

HEAVY QUARKONIA PRODUCTION IN HEAVY-ION COLLISIONS

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ORGANISERS:

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NUMBER OF PARTICIPANTS: 43

MAIN TOPICS:

- Charmonium results from CERN-SPS and RHIC experiments
- Color-screening and dissociation of charmonia in medium; potential models
- Lattice QCD studies of heavy-quark potential and quarkonium correlators
- Charmonium production process and cold nuclear matter effects
- Statistical models for hadron production
- Kinetic and phenomenological approaches for charmonium evolution in heavy-ion collisions
- Future experiments at CERN-LHC, RHIC-2 and CBM at FAIR

SPEAKERS:

Anton Andronic (*GSI*),
Roberta Arnaldi (*Torino*),
Andrea Beraudo (*Torino*),
Hamza Berrehrah (*Nantes*),
Nora Brambilla (*Munich*),
Peter Braun-Munzinger (*GSI*),
Elena Bratkovskaya (*Frankfurt*),
Daniel Cabrera (*Madrid*),
Heng-Tong Ding (*Bielefeld*),
David d'Enterria (*CERN*),
Elena G. Ferreira (*Salamanca*),
Anthony Frawley (*Florida*),
Taku Gunji (*Tokyo*),
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Peter Petreczky (*BNL*),
Dariusz Prorok (*Wroclaw*),
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Felix Riek (*Texas A&M*),
Helmut Satz (*Bielefeld*),
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Peter Senger (*GSI*),
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Ramona Vogt (*Livermore*),
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Cheuk-Yin Wong (*Oak Ridge*),
Clint Young (*Stony Brook*),
Xingbo Zhao (*Texas A&M*),

SCIENTIFIC REPORT:

Aim and Purpose

Significant progress has been made recently in the field of charmonium (or more general heavy quarkonium) production in heavy-ion collisions, both theoretically (lattice QCD and effective models at finite temperature, phenomenological implementations for A-A collisions) and experimentally (most notably in the understanding of “cold nuclear matter” effects at RHIC and the CERN-SPS). It was therefore an ideal time to revisit these developments and update the understanding of charmonium properties in medium and their consequences for heavy-ion collisions, also in view of upcoming experiments at CERN-LHC and the new domain of dense matter to be probed at FAIR-CBM. The following topics have been selected for lectures and topical discussions at the workshop:

- Quarkonium spectral functions and correlators: potential/T-matrix models versus lattice QCD (lQCD)
- Quarkonia (nonequilibrium) statistics: kinetics of dissociation vs. recombination processes in the medium.
- Data from CERN-SPS and RHIC; prospects for future experiments.
- Cold nuclear matter (CNM) effects on heavy quarkonia production in nuclear collisions.

The aim of the workshop was to bring together world-leading experts in this field in theory and experiment in order to discuss the new developments, interpretations and perspectives.

Results and Highlights

Progress has been made in the main directions defined above.

- Exchanges between experts in lQCD, effective field theory and potential models have been organized; one of the central topics, the extraction of heavy-quark potentials from thermal lQCD (“ $F(r, T)$ vs. $U(r, T)$ ”), has been addressed in depth (Beraudo, Brambilla, Cabrera, Kaczmarek, Laine, Petreczky, Riek, Satz, Wong and others), including a dedicated discussion session (convener: Rapp). The problem has not been resolved, but arguments and problems to distinguish different quantities have been better identified and sharpened. The role and relations of different inelastic reaction rates have been clarified.

- The nonequilibrium aspects of quarkonia creation and evolution within kinetic approaches including dissociation and/or recombination in the medium have been discussed. The role of hadronic states, the relation of timescales (heavy-quark vs. quarkonium vs. plasma formation) and their role at different collision energies have been elaborated (Andronic, Bratkovskaya, Braun-Munzinger, Ko, Redlich, Zhao and others).
- New experimental results, in particular from p-A and d-Au collisions at RHIC (Frawley, Leitch) and SPS (Arnaldi, Scomparin), have led to a highlight of this workshop: a systematic evaluation of CNM effects has been used to isolate a centrality-dependent “anomalous suppression” factor, $S_{J/\psi}$. Albeit not fully model-independent, the resulting $S_{J/\psi}$ exhibits, within exp. errors, universal behavior in system size and collision energy when plotted as a function of charged-particle multiplicity, $dN_{ch}/d\eta$. Moreover, $S_{J/\psi}(dN_{ch}/d\eta)$ seems to feature an “onset-behavior” for suppression at approximately $dN_{ch}/d\eta \simeq 300$. It is tempting to associate this with an energy-density variable and thus relate it to the onset of Quark-Gluon Plasma formation in A-A reactions. Current model predictions overestimate the suppression at low centralities (partly due to the updated CNM baseline), but several theoretical questions will have to be revisited (e.g., variations in the QGP formation time, magnitude of J/ψ binding and dissociation in both QGP and hadron gas, etc.). This will further tighten the connection with the theoretical developments discussed above.

Conclusions

The workshop has served its goal of bringing together at the ECT* theorists and experimentalists fostering a fruitful exchange leading to significant progress in identifying central problems in heavy-quarkonia production in heavy-ion collisions, and advance viable avenues of solution. The forefront of the experimental status has been pushed forward, and theoretical concepts have been presented, discussed and scrutinized. By the end of the workshop and within the two weeks following it we have received many positive feedback from participants and from colleagues who followed the talks online on the website. Contacts among leading researchers in the field have been facilitated, new projects have been initiated, and existing collaborations (e.g., Frawley, Leitch, Lourenco, Vogt, Woehri) have worked on joint publications.

The workshop can thus be considered a successful one providing a step forward in the physics of heavy quarkonia in medium.

Optional

The talks can be browsed from the website: <http://www.ect.it>

It was very helpful that the center provided assistance (Gianmaria Ziglio) in uploading the talks on a daily basis already during the workshop. his was very welcome and contributed to the success of the meeting.