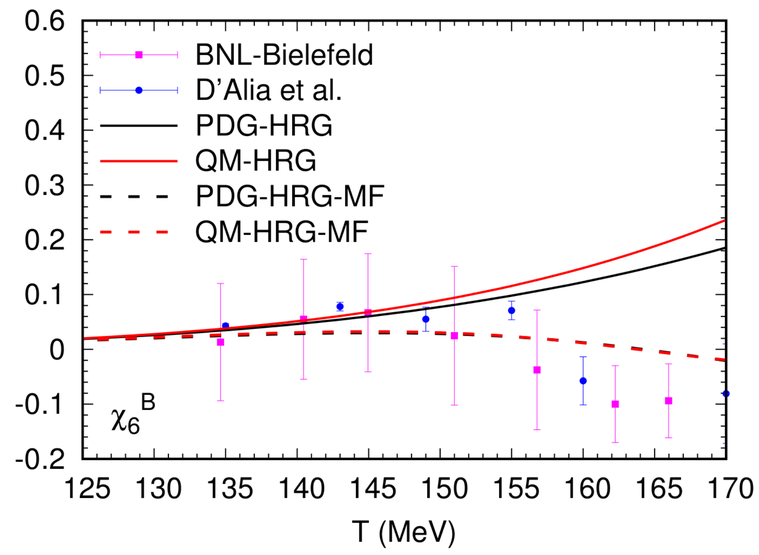
Trace anomaly:
Budapest-Wuppertal: Borsanyi *et al.*, PLB730, 99 (2014)
hotQCD: Bazavov *et al.*, PRD90, 094503 (2014)



Trace anomaly (top left) and baryonic fluctuations χ_2^B, χ_4^B and χ_6^B in hadron resonance gas (HRG) with different particle lists (PDG vs. quark model, QM) and with repulsive mean field (MF) or without, compared with lattice data.



χ_n^B:
Budapest-Wuppertal: Borsanyi *et al.*, JHEP1201, 138 (2012)
BNL-Bielefeld: Bazavov *et al.*, PRD95, 054504 (2017), PRL111, 062005 (2013)
D'Elia et al.: D'Elia *et al.*, PRD95, 094503 (2017)



- lattice favours more resonances than observed
- strength of repulsion fixed by experimental phase shifts
- repulsion improves fit to fluctuations

[1] Institute of Theoretical Physics, University of Wrocław, 50-204 Wrocław, Poland

[2] Physics Department, Brookhaven National Laboratory, Upton, NY 11973, USA