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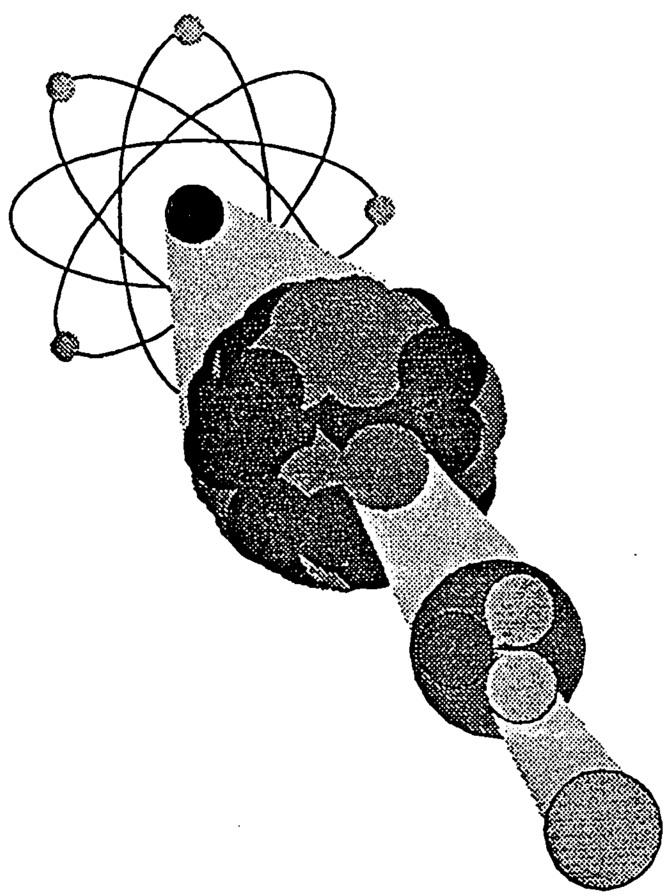
Nuclear and Particle Physics

The 15th AINSE Nuclear and Particle Physics Conference

July 1994



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Nuclear and Particle Physics

The 15th AINSE Nuclear and Particle Physics Conference

at the 6th APPC and 11th AIP Congress

Griffith University, Brisbane

4 to 8 July 1994

Committee

Professor GD Dracoulis	*ANU*	joint
Associate Professor LS Peak	*Univ. of Sydney*	Chairmen
Dr JW Boldeman	*ANSTO*	
Dr IJ Donnelly	*ANSTO*	
Dr RB Gammon	*AINSE*	
Dr BA Robson	*ANU*	
Dr MM Winn	*Univ. of Sydney*	

PROGRAMME

MONDAY 4TH JULY 1994

TIME	PAPER NO.	
SESSION 1		CHAIR: Prof G Dracoulis (Australian National University)
2.00 - 2.45	1 (Invited)	POSITRON PRODUCTION IN HEAVY ION COLLISIONS - CURRENT STATUS OF THE PROBLEM. R R Betts (Argonne National Lab), for the APEX Collaboration.
2.45 - 3.15	2 (Invited)	BARRIERS IN FUSION - FINGERPRINTS OF NUCLEAR STRUCTURE IN NEAR-BARRIER REACTIONS. M Dasgupta *et al* (Australian National University).
3.15 - 3.30	3	SPATIAL PARITY AND TIME REVERSAL INVARIANCE VIOLATIONS AND QUANTUM CHAOS MANIFESTATIONS IN ATOMIC NUCLEI. O K Vorov (University of NSW).
3.30 - 4.00		AFTERNOON TEA
SESSION 2		CHAIR: Dr J Boldeman (ANSTO)
4.00 - 4.45	4 (Invited)	KEK RESEARCH FACILITIES AND THEIR ROLE IN THE ASIA-PACIFIC REGION. K Nakai (National Laboratory for High Energy Physics, Japan).
4.45 - 5.00	5	STUDIES ON THE ELECTRIC FIELD DISTRIBUTION IN SEMI-INSULATING GaAs AND ITS EFFECT ON DETECTOR PERFORMANCE. M L Williams (ANSTO and University of Sydney) and I J Donnelly (ANSTO).
5.00 - 5.30	6 (Invited)	SUPERCONDUCTING LINAC BOOSTER AT THE ANU - PROGRESS REPORT. D C Weisser (Australian National University).

