Modern Aspects of Quark-Gluon Plasma Physics SS 2023: Quiz questions

1.1 The first collider with which ultra-relativistic heavy-ion collisions were studied was

A. HERA
B. LHC
C. RHIC
D. Tevatron

1.2 How can the potential between a heavy quark and the corresponding antiquark be describes at large distances?

A. $V(r) = -k/r$
B. $V(r) = -k/r^2$
C. $V(r) = k \cdot r$
D. $V(r) = \text{const}$

1.3 The existence of a quark-gluon plasma phase is a consequence of asymptotic freedom in QCD

A. yes
B. no

1.4 The fact that the strong coupling vanishes for large momentum transfers is called

A. asymptotic freedom
B. confinement
C. Yukawa coupling
D. Zweig rule

1.5 What fraction of its energy does a high-energy nucleon typically lose in a (non-diffractive) inelastic collision with another nucleon?

A. 0.2%
B. 1%
C. 85%
D. 99.9%

1.6 The lifetime of the QGP created in central Pb-Pb collisions at the LHC is about

A. 1 fm/c
B. 10 fm/c
C. 100 fm/c
D. 1000 fm/c

1.7 The transition from a quark-gluon plasma to a gas of hadrons at vanishing baryon-chemical potential is expected to be

A. a first-order phase transition
B. a second-order phase transition
C. a cross-over

1.8 The transition temperature from the quark-gluon plasma to a gas of hadrons is of the order of the

A. electron mass
B. pion mass
C. proton mass
D. Higgs mass

1.9 The difference between the current (Higgs) mass of u and d quarks of a few MeV and their constituent quark mass of about 300 MeV is related to

A. parity violation
B. flavor-changing neutral currents
C. chiral symmetry breaking
D. CP violation

1.10 The energy per unit length stored in a QCD string is about

A. 1 eV/fm
B. 1 keV/fm
C. 1 MeV/fm
D. 1 GeV/fm

Answers: 1.1 C, 1.2 C, 1.3 B, 1.4 A, 1.5 C, 1.6 B, 1.7 C, 1.8 B, 1.9 C, 1.10 D

2.1 Rapidity under Lorentz transformation by Δy behaves

A. additively in Δy
B. multiplicatively in Δy
C. exponentially in Δy
D. logarithmically Δy

2.2 How does a rapidity distribution of produced particles look, if one makes a Lorentz transformation from a system moving at y_{cm} into a one moving with y' along the beam axis?

A. The shape and the position of the rapidity distribution remain the same
B. The distribution remains centered around y_{cm} but becomes narrower
C. The distribution remains centered around y_{cm} but becomes wider
D. The shape of the rapidity distribution remains the same but it is shifted

2.3 A particle with mass $m > 0$ moves along the beam axis with rapidity y. The Lorentz factor γ is then given by

A. cosh y
B. arctanh y
C. tanh y
D. exp y

Answers: 2.1 A, 2.2 D, 2.3 A

3.1 Gibbs condition for constructing a phase transition: at the critical point

A. the energy density is continuous

B. the pressure is continuous
C. the particle density is continuous
D. the entropy is continuous

3.2 What is the physical meaning of the bag constant?

A. It is the energy to make a hole of volume V in the physical vacuum
B. It describes the thermal pressure of a relativistic gas
C. It is the energy density of the physical vacuum
D. It is the energy density of a nucleon

3.3 The energy density of a relativistic gas scales with the temperature T as ...

A. $1/T$
B. T^2
C. T^4
D. $\ln T$

Answers: 3.1 B, 3.2 A, 3.3 C

4.1 The total proton-proton cross-section in the energy range 10 GeV to 10 TeV is about

A. 50 nb
B. 50 microbarn
C. 50 mb
D. 50 b

4.2 In the Bjorken formula for the energy density $\varepsilon = \frac{1}{A \cdot \tau_0} \frac{\mathrm{d}E_\mathrm{T}}{\mathrm{d}y}\Big|_{y=0}$, τ_0 is the time ...

