Symposium SAMOP Dissertation-Prize 2019 (SYAD)

jointly organized by all divisions of the section AMOP

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The divisions of the section AMOP award a PhD prize 2019. The prize acknowledges outstanding research from a PhD work, and its excellent written and oral presentation. Eligible for nomination were outstanding PhD theses from the research fields of AMOP completed in 2017 or 2018. Based on the nominations, a jury formed by representatives of the AMOP research areas selected four finalists for the award. The finalists are invited to present their research in this dissertation-prize symposium. Right after the symposium, the awardee will be selected by the prize committee.

Overview of Invited Talks and Sessions

(Lecture room U Audimax)

Invited Talks

SYAD 1.1	Tue	10:30–11:00	U Audimax	**Quantum States and their Marginals: from Multipartite Entanglement to Quantum Error-Correcting Codes** — •Felix Huber
SYAD 1.2	Tue	11:00–11:30	U Audimax	**The Uniform Electron Gas at Warm Dense Matter Conditions** — •Simon Groth
SYAD 1.3	Tue	11:30–12:00	U Audimax	**Relativistically intense laser-microplasma interactions (and potential applications)** — •Tobias Ostermayer
SYAD 1.4	Tue	12:00–12:30	U Audimax	**Motional quantum state engineering for quantum logic spectroscopy of molecular ions** — •Fabian Wolf

Sessions

SYAD 1.1–1.4	Tue	10:30–12:30	U Audimax	**SAMOP Dissertation-Prize**

SYAD 1: SAMOP Dissertation-Prize

Time: Tuesday 10:30–12:30 Location: U Audimax

Invited Talk SYAD 1.1 Tue 10:30 U Audimax

Quantum States and their Marginals: from Multipartite Entanglement to Quantum Error-Correcting Codes — •Felix Huber — ICFO - The Institute of Photonic Sciences, Castelldefels (Barcelona), Spain

At the heart of quantum entanglement lies the relation between the whole and its parts, or in other words, the relation between a quantum state and its marginals. Despite decades of research and its importance in many-body physics and theoretical chemistry, an encompassing characterization of this relation continues to remain elusive.

In my talk, I will explore different aspects of the so-called quantum marginal problem: given parts of a quantum state, what can one infer about the joint state? I will show how this question not only connects to the topic of entanglement, but that it is also related to the existence of quantum error-correcting codes, to questions in graph theory, and to the characterization of thermal states of local Hamiltonians. In this context, constraints can be found that govern how quantum correlations can be shared among many particles. In turn, this restricts what types of entanglement could possibly exist, and also imposes limits upon information processing tasks such as quantum error correction.

Invited Talk SYAD 1.2 Tue 11:00 U Audimax

The Uniform Electron Gas at Warm Dense Matter Conditions — •Simon Groth — Institute of Theoretical Physics and Astrophysics, Christian-Albrechts-University Kiel, Germany

Warm dense matter (WDM), an extreme state with densities exceeding solid state densities and temperatures of up to 10^8 Kelvin, has emerged as one of the frontiers of modern plasma science. These conditions occur in astrophysical objects such as brown dwarfs and giant planets, as well as on the path to inertial confinement fusion—a possible source of clean energy. Consequently, WDM is nowadays intensively investigated in large research facilities around the globe.

Intriguingly, a rigorous theoretical description of WDM is highly challenging due to the presence of an intricate interplay of 1) Coulomb coupling, 2) thermal excitations, and 3) quantum degeneracy effects. Thermal density functional theory (DFT), which constitutes the most promising simulation technique, requires as input an accurate parametrization of the exchange-correlation free energy, f_{xc}, of the uniform electron gas (UEG)—perhaps the most fundamental model system in physics. To obtain such an exchange-correlation functional, we developed two quantum Monte Carlo methods and presented the first exact data for the warm dense UEG. In this way, we provided the key ingredient to thermal DFT and placed ab initio simulations of WDM on the same footing as its ubiquitous ground state analogon.

Invited Talk SYAD 1.3 Tue 11:30 U Audimax

Relativistically intense laser-microplasma interactions (and potential applications) — •Tobias Ostermayer — Ludwig-Maximilians-Universität München, 85748 Garching, Germany — Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — Now at: Lawrence Berkeley National Laboratory, CA94720 Berkeley, USA

This talk covers several aspects of relativistically intense laser-microplasma interactions. A Paul-trap based target system was developed to provide fully isolated, well defined and well positioned microsphere-targets for experiments with focused Peta-Watt laser pulses. The laser interaction turned such targets into microplasmas, emitting proton beams with kinetic energies exceeding 10 MeV. The proton beam kinetic energy spectrum and spatial distribution were tuned by variation of the acceleration mechanism. This reached from broadly distributed spectra in relatively cold plasma expansions to spectra with relative energy spread down to 20% in isotropic multi-species Coulomb explosion and in directed acceleration processes. Numerical simulations and analytical calculations support these experimental findings.

In a second effort, tungsten micro-needle-targets were used at a Peta-Watt laser to produce few-keV x-rays and 10-MeV-level proton beams simultaneously, both measured to have only few-um effective source-size. This source, with its particular characteristics, was used to demonstrate the first single-shot bi-modal radiography of biological and technological samples.

Invited Talk SYAD 1.4 Tue 12:00 U Audimax

Motional quantum state engineering for quantum logic spectroscopy of molecular ions — •Fabian Wolf — QUEST Institut, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Precision spectroscopy has been a driving force for the development of our physical understanding. In particular laser cooling and manipulation improved the achievable precision. However, only few atomic and molecular species offer suitable transitions for laser cooling. This restriction can be overcome in trapped ion systems through quantum logic spectroscopy. Coherent laser manipulation, originally developed in the context of quantum information processing, allows to combine the special spectroscopic properties of one ion species (spectroscopy ion) with the excellent control over another species (logic ion).

In my talk, I will present the first implementation of a quantum logic assisted scheme for reading out the internal state of a molecular ion. In this scheme, an atomic Mg-ion is used to detect a state dependent force that acts on the molecular MgH-ion. Furthermore, a quantum-enhanced force sensing protocol is demonstrated, which can be applied to the previously described measurement, but has further applications in the general field of quantum metrology.