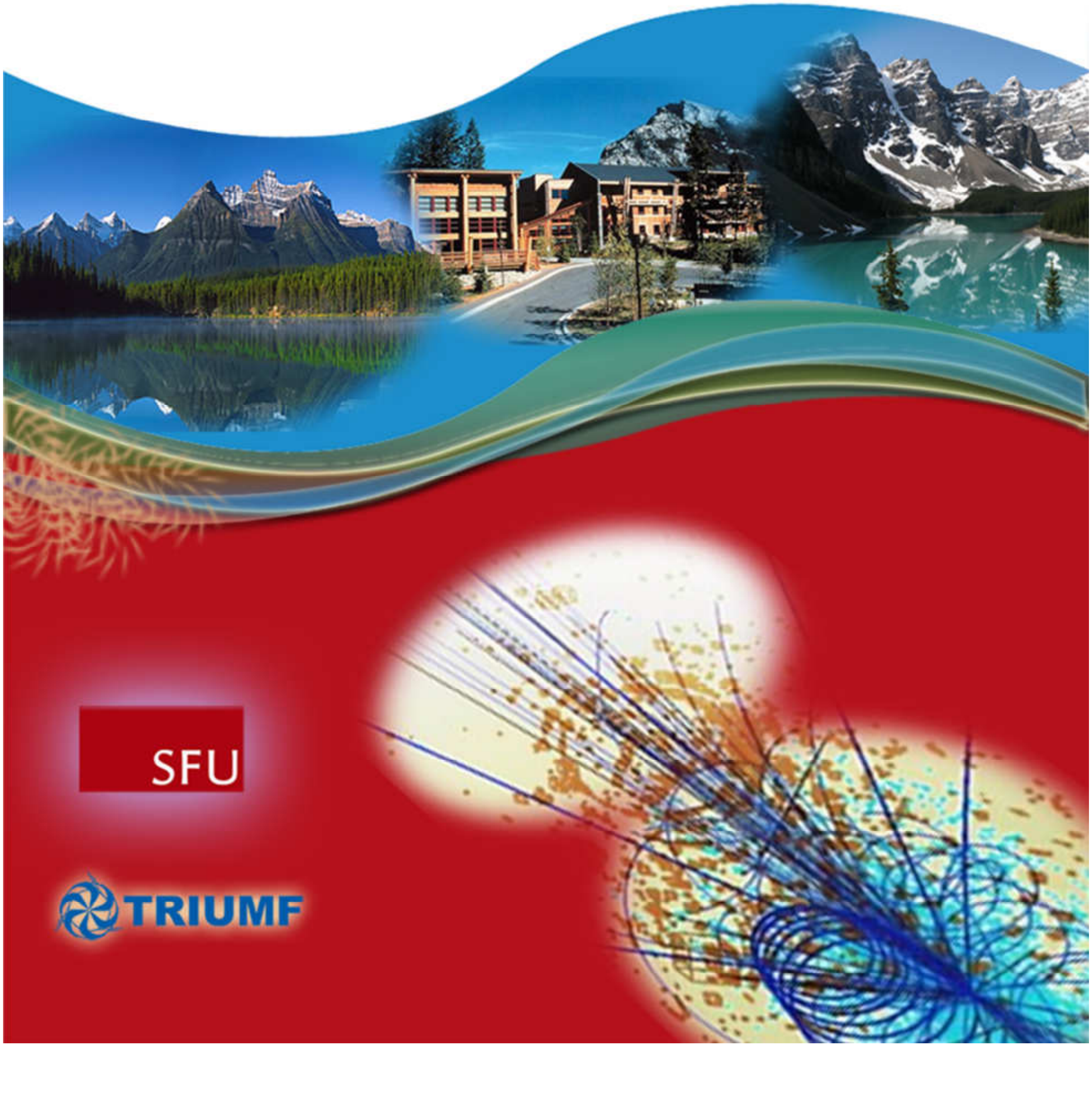
WNPPC11

The 48th Winter Nuclear and Particle Physics Conference

February 18-20, 2011

Banff, Alberta, Canada



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Welcome to WNPPC 2011!

We are pleased to welcome you to WNPPC 11. The next few days will be full of information, with some time to enjoy the beautiful mountain surroundings along the way. Here are a few notes to start your weekend off right.

<u>Wireless Internet:</u>

Free Wireless Internet is available throughout the Banff Centre in several buildings. To take advantage of this service, you must have wireless capability on your laptop that is preconfigured for DHCP. The wireless network is titled "Banffcentre" and should appear in your list of available networks.

Access instructions can be found here:

http://www.banffcentre.ca/conferences/services/computer_services.asp

<u>Bagged Lunch:</u>

A bagged lunch will be provided for those who requested it in advance. These will be available in the TCPL Foyer (outside the meeting room).

<u>Building Names and Abbreviations:</u>

TCPL = TransCanada Pipelines Pavilion Building

- Meeting Room PAV 201

PDC = Professional Development Centre

- Front Desk and Bedrooms

SBB = Sally Borden Building

- Vistas Dining Room, 4th Floor

Fitness and Recreation:

The Banff Centre's Sally Borden Recreation Facility is available to all overnight guests of the Banff Centre at no extra charge. The facility includes a 25 metre pool, steam rooms, whirlpool, weight room, full-sized gymnasium with indoor running track, badminton, squash court, and climbing wall.

Skiing:

For those looking to take advantage of the local mountains on Saturday afternoon, there are two ski hills near Banff.

Ski Banff @ Norquay	www.banffnorquay.com
Sunshine Village	www.skibanff.com

Tourism Information

For more information of Banff, visit www.banfflakelouise.com

Invited Speakers:

The organizing committee would like to thank all of the invited speakers for accepting our invitation and attending at their own expense.

K. Starosta Simon Fraser University
H. Trottier, Simon Fraser University
A. Garnsworthy, TRIUMF
P. Navrátil, TRIUMF
M. Gericke, University of Manitoba
C. Kraus, Laurentian University
J. Dilling, TRIUMF/University of British Columbia
R. Ouyed, University of Calgary
R. Thompson, University of Calgary

We welcome all comments and hope you enjoy the conference. For more information, please talk to the organizers or e-mail wnppc@triumf.ca.

Corina Andreoiu, WNPPC2011 Chair
Simon Fraser University
corina_andreoiu@sfu.ca

Jana Thomson
WNPPC Conference Coordinator
TRIUMF
wnppc@triumf.ca

Session: Friday Evening

SUPERCONDUCTING ACCELERATORS AT TRIUMF:

CAPABILITIES AND FUTURE PLANS

D. Longuevergne, C. Beard, P. Kolb, E. R. Laxdal, M. Marchetto, L. Merminga, V. Zvyagintsev

TRIUMF, 4004 Wesbrook Mall, Vancouver BC V6T 2A3, Canada

ISAC II is a superconducting heavy ion linear accelerator operating at TRIUMF since 2006. In 2010, a new upgrade to the linac was installed and commissioned and the ISAC-II SC-linac is now providing an accelerating voltage of 40MV yielding energies above the Coulomb Barrier for all ISAC radioactive ion beams.

A major new project at TRIUMF is ARIEL (Advanced Rare IsotopE Laboratory), a facility aimed at expanding the variety and productivity of the TRIUMF radioactive beam program. At the core of ARIEL is the addition of a CW superconducting electron driver (E-linac) to produce radioactive ion beams through photofission. The first stage, to be completed in 2013 will provide 25 MeV at 4 mA. Following in 2017, the second stage will double the energy to 50 MeV at 10 mA.

