Symposium Plasmas in the Universe (SYPU)

jointly organised by
the Hadronic and Nuclear Physics Division (HK) and
the Plasma Physics Division (P)

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Overview of Invited Talks and Sessions

(Lecture hall Audimax)

Invited Talks

SYPU 1.1	Wed	9:00– 9:30	Audimax	**Recent progress in simulations of dense quantum plasmas and warm dense matter** — •Michael Bonitz, Paul Hamann, Tobias Dornheim, Zhandos Moldabekov, Alexey Filinov, Jan Vorberger, Pavel Levashov
SYPU 1.2	Wed	9:30–10:00	Audimax	**The quark gluon plasma: from the laboratory to neutron stars** — •Jan Steinheimer
SYPU 1.3	Wed	10:00–10:30	Audimax	**Characterizing the QCD Plasma** — •Andrea Dubla

Sessions

SYPU 1.1–1.3	Wed	9:00–10:30	Audimax	**Plasmas in the Universe**

SYPU 1: Plasmas in the Universe

Time: Wednesday 9:00–10:30 Location: Audimax

Invited Talk SYPU 1.1 Wed 9:00 Audimax

Recent progress in simulations of dense quantum plasmas and warm dense matter — •Michael Bonitz[1], Paul Hamann[1], Tobias Dornheim[2], Zhandos Moldabekov[2], Alexey Filinov[1], Jan Vorberger[3], and Pavel Levashov[4] — [1]Institute for Theoretical Physics and Astrophysics, Kiel University — [2]Center of Advanced Systems Understanding, Görlitz — [3]Helmholtz-Zentrum Dresden Rossendorf — [4]Joint Institute for High Temperatures, Moscow

Presently we are witnessing dramatic progress in experiments with dense quantum plasmas where matter is being compressed to densities exceeding solid density - parameters that occur in many astrophysical plasmas (planet interiors, dwarf stars etc.). At the same time, accurate laser and x-ray based diagnostic tools have emerged that probe the properties of such "warm dense matter". To understand these experiments and predict new ones poses a challenge to theory and simulations [1] and requires a smart combination of different methods including density functional theory, generalized quantum hydrodynamics (QHD), quantum kinetic equations [2], and quantum Monte Carlo [3]. The talk gives an overview on recent developments.

[1] M. Bonitz et al., Phys. Plasmas **27**, 042710 (2020); [2] M. Bonitz, *Quantum Kinetic Theory*, 2nd ed. Springer 2016; [3] T. Dornheim, S. Groth, and M. Bonitz, Phys. Reports **744**, 1-86 (2018)

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Invited Talk SYPU 1.2 Wed 9:30 Audimax

The quark gluon plasma: from the laboratory to neutron stars — •Jan Steinheimer — FIAS, Frankfurt am Main

The Quark Gluon Plasma (QGP) is a state of matter that existed in the early universe and can only be created in relativistic collisions of heavy nuclei and possibly in the interior of neutron stars and their mergers. The QGP can be considered a color-plasma where the color charges are screened by the strong interaction (QCD) which allows them to move freely. Yet, due to the non-Abelian nature of QCD, and the fact that the force-carriers (Gluons) themselves carry a color charge, the process of the color screening in the QGP is not well understood. Current research on the QGP focusses on its thermodynamic properties as well quantities which may be related to its microscopic features like transport properties. There are still many open questions regarding the properties and especially phase structure of the QGP at large baryon densities in the context of recent astrophysical observations of neutron star mergers, which may probe yet unknown properties of the QGP. In this talk I will briefly review the main properties of the QGP and why it behaves differently than a QED plasma. I will summarize how QGP properties are extracted from high energy nuclear collisions. Finally, I will discuss how these findings can be related to matter found in the inside of neutron stars and especially in the violent mergers of such stars.

Invited Talk SYPU 1.3 Wed 10:00 Audimax

Characterizing the QCD Plasma — •Andrea Dubla — GSI Helmholtz Center for Heavy Ion Research

Under extreme conditions of high temperature and density, QCD predicts the formation of a new state of matter, the so-called quark-gluon plasma (QGP), in which quarks and gluons are the relevant degrees of freedom. Our universe is thought to have been in such a primordial state for the first few millionths of a second after the Big Bang, before quarks and gluons were bound together to form protons and neutrons. Heavy-ion collisions at ultra-relativistic energies at the Large Hadron Collider at CERN produce the unique conditions to form the QGP in the laboratory. Recreating this primordial state of matter and understanding how it evolves will allow us to shed light on questions about how matter is organized and the mechanisms that confine quarks and gluons. This talk gives an overview of the experimental program, based on selected recent results and comparison with model calculation, that allowed after decades to characterize with unprecedented precision this form of strongly interacting matter and its dynamic.