TUESDAY 5TH JULY 1994

TIME	PAPER NO.	
SESSION 3		CHAIR: **Dr L Tassie** (Australian National University)
8.30 - 9.00	7 (Invited)	THE CREATION OF THE LIGHT ELEMENTS: COSMOLOGY AND COSMIC-RAYS. **T Kajino** (National Astronomical Observatory, Tokyo, Japan).
9.00 - 9.15	8	MASS NUMBER DEPENDENCES AND SEMI-CLASSICAL DESCRIPTIONS OF THE NUCLEAR PAIRING GAP. P Schuck (INS, Grenoble) and **K Taruishi** (Numazu College of Technology, Japan)
9.15 - 9.30	9	LOW ENERGY STRIPPING REACTIONS ON LIGHT NUCLEI. **M H Hadizadeh**, H Miri (Ferdowsi University of Mashhad, Iran), and H Afarideh (Atomic Energy Organisation of Iran).
9.30 - 9.45	10	POSITIVE PHOTOPION PRODUCTION FROM $^{12,13}C$ USING TAGGED PHOTONS. **J C Kim** *et al* (Seoul National University, Korea).
9.45 - 10.00	11	THE ENTROPY IN ULTRA-RELATIVISTIC HEAVY ION COLLISIONS. **Li Panlin** (Institute of Nuclear Research, Shanghai, China), Li Zhiliang (Shanghai University of Science and Technology, China) and Shi Xinhui (Qing Tao University, China).
10.00 - 10.30		MORNING TEA
SESSION 4		CHAIR: **Dr L W Mitchell** (Flinders University)
2.00 - 2.45	12 (Invited)	RADIOACTIVE NUCLEAR BEAMS. **W Gelletly** (University of Surrey, UK).
2.45 - 3.00	13	RESOLUTION OF ANOMALOUS FISSION ANISOTROPIES FOR THE REACTION OF $^{16}O + ^{208}Pb$. **D J Hinde** *et al* (Australian National University).
3.00 - 3.15	14	DETERMINATION OF THE QUADRUPOLE MOMENT OF THE PROTON $i_{13/2}$ ORBITAL. **S Bayer**, A P Byrne and G D Dracoulis (Australian National University).
3.15 - 3.30	15	SENSITIVITY OF QUASI-ELASTIC EXCITATION FUNCTIONS TO BARRIER DISTRIBUTIONS. **H Timmers** *et al* (Australian National University).
3.30 - 4.00		AFTERNOON TEA

TUESDAY 5TH JULY 1994

TIME	PAPER NO.	
SESSION 5		CHAIR: **Prof A W Thomas** (University of Adelaide)
4.00 - 4.45	16 (Invited)	PROPOSED EUROPEAN HIGH ENERGY ELECTRON LABORATORY **Pierre Guichon** (Saclay, France)
4.45 - 5.00	17	K^+ - NUCLEUS INTERACTIONS AT LOW MOMENTUM. **K.Yamauchi, K Tamura and Y Sakamoto** (Kyoto Sangyo University, Japan).
5.00 - 5.15	18	A SEARCH FOR SIGNATURES OF SCALAR TOP QUARK AT *ep* COLLIDER HERA - A CASE OF R-PARITY BREAKING COUPLING. **Tadashi Kon** (Seiki University, Japan), **Tetsuro Kobayashi** (Fukui Institute of Technology, Japan) and **Shoichi Kitamura** (Tokyo)
5.15 - 5.30	19	MEASUREMENT OF BACKGROUND NEUTRON FLUX AT A DEPTH OF 1230 m BELOW GROUND. **S R Hashemi-Nezhad and L S Peak** (University of Sydney).

WEDNESDAY 6TH JULY 1994

TIME	PAPER NO.	
SESSION 6		CHAIR: **Dr B A Robson** (Australian National University)
8.30 - 9.00	20 (Invited)	ASPECTS OF NUCLEAR FISSION. **J P Lestone** (Australian National University).
9.00 - 9.15	21	INELASTIC AND TRANSFER CHANNELS IN HEAVY-ION FUSION FOR ^{144}Sm + ^{16,17}O. **C R Morton** *et al* (Australian National University).
9.15 - 9.30	22	BARRIER DISTRIBUTION FOR THE FUSION OF ^{16}O AND ^{92}Zr. **J C Mein** *et al* (Australian National University).
9.30 - 9.45	23	A STUDY OF ULTRA-RELATIVISTIC HEAVY ION COLLISIONS USING AN AUTOMATED VIDEO SCANNER SYSTEM. **R Amirikas** (University of Sydney) and EMU01 Collaboration.
9.45 - 10.00	24	SHAPE COEXISTENCE IN ^{185}Tl AND ^{187}Tl - INVESTIGATION OF THE DEFORMED MINIMA. G J Lane *et al* presented by **A M Baxter** (Australian National University).