The ISAC II SC-Linac present capabilities and a summary of developments and plans towards e-Linac will be presented.

RECOIL-DISTANCE LIFETIME MEASUREMENTS FOR EXOTIC NUCLEI

K. Starosta

Department of Chemistry, Simon Fraser University, Burnaby, BC V5A 1S6

Electromagnetic transition rates are observables critical for evaluation of nuclear structure effects and verification of nuclear models. Doppler-shift lifetime measurements provide an opportunity to directly access information about electromagnetic transition rates in a way which is fully independent on the reaction mechanism. As such, Recoil Distance and related Doppler Shift Attenuation Methods, when implemented at radioactive beam facilities, hold the promise of reaching far from stability and providing lifetime information for intermediate-spin excited states in a wide range of nuclei. This is well proven by recent implementation of the Recoil Distance Method with intermediate energy beams from fragmentation at the National Superconducting Cyclotron Laboratory. In response to new opportunities opened by availability of re-accelerated beams from the ISAC-II facility at TRIUMF, a plunger-type recoil distance method device, the TIGRESS Integrated Plunger (TIP), is under construction at Simon Fraser University to be used with the TIGRESS segmented Germanium array as part of the ISAC-II experimental program. The TIP is designed to achieve control of sub-micrometer shifts between target and degrader and can be run in a self-standing mode or to in tandem with a CsI array of charged particle detectors for reaction channel selection from fusion-evaporation reaction. A compact CsI array with digital readout to be developed as a part of the TIP facility is designed to be run without the plunger using the TIP vacuum vessel, for example in Doppler Shift Attenuation experiment. TIP is also designed to be coupled with the forthcoming TIGRESS auxiliary deuterated neutron detector array DESCANT and the electromagnetic spectrometer EMMA. A summary of the development and envisioned experimental program will be presented.

THE TIGRESS INTEGRATED PLUNGER (TIP) CONTROL SYSTEM DEVELOPMENT

A. Chester, K. Starosta, R. Ashley

Department of Chemistry, Simon Fraser University, Burnaby, BC V5A 1S6

Along the N = Z line, prolate and oblate shapes are stabilized by shell gaps which open simultaneously for positive and negative quadrupole deformations. This leads to the phenomenon of shape coexistence predicted for the N = Z = 34 ^{68}Se isotope. Electromagnetic transition rates provide an observable sensitive to shape but current nuclear model predictions vary by an order of magnitude. Doppler shift lifetime measurements provide an opportunity to directly access information about electromagnetic transition rates and discriminate between model calculations. To take advantage of this opportunity, a plunger-type recoil distance method device, the TIGRESS Integrated Plunger (TIP) is under construction at Simon Fraser University to be used with the TIGRESS segmented Germanium array at TRIUMF as part of the ISAC-II experimental program. The TIP will be coupled with a CsI array of charged particle detectors for reaction channel selection. A summary of the development of the capacitance feedback control mechanism which allows for target/stopper shift control with micrometre precision will be presented.

GAUGING THE EXOTICS:

PENNING TRAP EXPERIMENTS AT TITAN

J. Dilling [1,2]

[1]TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C. Canada and

[2] Department of Physics and Astronomy, University of British Columbia, Vancouver, BC, Canada

Nuclei with an extreme unbalanced ratio of protons-to-neurons are referred to as exotic. The most exotic ones ever found on Earth are the halo nuclei of helium and lithium with a ration of three times more neutrons than protons. Teetering on the edge of nuclear stability, the properties of these exotic halo nuclei have long been recognized as one of the most stringent tests of our understanding of the strong force and provide ideal tests candidates for advanced theory. Only recently has it become possible to carry out precision mass measurement of the halos, such as ^{11}Li, using a Penning trap spectrometer. Measurements were carried out at the TITAN (Triumf's Ion Trap for Atomic and Nuclear science) facility at TRIUMF where a trap system is coupled to the ISOL-based rare beam facility ISAC. Penning traps are proven to be the most precise device to make mass measurements, but were until now not able to reach these atoms, due to limitations in production yield and short half-lives. At TRIUMF we managed, and in addition to its unprecedented accuracy, dm/m = $6 \cdot 10^{-8}$, the measurement of ^{11}Li is remarkable for the fact that with a half-life of only 8.8 ms, it is the shortest-lived nuclide ever to be weighed with this technique. Furthermore, new and improved masses for ^{6,8}He, and ^{11,12}Be, hence precision mass measurements on 1, 2, and 4-neutron halos have been performed.

Using theses precision masses, other properties, such as charge radii form laser spectroscopy, can be derived. This allows one to test and refine state-of-the-art nuclear theory, and shows that three-body forces need to be considered when describing these nuclei. An overview of the TITAN mass measurement program and its impact in the general understanding of exotic nuclei will be given.

THE TITAN PENNING TRAP FOR COOLING HIGHLY-CHARGED RADIOACTIVE IONS AT ISAC

V.V. Simon[1,2,3], U. Chowdhury[1,4], P. Delheij[1], J. Dilling[1,5], B. Eberhardt[1], G. Gwinner[4]

[1]TRIUMF, Vancouver, BC, Canada

[2]University of Heidelberg, Heidelberg, Germany

[3]Max Planck Institute for Nuclear Physics, Heidelberg, Germany

[4]University of Manitoba, Winnipeg, MB, Canada

[5]University of British Columbia, Vancouver, BC, Canada

Accurate mass measurements provide vital information and offer key knowledge for the description of nuclear astrophysical processes, nuclear structure, and for tests of fundamental symmetries. Many of the relevant isotopes, for example isotopes involved in the nucleosynthesis of the heavy elements in the universe, are radioactive and short-lived.

TITAN is an experimental setup at ISAC dedicated to high precision mass measurement of nuclei with short half-lives. The lifetime of radioactive nuclei restricts the achievable mass resolution, which is proportional to the observation time in resonance-based mass spectrometry in Penning traps. One way to overcome this restriction is by increasing the charge state. TITAN has demonstrated this capability and is presently the only facility with an operational online charge breeding Electron Beam Ion Trap (EBIT). Using an EBIT results in an energy spread of the ions of tens of eV/q, which in turn is negatively reflected in the mass measurement in the precision Penning trap.

A Cooler PEnning Trap (CPET) is presently being developed to cool highly charged ions prior to the mass measurement which will increase the efficiency and precision. This is a novel concept and both electron and proton cooling will be tested. Additionally, CPET will incorporate mass selective cooling techniques, which provide specific mass-to-charge ratios for the extracted ion. The concept of preparing highly charged ions in a Penning trap as well as the status of the project will be presented. Design of the CPET is complete, and simulations of the cooling techniques have been performed. Electrode assembly is finished and an offline test setup is planned to be operational in Spring/Summer 2011.

DOUBLE BETA DECAY, MAJORANA NEUTRINOS,

AND THE TRICKS NATURE CAN PLAY

D. Frekers

University of Muenster, Institute for Nuclear Physics, D 48149 Muenster, Germany

I will talk about some general aspects of double-beta decay and what this decay will tell us in terms of the various mass scenarios for Majorana neutrinos. Further, extracting a neutrino mass in case a neutrinoless decay is observed and differentiating between the different mass scenarios, requires a good understanding of the underlying nuclear physics, i.e. the "double beta decay nuclear matrix elements". Whereas the matrix elements for the 2–neutrino decay can rather easily be determined using charge-exchange reactions, the ones for the neutrinoless decay are complicated and require a strong concerted effort from many different sides, theory and experiment alike. I will talk about experiments, which have already provided some unexpected results and about those, which are still needed to advance our knowledge about the nuclear physics part of double-beta decay. The latter include experiments, which make use of radioactive beams and ion traps.

