# A 5: SAMOP Dissertation Prize Symposium

Time: Monday 14:00–16:00 Location: V47.01

**Invited Talk** A 5.1 Mon 14:00 V47.01

**A Quantum Information approach to Statistical Mechanics** — •Gemma De las Cuevas — Max-Planck-Institut fuer Quantenoptik, Garching, Germany

The field of quantum information and computation harnesses and exploits the properties of quantum mechanics to perform tasks more efficiently than their classical counterparts, or that may uniquely be possible in the quantum world. Its findings and techniques have been applied to a number of fields, such as the study of entanglement in strongly correlated systems, new simulation techniques for many-body physics or, generally, to quantum optics. We aim at broadening the scope of quantum information theory by applying it to problems in statistical mechanics. We focus on classical spin models, which are toy models used in a variety of systems, ranging from magnetism, neural networks, to quantum gravity, and we tackle them from three different angles. First, we show how the partition function of a class of widely different classical spin models (models in different dimensions, different types of many-body interactions, different symmetries, etc) can be mapped to the partition function of a single model. Second, we give efficient quantum algorithms to estimate the partition function of various classical spin models, such as the Ising or the Potts model. Finally, we outline the possibility of applying quantum information concepts and tools to certain models of discrete quantum gravity.

**Invited Talk** A 5.2 Mon 14:30 V47.01

**Bose-Einstein condensation of photons** — •Jan Klärs — Institut für Angewandte Physik, Universität Bonn, Germany

Does a photon gas condense at low temperatures? Black-body radiation, presumably the most omnipresent Bose gas at all, does not show a phase transition at low temperatures. Here, temperature and photon number cannot be tuned independently. If the temperature of the photon gas is lowered, then also the photon number will decrease (Stefan-Boltzmann law). Under these conditions, a condensation, i.e. a macroscopic occupation of the cavity ground mode, will not occur.

Here, I report on experiments with a two-dimensional photon gas in a dye-filled optical microcavity. In this system, the two transversal motional degrees of freedom of the photons are thermally coupled to the cavity environment by multiple absorption-emission cycles in the dye medium. The cavity mirrors provide an effective photon mass and a confining potential, making the system formally equivalent to a two-dimensional gas of trapped, massive bosons. For such a system, a Bose-Einstein condensation is expected to set in at low temperatures or high photon densities. I will discuss experiments that demonstrate both the thermalization and the condensation process.

**Invited Talk** A 5.3 Mon 15:00 V47.01

**Broadband Optical Quantum Memory at Room Temperature** — •Klaus Reim — Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom — Department of Physics, ETH Zurich, CH-8093 Zurich, Switzerland

The quest for upgrading our current, classical information technology architecture with quantum technology is on. Imagine a global quantum network where quantum information is generated and processed in local nodes using future quantum computers and then shared with people on different continents via completely secure quantum channels. Such a quantum network does require several components to function properly, and a quantum memory must certainly be one of them!

In my talk I am going to present our ensemble-based, far off-resonant Raman-approach to quantum memories and explain what distinguishes it from other quantum memories. Furthermore, I will discuss the experimental challenges we faced, e.g. the generation of the 9.2 GHz frequency-shifted single-photon-level signal field or its separation from the co-propagating, 10 orders of magnitude stronger control field. I will explain how we managed to implement this broadband and robust quantum memory scheme and point out its potential for future quantum applications.

**Invited Talk** A 5.4 Mon 15:30 V47.01

**First Spin-Flips Ever Observed with a Single Trapped Proton** — •Stefan Ulmer[1,2], Cricia Rodegheri[2,3], Klaus Blaum[2,4], Holger Kracke[3], Andreas Mooser[3], Wolfgang Quint[3,5], and Jochen Walz[3] — [1]RIKEN Advanced Science Institue, Wako, Japan — [2]Max-Planck Institute for Nuclear Research, Heidelberg, Germany — [3]Johannes-Gutenberg Universität, Mainz, Germany — [4]Ruprecht-Karls Universität, Heidelberg, Germany — [5]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Proton spin-flips were observed for the first time using a single isolated particle stored in a cryogenic Penning trap. The spin quantum jumps are detected via the continuous Stern-Gerlach effect. This experimental principle has already been applied to compare the magnetic moments of the electron and the positron, or to measure the g-factor of the electron bound to hydrogen-like ions. These experiments involved magnetic moments on the level of the Bohr-magneton. However, the magnetic moment of the proton is about three orders of magnitude smaller and spin-flips are much harder to detect. We demonstrated for the first time that spin quantum jumps of a single trapped proton can be detected, which is a major step towards a high-precision measurement of the particle's magnetic moment at the level of $10^{-9}$ or better. Since the techniques developed for the proton can be directly transferred to the antiproton, this is a crucial milestone towards a million-fold improved test of matter-antimatter-symmetry on the baryon-sector.