A. ... when all unstable particles have decayed
B. ... when interactions between the produced hadrons cease
C. ... of the transition from the QGP to the hadron gas
D. ... when a thermalized partonic system is formed

4.3 At RHIC and LHC energies, the mean transverse momentum of the produced pions is about

A. 350-500 eV
B. 350-500 MeV
C. 350-500 GeV
D. 350-500 TeV

4.4 Fragmentation functions describe ...

A. the number of partons in a nucleon at a given Bjorken x
B. the cross section for a hard parton-parton scattering
C. how quarks and gluons transform into color-neutral particles
D. the spin structure of the nucleon

Answers: 4.1 C, 4.2 D, 4.3 B, 4.4 C

5.1 Systematic behavior of the thermal model parameters with collision energy

A. T increases, μ_{B} drops
B. T increases and levels off at a finite value, μ_{B} drops to zero
C. both T and μ_{B} increase
D. T decreases and levels off, μ_{B} increases and levels off

5.2 How do particle yields change with increasing collision energy of the nuclei?

A. All increase monotonically
B. Mesons increase, baryons and antibaryons drop
C. Mesons increase, baryons drop, antibaryons increase
D. Meson decrease, baryons and antibaryons increase

5.3 Hadrochemical freeze-out is the instance when

A. a thermalized QGP is formed
B. hadron spectra are frozen out
C. hadron abundancies are frozen in
D. hadrons hit the detector

Answers: 5.1 B, 5.2 C, 5.3 C

6.1 Which of these effect can give rise to "non-flow effects" that affect the v_n values extracted from two-particle correlations:

A. Bose-Einstein correlation
B. jet correlations
C. resonance decays
D. gravitational attraction

6.2 In hydro models, the anisotropic flow coefficients v_n

A. decrease for increasing η/s
B. are not affected by η/s
C. increase for increasing η/s

6.3 The difference in $v_2(p_T)$ at low p_T for particles with different masses ('mass ordering') can be explained by

A. the hydrodynamic evolution of the QGP
B. the ideal gas approximation of the QGP
C. the statistical model
D. by non-flow effects

6.4 When modeling the expansion of the QGP as a hydrodynamic flow of an ideal fluid, the total entropy

A. increases with time
B. decreases with time
C. remains constant
D. is not defined

6.5 The longitudinal flow of the QGP created in a heavy-ion collision is described by the

A. Bjorken model
B. Feynman model
C. Glauber model
D. Einstein model

6.6 To close the system of equations in the hydro-modeling of heavy-ion collisions one needs the

A. Maxwell equations
B. Cooper-Frye formula
C. Glauber model
D. equation of state

Answers: 6.1 ABC, 6.2 A, 6.3 A, 6.4 C, 6.5 A, 6.6 D

7.1 For an expanding fireball the apparent radius from pion HBT correlations is

A. smaller than the geometrical size
B. equal to the geometrical size
C. bigger than the geometrical size
D. not unambiguously related to the source size

7.2 For an RMS width of the momentum difference of two identical bosons of 20 MeV, the source size

A. 1 fm
B. 10 fm
C. 1 nm
D. 10 nm

7.3 The relevant variable for Hanbury Brown-Twiss correlations is

A. the momentum difference of two identical hadrons
B. the sum of momenta of two identical hadrons
C. the invariant mass of two identical hadrons
D. the total energy of two identical hadrons in the lab system

7.4 Hanbury Brown-Twiss correlations are based on

A. the strong interactions between pions
B. the quantum statistics of identical bosons or fermions
C. the Coulomb interaction between like-sign particles

D. the correlation of particles through resonance decays

Answers: 7.1 A, 7.2 B, 7.3 A, 7.4 B

8.1 Which of the following observables needs to be measured to signal criticality?

A. number of protons for different centralities averaged over many events
B. average of difference between protons and antiprotons as a function of momentum
C. event-by-event difference between number of protons and antiprotons in a rapidity and transverse momentum interval
D. event-by-event difference between number of protons and antiprotons over full solid angle and all momenta

8.2 QCD matter near a critical point exhibits

A. no correlations
B. long-range correlations
C. short-range correlations
D. scaling behavior

8.3 For a baryon chemical potential $\mu_{\mathrm{B}} < 400\,\mathrm{MeV}$, lattice QCD predicts

A. a first order phase transition
B. a second order phase transition
C. a continuous cross over

8.4 Nuclear matter can be described as a liquid with binding energy per nucleon of

A. 16 eV
B. 16 keV
C. 16 MeV
D. 16 GeV

Answers: 8.1 C, 8.2 BD, 8.3 C, 8.4 C

9.1 In a static medium with a length L smaller than the coherence length, the following holds for the radiative energy loss ΔE:

A. $\Delta E \sim 1/L$
B. $\Delta E \sim L$
C. $\Delta E \sim L^2$
D. $\Delta E \sim L^3$

9.2 The Landau-Pomeranchuk-Migdal regime for the interaction of a parton with a medium corresponds to

A. to the limit of vanishing energy loss
B. incoherent multiple scattering
C. coherent scattering with destructive interference
D. the complete stopping of the parton

9.3 The nuclear modification factor for charged hadrons with $p_T > 2 - 3$ GeV/c in p-Pb collisions is about

A. 0
B. 0.5
C. 1
D. 2

9.4 Prompt photons, W and Z bosons follow N_{coll} scaling in A-A collisions. This means that the nuclear modification factor of these particles is

A. equals to 0
B. about 0.5
C. about 1
D. about 5

Answers: 9.1 C, 9.2 C, 9.3 C, 9.4 C

10.1 Decay of the $c\bar{c}$ (1S) state, the J/ψ: it is normally detected in experiments via its decay into

A. $\gamma\gamma$
B. e^+e^-
C. $\mu^+\mu^-$

D. $p\bar{p}$

10.2 Deconfinement of heavy quarks in the QGP implies for charmonium yields

A. equal suppression at all collision energies
B. larger suppression the larger the collision energy is
C. reversal of suppression at low energies into enhancement at high energies
D. it is always related to the pp yields by the number of nucleon-nucleon collisions N_{coll}
E. it is always related to the pp yields by the number of participants N_{part}

10.3 Quark-antiquark potential for heavy quarks at $T = 0$ and $T > 0$: at high temperatures, the following holds for the long-distance part of the potential (large distances r):

A. $V_{\mathrm{Q\bar{Q}}}(r)_{\mathrm{high}\,T} > V_{\mathrm{Q\bar{Q}}}(r)_{T=0}$
B. $V_{\mathrm{Q\bar{Q}}}(r)_{\mathrm{high}\,T} \approx V_{\mathrm{Q\bar{Q}}}(r)_{T=0}$
C. $V_{\mathrm{Q\bar{Q}}}(r)_{\mathrm{high}\,T} \approx 0$
D. $V_{\mathrm{Q\bar{Q}}}(r)_{\mathrm{high}\,T} < 0$

10.4 Charm baryons can be identified by measurement of their

A. charge
B. life time
C. energy
D. invariant mass

10.5 The charm fugacity parameter is

A. a free parameter in the SHMc
B. determined by the number of strange quark pairs produced in the collision
C. determined by the number of charm quark pairs produced in the collision
D. a charm suppression factor

10.6 The Ω_{c}^{0} baryon has spin

A. 0
B. 1/2

C. 1
D. 3/2

10.7 The mass of the charm quark is

A. determined by invariant mass measurements
B. determined by analysis in the framework of lattice QCD
C. obtained from the measured mass of the J/psi meson
D. obtained from the measured mass of the D0 meson

Answers: 10.1 BC, 10.2 C, 10.3 C, 10.4 D, 10.5 C, 10.6 B, 10.7 B

11.1 The hadronic medium created in the late stage of a heavy-ion collision could affect the properties of the ρ meson. Dilepton measurements point to

A. a negligible effect of the hadronic medium on the ρ meson
B. a reduced mass of the ρ meson
C. a broadened ρ meson without a mass shift
D. an increased mass of the ρ meson

11.2 Chiral symmetry refers to the conservation of

A. color charge
B. lepton number
C. right- or left-handedness
D. spin

11.3 When extracting an effective QGP temperature from the slope of the thermal photon transverse momentum spectrum, one has to take into account

A. the blueshift effect
B. time dilation
C. the photon polarization
D. Wien's displacement law

11.4 In heavy-ion physics, direct photon are defined as photons

A. not coming from hadron decays
B. produced in the preequilibrium stage
C. produced in the QGP
D. produced in initial hard scattering processes

Answers: 11.1 C, 11.2 C, 11.3 A, 11.4 A