Session: Saturday Morning

 

THE FUTURE SPICE ANCILLARY DETECTOR FOR TIGRESS

A.B. Garnsworthy

TRIUMF, 4004 Wesbrook Mall, Vancouver BC V6T 2A3, Canada

Design work is underway for the future SPectrometer for Internal Conversion Electrons (SPICE) ancillary detector system which will be coupled to the TIGRESS Ge array at TRIUMF's ISAC II. SPICE will use a rare-earth permanent magnetic lens to collect and transport Internal Conversion Electrons (ICEs), emitted from de-exciting nuclear states populated in nuclear reactions, to a set of semiconductor detectors which are shielded from direct sight of the production site. This arrangement aims to optimize the signal-to-noise ratio observed in the electron detectors by minimizing backgrounds resulting from photons, back-scattered electrons, beta decay, delta electrons and secondary electrons. SPICE will have a particular sensitivity to higher energy ICEs between 500keV and 4MeV which will facilitate studies of shape coexistence and shell evolution in exotic nuclei. An overview of the design considerations, unique physics applications and expected performance of the device will be presented.

OBSERVING A LIGHT DARK MATTER BEAM WITH NEUTRINO EXPERIMENTS

P. deNiverville

Department of Physics & Astronomy, University of Victoria, Victoria, BC, V8W 3P6 Canada

We consider the sensitivity of high luminosity neutrino experiments to light stable states, as arise in scenarios of MeV-scale dark matter. To ensure the correct thermal relic abundance, such states must annihilate into light mediators which themselves necessarily decay back into the Standard Model before Big Bang Nucleosynthesis, providing a portal for access to the dark matter state in colliders or fixed targets. This framework implies that neutrino beams produced at a fixed target will also carry an additional "dark matter beam", which can mimic neutrino scattering off electrons or nuclei in the detector. We therefore study two proton fixed-target facilities with high luminosity, LSND and MiniBooNE, and determine the existing limits on light dark matter. We find in particular that MeV-scale dark matter scenarios motivated by an explanation of the galactic 511 keV line are strongly constrained.

HIGH-STATISTICS STUDY OF THE BETA-DECAY OF ^{110}IN*

A. Diaz Varela, P.E. Garrett, J. Bangay, G.A. Demand, K.L. Green, K.G. Leach,

C. Sumithrarachchi, C.E. Svensson, S. Triambak, J. Wong

Department of Physics, University of Guelph, ON, N1G 2W1, Canada

G.C. Ball, A.B. Garnsworthy, G. Hackman

TRIUMF

W.D. Kulp, J.L. Wood

Georgia Tech

S.W. Yates

University of Kentucky

D. Cross

Simon Fraser University

The stable even-even Cd isotopes have been considered excellent examples of vibrational nuclei, especially ^{110}Cd and ^{112}Cd. We have initiated a program at the TRIUMF-ISAC radioactive beam facility using the 8pi spectrometer and its associated auxiliary detectors to study these isotopes via high-statistics beta-decay measurements. To date, the decays of ^{112}Ag/^{112}In and ^{110}In have been studied. The present work concentrates on the beta decay measurement of ^{110}In to ^{110}Cd. The data were collected in scaled-down gamma singles, gamma-gamma coincidence, and gamma-electron coincidence mode. A total of 850 million events have been sorted into a random-background subtracted gamma-gamma matrix. Details of the analysis to date will be reported.

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*Work supported by the Natural Sciences and Engineering Research Council of Canada and the National Research Council of Canada.

ANTIHYDROGEN TRAPPED: PROJECT ALPHA'S ROAD

TO THE CREATION, STORAGE, AND EVENTUAL STUDY OF ANTIHYDROGEN

R. Thompson

Department of Physics and Astronomy, University of Calgary, Calgary AB, Canada

Antihydrogen, or more specifically high precision spectroscopy of antihydrogen, offers some of the most promising avenues for extremely sensitive tests of CPT symmetry. However, such precision studies would require that the antihydrogen be stored at low temperature while being probed with microwave or ultraviolet laser radiation. Project ALPHA (Antihydrogen Laser PHysics Apparatus) is one of several independent experiments currently underway at the Antiproton Decelerator (AD) at CERN, each designed to generate, trap, and study antihydrogen for tests of CPT. In November 2010, the ALPHA Collaboration announced the first successful storage of neutral antimatter atoms in a magnetic bottle trap. This presentation will describe the techniques employed to generate and trap antihydrogen. It will discuss the challenges of mixing antiprotons and positrons to form, detect, and analyze low temperature antihydrogen in the presence of the inhomogeneous magnetic fields that make up the neutral particle trap, and provide an overview of techniques being developed to manipulate the positron and antiproton plasmas to optimize the antihydrogen formation process. Finally, an outlook towards future spectroscopic studies that could be carried out on trapped antihydrogen using the techniques of laser and microwave spectroscopy will be provided.

ELECTROSTATIC MODE DIAGNOSTICS IN THE ALPHA EXPERIMENT*

T. Friesen

Department of Physics and Astronomy, University of Calgary, Calgary AB, Canada

and the ALPHA Collaboration**

The ALPHA experiment is an antihydrogen experiment based at CERN with the goal of trapping and studying antihydrogen. The apparatus consists of a Penning trap for charged particles and an overlayed magnetic trap to confineneutral antihydrogen. In November 2010 ALPHA demonstrated the first ever trapping of antihydrogen atoms, a major milestone towards antihydrogen spectroscopy. With the ability to trap the antihydrogen atoms long enough to study we can push forward towards the performing the first resonant interactions with antihydrogen's internal degrees of freedom. This talk will discuss recent progress made by ALPHA towards microwave spectroscopy of antihydrogen's hyperfine structure. I will discuss some of the challenges ALPHA faces and how electrostatic plasma modes can be used to characterize a microwave field in the trap.

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*Work supported by CNPq, FINEP (Brazil), ISF (Israel), MEXT (Japan), FNU (Denmark), AIF, NSERC, NRC/TRIUMF (Canada), DOE, NSF (USA), EPSRC and Leverhulme Trust (UK).

**ALPHA Collaboration: University of Aarhus University: G. Andersen, P.D. Bowe, J.S. Hangst; Auburn University: F. Robicheaux; RIKEN: D. Miranda, Y. Yamazaki; Stockholm University: S. Jonsell; Federal University of Rio de Janerio: C.L. Cesar; University of Tokyo: R.S. Hayano; University of Wales, Swansea: M. Charlton, S. Eriksson, W. Bertsche, E. Butler, A.J. Humphries, L.V. Jorgensen, N. Madsen, D.P. van der Werf; University of California, Berkeley: M. Baquero-Ruiz, S. Chapman, J. Fajans, A. Povilus, J. Wurtele; Nuclear Research Center, Negev, Israel: E. Sarid; University of Liverpool: P. Nolan, P. Pusa; University of British Columbia: A. Gutierrez, W.N. Hardy, S. Seif El Nasr; University of Calgary: T. Friesen, R. Hydomako, R.I. Thompson; Simon Fraser University: M.D. Ashkezari, M. Hayden; TRIUMF: M.C. Fujiwara, D.R. Gill, L. Kurchaninov, K. Olchanski, A. Olin, J.W. Storey; York University: C. Amole, S. Menary

MICROWAVE SPECTROSCOPY OF ANTIHYDROGEN

M.D. Ashkezari

[1]Department of Physics, Simon Fraser University, Burnaby, BC V5A 1S6

and the ALPHA Collaboration*

ALPHA is a collaborative project based at CERN that involves 15 institutions from 8 different countries. One of its central goals is to perform spectroscopic measurements on antihydrogen atoms, leading to precision comparisons of fundamental symmetries between matter and antimatter and a model-independent experimental test of the CPT theorem. A critical milestone related to this effort was reported in November 2010: the first-ever stable and reproducible magnetic trapping of neutral antihydrogen atoms.

