Ion Traps in Atomic and Nuclear Physics / *Pièges à ions en physique atomique et nucléaire*

[Room/Salle : Campaign A] ***Chair: K. Sharma, U.Manitoba***

WE-A11-1 10h00

MATTHEW PEARSON, TRIUMF

Nuclear Physics From Cold, Trapped Atoms

Neutral atom traps provide a well localised, backing free sample of cold atoms. In addition the sample is both isotopically and isomerically pure and held within a highly controllable environment. When coupled, on-line to a radioactive beam facility this allows for precision atomic spectroscopy to be performed along a chain of isotopes. These measurements can yield detailed information on the ground state nuclear moments and nuclear spin as well as the charge and magnetisation distributions within the nucleus. Recent measurements on Potassium isotopes performed at TRIUMFs TRINAT facility will be shown along with future plans.

WE-A11-2 10h30

JAMES D.D. MARTIN, University of Waterloo

*Dipole-Dipole Interactions Between Ultracold Rydberg Atoms**

Highly excited Rydberg atoms may strongly interact through dipole-dipole coupling. Thus, temporary excitation to Rydberg states has been proposed for implementing quantum gates between single neutral atoms storing qubits [1], and as a means to encode qubits in small clouds of neutral atoms (such as in magnetic microtraps) [2]. To investigate the feasibility of these proposals we have experimentally studied the dipole-dipole interactions between cold Rydberg atoms. Cold Rubidium atoms from a magneto-optical trap are excited to Rydberg states using a novel modeless dye laser. The dipole-dipole interactions are then probed using microwave transitions and selective field ionization. Both resonant and non-resonant dipole-dipole interactions have been studied.

1. Jaksch *et al*., Phys. Rev. Lett., v. **85**, 2208 (2000).
2. Lukin *et al*., Phys. Rev. Lett., v. **87**, 37901 (2001).

* In collaboration with K. Afrousheh, P. Bohlouli-Zanjani, M. Fedorov and D. Vagale and supported by NSERC, Canada Foundation for Innovation, and Ontario Innovation Trust.

11h00 Coffee Break / Pause café

WE-A11-3 11h30

JENS DILLING, TRIUMF

Ion Traps in Nuclear Physics: The Ultimate Tool for Precision Experiments

Ion traps where originally developed for atomic physics purposes, but were quickly adapted by the nuclear physics community due to its unique features and strait forward compatibility. Some of the most attractive attributes is that these traps allow one to store a sample over an extended period of time in a very well defined environment. This permits long observation times, hence leads to better precision in the measurements, or provides for addition manipulation, often necessary to carry out the procedure of interest. Ion traps in nuclear physics are therefore mostly used for either high precision experiments, or serve as intermediate steps where additional manipulation techniques, like cooling or accumulation, can be applied. An additional asset is the general applicability of ion traps to all charged particles, particularly important in nuclear physics, where one has for example excess to a broad variety of different isotopes. This talk reviews the various trapping techniques as currently used in nuclear physics and shows, how and why some of the best precision experiments, like CPT-tests and weak-interaction Standard model test employ ion traps. An overview of present world-wide activities is given.

WE-A11-4 12h00

Recent Atomic Mass Measurements on Nuclei Far From Stability with the Canadian Penning Trap Mass Spectrometer, **K.S. Sharma [1]** and J.A. Clark [1,2], R.C. Barber [1], B. Blank [2,3], C. Boudreau [2,4], F. Buchinger [4], J.E. Crawford [4], S. Gulick [4], J.C. Hardy [5], A. Heinz [2,6], J.K.P. Lee [4], A.F. Levand [2], B. Lundgren [2], R.B. Moore [4], G. Savard [2], N. Scielzo [2], D. Seweryniak [2], G.D. Sprouse [7], W. Trimble [2], J. Vaz [1,2], J.C. Wang [1,2], Y. Wang [1,2], Z. Zhou [2], [1] *University of Manitoba*, [2] Argonne National Laboratory, [3] Centre d'Etudes Nucléaires de Bordeaux-Gradignan, [4] McGill University, [5] Texas A&M University, [6] Yale University and [7] Stony Brook University — The Canadian Penning Trap (CPT) mass spectrometer, installed at the ATLAS facility of the Argonne National Laboratory, was designed to be able to measure the masses of a wide variety of nuclides, having half –lives as low as 50ms, to an accuracy approaching 1ppb of the mass. Such data are important because they provide input to astrophysical theories of nucleosynthesis, allow tests of fundamental symmetries in the standard model for particle physics and provide stringent constraints on theories that predict nuclear masses. Recent enhancements to the instrument together with the results of recent precision mass measurements among proton and neutron rich nuclei will be discussed.

WE-A11-5 **12h15**

<u>Tripartite Entanglement of a Trapped Atom in an Optical Cavity</u>*, **T.J. Harmon**, R.I. Thompson and B.C. Sanders, *University of Calgary* — Single-atom cavity quantum electrodynamics (QED) is important at a scientific level as a testbed for atom-field coupling in combined systems and to explore atom-field entanglement, which is important for tests of QED and applications to quantum information science. At a technological level, single-atom cavity QED offers the prospect of single-photon sources, quantum memory storage, and quantum computing. The theory of the atom in the cavity is well described by the Jaynes-Cummings model, which treats the atom as an electric dipole interacting with a single mode of the cavity field. However, recent progress with trapping neutral atoms and ions allows quantum features of the motion to arise. The resultant electron-photon-phonon entanglement is especially interesting as a manifestation of tripartite entanglement, which can now be investigated in cavity QED. We are particularly interested in probing this tripartite entanglement and propose the method of photon coincidence spectroscopy (PCS), which combines features of spectral hole burning and photon correlation measurements, for probing this entanglement. In the specific case of a trapped ion, cooled below the Lamb-Dicke limit and positioned inside a cavity, we have developed an exact, analytical solution for the coupling of the sinusoidally-oscillating atom to the cavity modes in the adiabatic approximation. This result allows a determination of the of the spectrum atom-cavity system. PCS techniques are then employed to observe two-photon spectral signatures of tripartite entanglement. We discuss the feasibility of this scheme in the context of current experimental capabilities.

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WE-A11-6 **12h30**

<u>Casting Light on Antimatter: Cold Antihydrogen with ATHENA</u>, **Makoto C. Fujiwara**, *RIKEN/TRIUMF* — Testing fundamental symmetries plays an important role in our understanding of Nature. The ATHENA experiment, located at CERN's Antiproton Decelerator (AD) facility, aims to make a precision test of CPT symmetry by comparing the properties of hydrogen with those of its antimatter counterpart, antihydrogen. After several years of development, we have achieved our initial goal in 2002: production of antihydrogen at low velocity [1] (see for a review [2]). With our results subsequently confirmed by another AD experiment, a next major goal is laser spectroscopy of cold antihydrogen. I will discuss our first production, together with the subsequent progress [3] and the prospects for antihydrogen spectroscopy.

1. M. Amoretti *et al*., Nature (London) 419, 456 (2002).
2. M.C. Fujiwara *et al*., Nucl. Instrum. Method. B 214, 11 (2004).
3. M.C. Fujiwara *et al*., Phys. Rev. Lett. 92, 065005 (2004).

12h45 **Session Ends / Fin de la session**