Antihydrogen synthesis is achieved in the ALPHA apparatus by mixing cold antiproton and positron plasmas that are held and manipulated in a series of electro/magnetostatic (Penning-Malmberg) traps. Low energy neutral anti-atoms are then confined to the vicinity of the region in which they are formed via interaction between their magnetic moments and a (0.5 Kelvin deep) minimum in the local magnetic field (a variation on an Ioffe-Pritchard trap).

Over the next several years our efforts will focus on studies of trapped antihydrogen. In the short-term, one of the most promising spectroscopic tools available to us involves microwave probes of atomic hyperfine states. During this talk I will describe some of the motivations for pursuing microwave spectroscopy of antihydrogen atoms, as well as the manner in which such experiments might be implemented.

* **M.D. Ashkezari**, M.E. Hayden (Simon Fraser University); A. Gutierrez, W.N. Hardy, S. Seif El Nasr (University of British Columbia); T. Friesen, R. Hydomako, R.I. Thompson (University of Calgary); M.C. Fujiwara, D.R. Gill, L. Kurchaninov, K. Olchanski, A. Olin, J.W. Storey, S. Stracka (TRIUMF); C. Amole, S. Menary (York University); G. Andersen, P.D. Bowe, J.S. Hangst (University of Aarhus University); F. Robicheaux (Auburn University); M. Baquero-Ruiz, S. Chapman, J. Fajans, A. Povilus, J. Wurtele (University of California, Berkeley); C.L. Cesar (Federal University of Rio de Janerio); P. Nolan, P. Pusa (University of Liverpool); E. Sarid (Nuclear Research Center, Negev, Israel); D. Miranda, Y. Yamazaki (RIKEN); S. Jonsell (Stockholm University); R.S. Hayano (University of Tokyo); M. Charlton, S. Eriksson, W. Bertsche, E. Butler, A.J. Humphries, L.V. Jorgensen, N. Madsen, D.P. van der Werf (University of Wales, Swansea).

AB INITIO THEORY OF LIGHT-ION REACTIONS

P. Navrátil

TRIUMF, 4004 Wesbrook Mall, Vancouver BC V6T 2A3, Canada

The exact treatment of nuclei starting from the constituent nucleons and the fundamental interactions among them has been a long-standing goal in nuclear physics. Above all nuclear scattering and reactions, which require the solution of the many-body quantum-mechanical problem in the continuum, represent a theoretical and computational challenge for *ab initio* approaches.

We build a new *ab initio* many-body approach capable of describing simultaneously both bound and scattering states in light nuclei, by combining the resonating-group method with the *ab initio* no-core shell model. In this way, we complement a microscopic-cluster technique with the use of realistic interactions, and a microscopic and consistent description of the nucleon clusters. I will present results for neutron and proton scattering on light nuclei, the first calculations of the d-^{3}H and d-^{3}He fusion, and our preliminary results for the ^{7}Be(p,γ)^{8}B capture reaction.

A THERMAL MUON SOURCE FOR MUON $g - 2$*

G.M. Marshall

TRIUMF, 4004 Wesbrook Mall, Vancouver, B.C. Canada

The muon anomalous magnetic moment, $a_\mu = (g - 2)/2$, offers an opportunity to test the Standard Model of particle physics and to characterize new interactions beyond it. This is made possible by the sensitivity of a_μ to new particle degrees of freedom, to the accuracy with which it has been calculated, and to the accuracy of the frequency measurement from which a_μ is determined. A difference of 3.2 standard deviations exists between the published experimental result of Brookhaven E821 and the best available theoretical calculations.

Two new experiments are proposed to complement an expected improvement in precision of the Standard Model prediction. One will be at Fermilab, taking advantage of a transported E821 storage ring with improvements in magnetic field, detection, and beam quality. The other will be at J-PARC, using low energy muons from the high power beam and leading to quite different systematic limitations. Both experiments aim for a factor of five improvement in precision.

The status of the muon anomalous magnetic moment measurement and its comparison to theory will be reviewed. The J-PARC experiment will be described, emphasizing its unique aspects, in particular the contribution of TRIUMF experiment S1249 to the crucial issue of producing a thermal source of muons for the required low emittance muon beam.

*Work supported by TRIUMF

DRIFT CHAMBER DESIGN OPTIMIZATION STUDIES FOR THE SuperB HIGH-LUMINOSITY FLAVOUR FACTORY*

D. Swersky

Department of Physics, McGill University, Montréal, QC Canada H3A 2T8

SuperB is a proposed high-luminosity asymmetric *B*-factory experiment planned for the electron-positron collider at the LNF in Frascati, Italy. The collider beams are tuned to a centre-of-mass energy of 10.58 GeV, which is the optimal energy for producing large numbers of B^+B^- and $B^0\overline{B}^0$ meson pairs. The experiment features a revolutionary energy-saving beam design, which will permit a data collection rate two orders of magnitude greater than anything obtained by existing B-factories to date. As a result of its high luminosity and data collection rate, the **SuperB** detector will be exposed to problematically large rates of physics backgrounds, such as Bhabha scattering in particular.

Due to the high rates of expected Bhabha backgrounds, it will be necessary to perform careful optimizations when selecting the **SuperB** drift chamber geometry and materials, in order to maintain the particle tracking system at acceptable levels of occupancy. In this presentation, I will discuss the results of Monte Carlo simulations performed using the ***SuperB Fast Simulation*** (***FastSim***) software framework, focusing on the following means of background reduction:

- Adjustment of the drift chamber length and alignment
- Alterations to the shape of the drift chamber endplates (i.e. “spherical”, “convex”, “wedding cake” designs)
- Insertion of a tungsten beam shield to reduce the dominant backgrounds from low-angle Bhabha scattering

I will conclude with a brief discussion of similar studies performed using the slower but more comprehensive **SuperB** ***Full Simulation***, comparing the results of such studies with those obtained from the ***FastSim***.

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*Work supported by McGill University.

Session: Saturday Evening

QUANTUM CHROMODYNAMICS ON A SPACE-TIME LATTICE

H. Trottier

Department of Physics, Simon Fraser University, Burnaby, BC V5A 1S6

Quantum Chromodynamics (QCD) has been accepted as the theory of the strong interactions for almost forty years, ever since the discovery of asymptotic freedom by Gross, Politzer and Wilczek, whose work was recognized with the 2004 Nobel Prize. Despite many successful quantitative predictions for high-energy processes, applications of QCD to strongly-coupled, low-energy hadronic physics, including such basic quantities as the proton mass were, until recently, much less successful. A space-time lattice discretization of QCD (proposed by Ken Wilson the year after asymptotic freedom) allows for a numerical solution, but the enormous computational burden of realistic lattice QCD simulations proved to be a major impediment. Happily, dramatic improvements in the predictive power of lattice QCD have occurred in the past few years, due to major theoretical progress in our understanding of quantum field theories on a lattice. These developments have had a significant phenomenological impact on particle physics. This pedagogical talk will give a conceptual review of the theory of QCD at high and low energies and the new developments in lattice QCD.

γ-RAY SPECTROSCOPY OF NEUTRON-RICH SILICON AND SULPHUR NUCLEI USING GRAZING REACTIONS*

Z. M. Wang on behalf of the collaborators involved in the work

School of Engineering, University of the West of Scotland, Paisley, PA1 2BE, United Kingdom and the Scottish Universities Physics Alliance (SUPA)

Simon Fraser University and TRIUMF, Vancouver, BC, Canada

Multi-nucleon transfer and deep-inelastic binary grazing reactions which occur when 215 MeV ^{36}S ions, delivered by the Tandem-ALPI accelerator complex at the INFN Legnaro National Laboratory, Italy, interact with a thin enriched $^{208}_{82}Pb_{126}$ target have been used to populated a number of neutron-rich projectile-like nuclear species. The γ-ray decay of the binary reaction products was studied using the CLARA array of escape-suppressed germanium clover detectors which was coupled to the large solid angle magnetic spectrometer, PRISMA. Measurements made with PRISMA allow reaction channel selection and Doppler correction capabilities which, in turn, result in clean γ-ray spectra for individual projectile-like nuclei. The γ-ray decay of yrast and near-yrast states of $^{30,31,32,33,34,35,36}Si$ and $^{34,35,36,37,38,39,40,41}S$ isotopes has been studied in the present work. A number of hitherto unobserved γ-ray transitions have been observed in the $^{31,32,33,34,36}Si$ and $^{36,37,38,39,40,41}S$ isotopes. Energy levels have been established and interpreted using the results of large-scale shell-model calculations performed with the Antoine and the Nathan codes using the latest SDPF-U-SI, SDPF-U and PSDPFB effective interactions.

*This work was supported in part by the EPSRC (UK) and by the European Union under contract number RII3-CT-2004-506065.

HIGH-PRECISION BRANCHING RATIO MEASUREMENT FOR THE SUPERALLOWED β^+ EMITTER ^{74}Rb

R. Dunlop, S. Chagnon-Lessard, P. Finlay, P.E. Garrett, B. Hadinia, K.G. Leach, C.E. Svensson, J. Wong

Department of Physics, University of Guelph, Guelph, Ontario, N1G 2W1, Canada

G.C. Ball, A.B. Garnsworthy, J. Glister, G. Hackman, E.R. Tardiff, S. Triambak, S.J. Williams

TRIUMF, 4004 Wesbrook Mall, Vancouver, British Columbia, V6T 2A3, Canada

J.R. Leslie

Queens University, Kingston, Ontario, K7L 3N6, Canada

C. Andreoiu, A. Chester, D. Cross, K. Starosta

Department of Physics, Simon Fraser University, Burnaby, British Columbia, V5A 1S6, Canada

S.W. Yates

Departments of Chemistry and Physics & Astronomy, University of Kentucky, Lexington, Kentucky 40506-0055

E.F. Zganjar

Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803-4001

Precision measurements of superallowed Fermi beta decay allow for tests of the Cabibbo-Kobayashi-Maskawa matrix (CKM) unitarity, the conserved vector current hypothesis, and the magnitude of isospin-symmetry-breaking effects in nuclei. A high-precision measurement of the branching ratio for the β^+ decay of ^{74}Rb has been performed at the Isotope Separator and ACcelerator (ISAC) facility at TRIUMF. The 8π spectrometer, an array of 20 close-packed HPGe detectors, was used to detect gamma rays emitted following the decay of ^{74}Rb. PACES, an array of 5 Si(Li) detectors, was used to detect emitted conversion electrons, while SCEPTAR, an array of plastic scintillators, was used to detect emitted beta particles. In this talk, the importance of the branching ratio measurement of the ^{74}Rb superallowed decay will be discussed and preliminary results from the recent measurements at ISAC will be presented.

ALPHA-DECAY STUDIES OF ^{172}AU-^{168}IR-^{164}RE CHAIN AND GAMMA-RAY SPECTROSCOPY OF ^{172}AU

B. Hadinia
University of Guelph, Guelph, Ontario, Canada

B. Cederwall, T. Bäck, A. Johnson, A. Khaplanov, R. Wyss,
Department of Physics, Royal Institute of Technology, Stockholm, Sweden

R. D. Page, E. S. Paul, T. Grahn, M. B. Gomez Hornillo
Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom

P. T. Greenlees, U. Jakobsson, P. M. Jones, R. Julin, J. Juutinen, S. Ketelhut, M. Leino,
M. Nyman, P. Peura, P. Rahkila, M. Sandzelius, J. Saren, C. Scholey, J. Sorri, J. Uusitalo
Department of Physics, University of Jyväskylä, Jyväskylä, Finland

R. Chapman, J. F. Smith
University of the West of Scotland, Paisley, Scotland, United Kingdom

E. Ideguchi, M. Niikura
CNS, University of Tokyo, Wako, Japan

E. Ganioglu, I. Őzgűr
Science Faculty, Physics Department, Istanbul University, Istanbul, Turkey

A number of alpha decays in ^{172}Au, ^{168}Ir, and ^{164}Re as well as gamma-ray transitions in ^{172}Au have been identified for the first time. The experiments were performed at the JYFL accelerator facility at the University of Jyväskylä, Finland, by colliding 342-MeV and 348-MeV ^{78}Kr beams onto a ^{96}Ru target. The alpha decays previously reported for ^{172}Au were confirmed and the decay chain extended down to ^{152}Tm through the discovery of an alpha-decaying state in ^{164}Re$^{(m)}$ (E_α= 5623(10) keV; $t_{1/2}$ = 864 ms). In addition, in the ^{172}Au$^{(m)}$-^{168}Ir$^{(m)}$ - ^{164}Re$^{(m)}$ chain, a new branch of alpha decay emanating from ^{172}Au$^{(m)}$ (E = 6800 keV; $t_{1/2}$ = 8 ms) was observed. The fine structure studies in this chain allowed the first excited states in the ^{172}Au$^{(m)}$ and ^{168}Ir$^{(m)}$nuclei to be established. Another new alpha-decaying state was also observed in ^{172}Au and was found to emanate from the ground state of this nucleus (E_α = 6762(10) keV; $t_{1/2}$ = 22 ms). A systematic overview of the Q values in the region has been presented. The observed decay of ^{164}Re$^{(m)}$ (E_α = 5623(10) keV; $t_{1/2}$ = 864 ms) appears to violate the smooth trend of decreasing Q values as a function of increasing neutron number. However, this violation would disappear by an additional tentatively observed alpha decay from ^{164}Re$^{(m)}$ (E = 5846 keV). Gamma-ray transitions of ^{172}Au have been identified for the first time using the method of recoil decay tagging. A partial level scheme for ^{172}Au has been constructed which indicates an irregular structure relative to its heavier isotopes and its lighter isotones. Possible configurations of the alpha-decaying states in ^{172}Au are discussed in terms of the systematics of this region and total routhian surface calculations.

STRUCTURE OF ^{152}SM AND ITS LOW-LYING NEGATIVE-PARITY BANDS VIA DEUTERON INELASTIC SCATTERING

S. Chagnon-Lessard, J.C. Bangay, L. Bianco, P.E. Garrett, K.G. Leach, A.A. Phillips, E.T. Rand, C.E. Svensson

Department of Physics, University of Guelph, ON, N1G 2W1, Canada

G.C. Ball

TRIUMF, 4004 Wesbrook Mall, Vancouver, BC, V6T 2A3, Canada

T. Faestermann, R. Krücken

Physik Department, Technische Universität München, D85748 Garching, Germany

R. Hertenberger, H.F. Wirth

Fakultät für Physik, Ludwig-Maximilians-Universität München, D85748 Garching, Germany

Nuclei near N=90 and Z=64 have recently been suggested to be ‘tetrahedral-magic’ [1]. One of the main signatures for tetrahedral symmetry is a vanishing quadrupole moment in low-lying negative-parity bands. This has the consequence that a rotational band possess very weak, or even vanishing, E2 matrix elements. With N=90 and Z=62, ^{152}Sm is a potential candidate for relatively stable tetrahedral symmetry. Complementing studies of ^{156}Dy [2], the structure of ^{152}Sm has been investigated using deuteron inelastic scattering with a 22 MeV polarized deuterium beam at the MP tandem Van de Graaff accelerator of the TU/LMUMunich. The deuterons from the reaction were momentum analyzed using the Q3D spectrometer. The work presented will highlight some of the results from the reaction, including high-quality spectra which exhibit forbidden state structures from the K=1- and K=2- bands. Absolute cross sections and analyzing powers have been extracted for levels up to 2 MeV. The low-lying negative-parity bands are observed to be strongly populated, however detailed coupled-channel calculations are required before transition elements can be extracted due to the many possible population pathways. Details of the experiment and analysis to date will be presented.

[1] J. Dudek et al., Phys. Rev. Lett. **88**, no. 25 (2002).

[2] D.J. Hartley et al., Bull. Am. Phys. Soc. **54**, no. 10 (2009).

SNO+ A MULTI-PURPOSE NEUTRINO DETECTOR

C. Kraus

Laurentian University, Sudbury, ON P3E 2C6, Canada

SNO+ proposes to fill the existing SNO detector with liquid scintillator. The unique location in SNOLAB, currently the world's deepest international underground facility, will enable a variety of physics measurements from further studies of solar neutrinos (pep and CNO), to geo- and reactor neutrinos, to supernova neutrinos to the possibility of studying neutrinoless double beta decay. With the addition of ^{150}Nd to the liquid scintillator SNO+ is capable of a competitive next-generation search for this rare process. The physics potential and experimental sensitivities will be discussed. The detector is currently undergoing the necessary changes, an overview will be provided.

BACKGROUND REDUCTION IN THE PICASSO EXPERIMENT

A. Kamaha, A. Noble

Department of Physics, Queen's University Kingston, Ontario K7L 3N6 Canada

The PICASSO experiment is located at the SNOLAB underground facility in the Creighton mine near Sudbury. Its aim is the direct detection of Dark Matter using bubble detector technology. The recoiling nuclei produced in WIMP nucleon interactions (^{19}F in the case of PICASSO) have sufficient energy to induce phase transitions in superheated droplet detectors. These transitions are subsequently recorded using sensitive piezo-electric transducers. For reasonable estimates of Dark Matter density, the interaction rates will be extremely low and understanding the background of events arising from other radiation (n, gamma, alpha) is fundamentally important. Techniques developed to determine the background contributions from the two main backgrounds (radon and fast neutrons) will be discussed as well as ways to mitigate against them.

DETERMINATION OF NON-UNIVERSAL SUPERGRAVITY MODELS AT THE LARGE HADRON COLLIDER

N. Kolev
Department of Physics, University of Regina, Regina, SK S4S 0A2 Canada

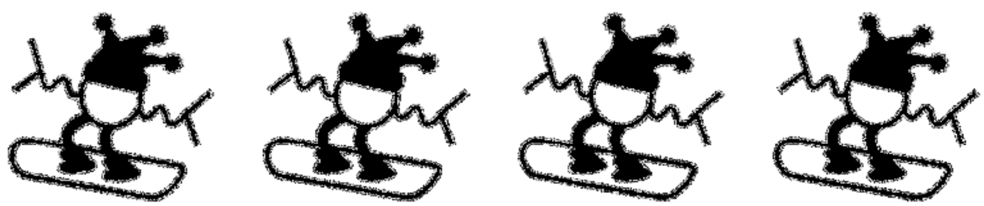
B. Dutta, T. Kamon, A. Krislock
Texas A&M University

Y. Oh
Kyungpook National University

SUSY models are found to be very successful as cosmological connection to particle physics using the precise measurement of the dark matter content of the universe. Data from the upcoming Large Hadron Collider (LHC) make it possible to test models.

We examine a well motivated non-universal supergravity model where the Higgs boson masses are not unified with the other scalars at the grand unified scale at the LHC. The dark matter content can easily be satisfied in this model by having a larger Higgsino component in the lightest neutralino. Typical final states in such a scenario at the LHC involve W bosons. We develop a bi-event subtraction technique to remove a huge combinatorial background to identify W to jet -jet decays. This is also a key technique to reconstruct supersymmetric particle masses in order to determine the model parameters. With the model parameters, we find that the dark matter content of the universe can be determined in agreement with existing experimental results.

Session : Sunday Morning



THE GLUEX BARREL ELECTROMAGNETIC CALORIMETER

Z. Papandreou

Department of Physics, University of Regina, Regina, SK S4S 0A2

The goal of the GlueX experiment at Jefferson Lab is to search for exotic hybrid mesons as evidence of gluonic excitations, in an effort to understand confinement in QCD. A key subsystem of the GlueX detector is the electromagnetic barrel calorimeter (BCAL) located inside a 2-Tesla superconducting solenoid. The BCAL is a "spaghetti calorimeter", consisting of layers of corrugated lead sheets, interleaved with planes of 1-mm-diameter, double-clad, Kuraray SCSF-78MJ scintillating fibres, bonded in the lead grooves using optical epoxy. The detector will consist of 48 modules and will be readout using nearly 4,000 large-area (1.26~cm^2 each) silicon photomultiplier arrays. Construction of the BCAL is well under way at the University of Regina and test results will be shown.

LARGE AREA MULTI-PIXEL PHOTON DETECTORS FOR THE GLUEX BARREL CALORIMETER

M. Tahani

Department of Physics, University of Regina, Regina, SK S4S 0A2

The new experimental hall in Jefferson Lab, Hall D, will house the GlueX experiment whose main physics objective is the observation and mapping of gluonic excitations that plays an important role in our understanding of quark confinement. A critical component of GlueX is the electromagnetic barrel calorimeter that will detect photons and charged particles utilizing a sampling calorimeter of a matrix of lead and scintillating fibres. The high magnetic field surrounding the calorimeter makes conventional photomultiplier tubes unsuitable, and thus provided the impetus to develop a new photo-sensor of large active area and immune to magnetic fields. The new technology is based on the limited Geiger avalanche silicon diode, commonly referred to as Silicon Photo-Multiplier (SiPM). This talk will describe the latest developments and the procedures in detector characterization.

$^{30}P(p,\gamma)^{31}S$ REACTION RATE VIA $^{32}S(d,t)^{31}S$ AND ITS ASTROPHYSICAL RELEVANCE

D. Irvine

Department of Physics & Astronomy, McMaster University, Hamilton, ON L8S 4M1, Canada

Isotopic abundance ratios of $^{30}Si/^{28}Si$ found in presolar SiC grains of suspected nova origin agree qualitatively with proposed oxygen-neon (ONe) nova composition but fail to agree quantitatively with ejecta predictions made by hydrodynamic ONe nova models. The Astrophysical $^{30}P(p,\gamma)^{31}S$ reaction rate is a key quantity used in predicting the amount of ejected ^{30}Si. Currently, there is a large uncertainty in the rate at nova temperatures ($0.10 < T < 0.4$ Gk) causing the predicted ^{30}Si abundance ratio to vary by as much as two orders of magnitude. The $^{30}P(p,\gamma)^{31}S$ reaction rate can be determined indirectly by measuring triton momenta from $^{32}S(d,t)^{31}S$ reactions. ^{31}S Resonant states measured above the proton threshold of 6133 keV and within the Gamow window which contribute most significantly to the rate can then be used to re-evaluate the rate and reduce the uncertainty.

THE STRUCTURE OF ^{30}S AND ITS ASTROPHYSICAL INFLUENCE

K. Setoodehnia

Department of Physics & Astronomy, McMaster University, Hamilton, ON L8S 4M1, Canada

The structure of proton-unbound ^{30}S states strongly determines the thermonuclear ^{29}P(p,γ)^{30}S reaction rate at temperatures characteristic of explosive hydrogen burning in classical novae and type I X-ray bursts. Specifically, the rate had been previously predicted to be dominated by two low-lying, unobserved, levels in the E_x = 4.7 – 4.8 MeV region, with spin and parity assignments of 3^+ and 2^+. In recent experimental work, two candidate levels were observed with energies of 4.699 MeV and 4.814 MeV, but no experimental information on their spins and parities was obtained. We have performed an in-beam γ-ray spectroscopy study of ^{30}S with the ^{28}Si(^{3}He, nγ)^{30}S reaction. This contribution will discuss the experimental setup and the results.

A QUARK STAR ACCRETING FROM A DEGENERATE DEBRIS RING AS A MODEL FOR LOW MAGNETIC FIELD SOFT GAMMA-RAY REPEATERS

D. Leahy

Department of Physics and Astronomy, University of Calgary, Calgary, AB, Canada

Soft gamma repeaters (SGRs) and anomalous X-ray pulsars (AXPs) are generally thought to be neutron stars powered by extreme magnetic fields (i.e. magnetars, with $B>B_Q=4.4 \times 10^{13}$ Gauss). The recent discovery of a soft gamma repeater with a low inferred magnetic field ($< 7.5 \times 10^{12}$ Gauss), SGR0418+5729, implies that a strong dipolar magnetic field might not be necessary for magnetar-like activity. Here, the quiescent and bursting properties of SGR0418+5729 are shown to be explained in the context of low-magnetic field Quark-Nova (QN) remnants, i.e. an old quark star surrounded by degenerate Keplerian debris ring, which was ejected during the QN explosion. A 16 Myr old quark star surrounded by a $10^{-10}\ M_{\odot}$ ring, with inner and outer radii of 30 km and 60 km, reproduces many observed properties of SGR0418+5729. SGR-like bursts are caused by magnetic penetration of the inner part of the ring and its subsequent accretion. Radiative feedback results in months-long accretion from the ring's non-degenerate atmosphere which matches well the observed decay phase.

TRENDS IN NICKEL AND TITANIUM IN DUAL-SHOCK QUARK-NOVAE (DS-QNE)

R. Ouyed

Department of Physics and Astronomy, University of Calgary, Calgary AB, Canada

In this talk I will describe spallation in dual-shock quark-novae and the implications for:

(i) Nickel and Titanium abundances in Massive stars regions;

(ii) abundances in Extremely Metal-Poor Stars.

PHOTOMETRIC AND SPECTROSCOPIC EVIDENCE OF QUARK NOVAE FOUND IN OBSERVATIONS OF SUPER-LUMINOUS SUPERNOVAE

M. Kostka, R. Ouyed, N. Koning, D. Leahy

Department of Physics and Astronomy, University of Calgary, Calgary AB, Canada

W. Steffen

Insituto de Astronomia, UNAM, Mexico

A dual shock quark nova describes the scenario in which a supernova explosion is followed on the order of days by the quark nova detonation of a neutron star. We have found that singular features found in both photometric and spectroscopic observations of super-luminous supernovae are properties inherent to the dual shock quark nova. In order to do this we first built a time-evolving geometric model of a dual shock quark nova and then ran radiative transfer code to simultaneously create a light curve and Hα spectrum for our quark nova model. We then fit our model light curve and spectra to observations of super-luminous supernovae. We found that the observed broad peak and late stage plateau in super-luminous supernova light curves are well described by continuum emission from two distinct components of the dual shock quark nova. As well the enigmatic broad Hα line characteristic of super-luminous supernovae is naturally described by emission from an inner region of mixed quark nova and supernova ejecta.

r-JAVA: A NEW CODE FOR SIMULATING R-PROCESS NUCLEOSYNTHESIS IN EJECTED NEUTRON STAR CRUSTS

N. Koning, M. Kostka, R. Ouyed

Department of Physics and Astronomy, University of Calgary, Calgary AB, Canada

C. Charignon

Department de Physique, Ecole Normale Superieure de Cachan, Cachan, France

P. Jaikumar

Department of Physics & Astronomy, California State University Long Beam, Long Beach, CA, USA

We have developed an r-process code for simulating r-process nucleosynthesis of heavy elements in ejected neutron star matter. The code can be applied to both the static and dynamic case. The static simulation can be run for a desired range of neutron irradiation with variable density and temperature. The dynamical simulations are designed such that anyone can use it once the neutron star mass, radius and total ejected mass are specified. Our code uses a general entropy expression that can be applied to degenerate as well as non-degenerate matter, allowing us to track the rapid density and temperature evolution of the ejecta during the initial stages of relativistic expansion. At present, our calculations are done in the waiting-point approximation, so we follow the simulations only as long as the temperature and neutron density are high enough.

In order to make this code more accessible to the astronomical community, we have written the code entirely in java. This talk will focus on and demonstrate how to use the graphical user interface to “r-Java” and show several resulting simulations.

THE QWEAK EXPERIMENT: A SEARCH FOR PHYSICS BEYOND THE STANDARD MODEL VIA A PRECISION MEASUREMENT OF THE WEAK CHARGE OF THE PROTON

M. Gericke

Department of Physics, University of Manitoba, Winnipeg, MB R3T 2N2, Canada

Qweak aims to make a precision measurement of the parity violating asymmetry in elastic electron-proton scattering, using longitudinally polarized electrons. At low momentum transfer, the measured asymmetry is directly related to the weak charge of the proton and the Standard Model makes a firm prediction for the size of the weak charge, based on the "running" of the weak mixing angle. Qweak constitutes the first attempt at a precision measurement of this quantity and, at the proposed precision, would be a test for physics beyond the Standard Model, at the several TeV mass scale. The planned 2400 hour measurement of the asymmetry would determine the weak charge of the proton with a 4% combined statistical and systematic error. In the absence of new physics, the experiment will provide a 0.3% determination of the weak mixing angle. Qweak was installed and commissioned during the summer and Fall of 2010 in Hall C, at Jefferson Laboratory and is currently taking data. I would like to provide a basic overview of the physics that is being addressed and present a description of the experiment, along with a first look at some recent diagnostic and production data.

MOMENTUM TRANSFER DETERMINATION AND EXTRAPOLATION IN THE QWEAK EXPERIMENT∗

J. Pan

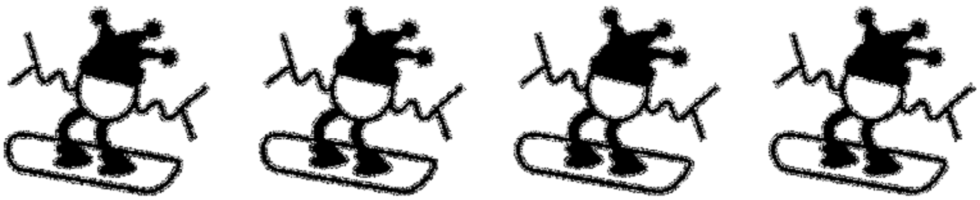
(for the Qweak Collaboration)

University of Manitoba, University of Winnipeg, Winnipeg, MB R3T 2N2

The Qweak experiment at Jefferson Laboratory is designed to precisely determine the proton's weak charge (Q_W^P) and thus the weak mixing angle ($\sin^2 \theta_W$) by measuring the parity violating asymmetry in elastic electron-proton scattering at low momentum transfer $Q^2 = 0.03$ (GeV/c)^2. The Qweak experimental result will enable a precise test of the Standard Model prediction for the running of Q_W^P with energy, and hence will probe new physics. The experiment will be operated in a high-current (integration) mode for the parity measurement and in a low-current (counting) mode for Q^2 determination. To reach the proposed experimental precision, the Q^2 needs to be measured to 0.5% with a set of high resolution tracking chambers and then be reconstructed with dedicated software. The tracking chambers however, are only operable in low-current mode. We therefore designed and built a scanning Čerenkov detector, the "focal-plane scanner", to extrapolate tracking measurements from low current to high current. In this talk, the Q^2 determination scheme and extrapolation method will be presented. Data acquired by the scanner detector during recent Qweak commissioning runs will also be reported.

∗Work supported by NSERC

Participants



Andreoiu Corina	Department of Chemistry Simon Fraser University 8888 University Drive Burnaby, BC V1A 1S6 Canada caa12@sfu.ca
Austin Roby	Department of Physics and Astronomy Saint Mary's University Halifax NS B3H 3C3 Canada austin@ap.smu.ca
Ball Gordon	TRIUMF 4004 Wesbrook Mall Vancouver, BC ball@triumf.ca
Chagnon-Lessard Sophie	Department of Physics University of Guelph Guelph, ON, Canada N1G 2W1 schagnon@uoguelph.ca
Chester Aaron	Simon Fraser University 8888 University Drive Burnaby, BC V1A 1S6 aaron.s.chester@gmail.com

Dehghani Ashkezari Mohammad	Simon Fraser University 8888 University Drive Burnaby, BC V1A 1S6 mda38@sfu.ca
deNiverville Patrick	Department of Physics and Astronomy University of Victoria Victoria, BC, V8P 5C2, Canada pgdeniv@uvic.ca
Diaz Varela Alejandra	Department of Physics University of Guelph Guelph, ON, Canada N1G 2W1 adiazvar@uoguelph.ca
Dilling Jens	TRIUMF 4004 Wesbrook Mall Vancouver, BC dilling@triumf.ca
Dunlop Ryan	Department of Physics University of Guelph Guelph, ON, Canada N1G 2W1 rdunlop@uoguelph.ca
Emadi Maysam	Simon Fraser University 8888 University Drive Burnaby, BC V1A 1S6 mea13@sfu.ca

Frekers Dieter	University of Muenster Institute. For Nuclear Physics D 48149 MUENSTER, Germany Frekers@triumf.ca
Friesen Timothy	Department of Physics and Astronomy University of Calgary Calgary, AB, Canada T2N 1N4 timfriesen@gmail.com
Garnsworthy Adam	TRIUMF 4004 Wesbrook Mall Vancouver, BC garns@triumf.ca
Gericke Michael	University of Manitoba Department of Physics Winnipeg, MB R3T 2N2, Canada mgericke@physics.umanitoba.ca
Hadinia Baharak	Department of Physics University of Guelph Guelph, ON, Canada N1G 2W1 bhadinia@uoguelph.ca

Irvine Dan	Department of Physics & Astronomy McMaster University Hamilton, ON L8S 4M1 Canada irvinedt@mcmaster.ca
Kamaha Alvine	Department of Physics Queen's University Kingston, Ontario K7L 3N6 Canada akamaha@owl.phy.queens.ca
Kolev Nikolay	Department of Physics University of Regina Regina, SK S4S 0A2 Canada kolev20n@uregina.ca
Koning Nico	Department of Physics and Astronomy University of Calgary Calgary, AB, Canada T2N 1N4 nkoning@iras.ucalgary.ca
Kostka Mathew	Department of Physics and Astronomy University of Calgary Calgary, AB, Canada T2N 1N4 mkostka@iras.ucalgary.ca
Kraus Christine	Department of Physics Laurentian University Sudbury, Ontario, Canada, P3E 2C6 tine@snolab.ca
Leahy Denis	Department of Physics and Astronomy University of Calgary Calgary, AB, Canada T2N 1N4 leahy@ucalgary.ca

Lennarz
Annika

University of Muenster
Institute. For Nuclear Physics
D 48149 MUENSTER, Germany

annika.lennarz@uni-muenster.de

Lolos
George

Department of Physics
University of Regina
Regina, SK S4S 0A2 Canada

george.lolos@uregina.ca

Longuevergne
David

TRIUMF
4004 Wesbrook Mall
Vancouver, BC

longueve@triumf.ca

Marshall
Glen

TRIUMF
4004 Wesbrook Mall
Vancouver, BC

glen.marshall@triumf.ca

Navrátil
Petr

TRIUMF
4004 Wesbrook Mall
Vancouver, BC

navratil@triumf.ca

Ouimet
Pierre-Philippe

Department of Physics
University of Regina
Regina, SK S4S 0A2 Canada

ouimet1p@uregina.ca

Ouyed
Rachid

Department of Physics and Astronomy
University of Calgary
Calgary, AB, Canada T2N 1N4

rouyed@ucalgary.ca

Pan Jie	University of Manitoba Department of Physics Winnipeg, MB R3T 2N2, Canada umpan3@cc.umanitoba.ca
Papandreou Zisis	Department of Physics University of Regina Regina, SK S4S 0A2 Canada zisis@uregina.ca
Ritz Adam	Department of Physics and Astronomy University of Victoria Victoria, BC, V8P 5C2, Canada aritz@uvic.ca
Setoodehnia Kiana	Department of Physics & Astronomy McMaster University Hamilton, ON L8S 4M1 Canada setoodk@mcmaster.ca
Simon Vanessa Véronique	TRIUMF 4004 Wesbrook Mall Vancouver, BC vsimon@triumf.ca
Starosta Krzysztof	Simon Fraser University 8888 University Drive Burnaby, BC V1A 1S6 starosta@sfu.ca

Swersky
Darren

Department of Physics
McGill University
Montréal, QC
Canada H3A 2T8

darren.swersky@mail.mcgill.ca

Tahani
Mehrnoosh

Department of Physics
University of Regina
Regina, SK S4S 0A2 Canada

tahani2m@uregina.ca

Thompson
Robert

Department of Physics and Astronomy
University of Calgary
Calgary, AB, Canada T2N 1N4

rthompso@ucalgary.ca

Trottier
Howard

Simon Fraser University
8888 University Drive
Burnaby, BC V1A 1S6

trottier@sfu.ca

Wang
Zhimin

Simon Fraser University
8888 University Drive
Burnaby, BC V1A 1S6

zhimin.wang@uws.ac.uk