WEDNESDAY 6TH JULY 1994

TIME	PAPER NO.	
SESSION 7		CHAIR: **Dr J R Leigh (Australian National University)**
2.00 - 2.45	25 (Invited)	NUCLEAR CLUSTERS **B R Fulton** (University of Birmingham, UK).
2.45 - 3.00	26	RESONANT STRUCTURES IN THE ^{16}O + ^{20}Ne SYSTEM. S C Li and **B A Robson** (Australian National University).
3.00 - 3.15	27	CHANNEL SELECTION IN HEAVY-ION REACTIONS BY CHARGED PARTICLE DETECTION. **A P Byrne**, G D Dracoulis and G J Lane (Australian National University).
3.15 - 3.30	28	FIRST OBSERVATION OF A $K^{\pi} = 8^{-}$ BAND FOR N = 74. **P H Regan** *et al* (Australian National University), A M Bruce (University of Brighton, UK) and P M Walker (University of Surrey, UK).
3.30 - 4.00		AFTERNOON TEA
SESSION 8		CHAIR: **Dr L K Fifield (Australian National University)**
4.00 - 4.30	29 (Invited)	CONFRONTING NUCLEAR STRUCTURE AND MAGNETIC MOMENTS. **A E Stuchbery** (Australian National University).
4.30 - 4.45	30	EVIDENCE FOR PRE-EQUILIBRIUM EFFECTS FOLLOWING IMPLANTATION OF Pt INTO Fe. **S S Anderssen** and A E Stuchbery (Australian National University).
4.45 - 5.00	31	EXAMINING SHAPE COEXISTENCE WITH A SIMPLE COLLECTIVE POTENTIAL. **P M Davidson** and G D Dracoulis (Australian National University).
5.00 - 5.15	32	HIGH SPIN STATES AND INTRINSIC STRUCTURE IN ^{175}Ta AND ^{176}Ta. **F G Kondev** *et al* (Australian National University).
5.15 - 5.30	33	MULTIPLETS AND COLLECTIVE STRUCTURES IN ^{202}Po. **T Kibédi** *et al* (Australian National University) and P M Walker (University of Surrey, UK).

THURSDAY 7TH JULY 1994

TIME	PAPER NO.	
SESSION 9		CHAIR: Dr W Woolcock (Australian National University)
8.30 - 9.00	34 (Invited)	KAON-NUCLEON SCATTERING AND KAON CONDENSATION. Chang-Hwan Lee and Dong-Pil Min (Seoul National University, Korea).
9.00 - 9.15	35	DYNAMICAL GENERATION OF THE SIGMA MODEL. R Delbourgo (University of Tasmania).
9.15 - 9.30	36	CHARGE SYMMETRY BREAKING IN THE NN INTERACTION FROM A QUARK-PION COUPLING MODEL. P E Schulz, G Q Liu and A W Thomas (University of Adelaide).
9.30 - 9.45	37	RHO-OMEGA MIXING. H B O'Connell, B C Pearce, A W Thomas and A G Williams (University of Adelaide).
9.45 - 10.00	38	TREATMENT OF MESON-NUCLEUS ELASTIC SCATTERING USING THE KDP FORMALISM B C Clark *et al* (Ohio State University)
10.00 - 10.30		MORNING TEA
SESSION 10		CHAIR: Dr I J Donnelly (ANSTO)
2.00 - 2.45	39 (Invited)	THE SUDBURY NEUTRINO OBSERVATORY. E B Norman (Lawrence Berkeley Laboratory, USA) for the SNO Collaboration.
2.45 - 3.15	40 (Invited)	SEARCH FOR NEUTRINO OSCILLATIONS. K E Varvell (ANSTO and University of Sydney).
3.15 - 3.30	41	INVISIBLE SUPERNOVA DIRECTION ESTIMATION. M Omori (University of Sydney).
3.30 - 4.00		AFTERNOON TEA

THURSDAY 7TH JULY 1994

TIME	PAPER NO.	
SESSION 11		CHAIR: **Prof R Delbourgo** (University of Tasmania)
4.00 - 4.30	42 (Invited)	QUARK-MESON COUPLING MODEL AND CHARGE SYMMETRY BREAKING IN NUCLEAR MATTER. **K Saito** (Tohoku College, Sendai, Japan and University of Adelaide).
4.30 - 4.45	43	PION EXCHANGE FORCE AND MESON VS QUARK DYNAMICS IN THE NUCLEON-NUCLEON INTERACTION. **G Q Liu** and A W Thomas (University of Adelaide).
4.45 - 5.00	44	WEAK DECAYS OF CHARMED AND BOTTOMED HADRONS AND HEAVY QUARK SYMMETRIES. **Dongsheng Liu** (University of Tasmania).
5.00 - 5.15	45	MODELLING DEUTERON PHOTODISINTEGRATION UP TO 200 MeV AND TESTING NUCLEON-NUCLEON POTENTIALS. **W S Woolcock** (Australian National University).
5.15 - 5.30	46	PION-NUCLEON SCATTERING REQUIRES A SOFT πNN FORM FACTOR. **B C Pearce** (University of Adelaide).

FRIDAY 8TH JULY 1994

TIME	PAPER NO.	
SESSION 12		CHAIR: **Prof L S Peak** (University of Sydney)
8.30 - 9.15	47 (Invited)	NEUTRINOS AND DARK MATTER FROM NUCLEAR SPECTROSCOPY. **H. Ejiri** (RCNP, Osaka, Japan).
9.15 - 9.30	48	ION TRANSPORT IN XENON GAS: APPLICATIONS TO DOUBLE BETA DECAY. **T M Maddern** and L W Mitchell (Flinders University).
9.30 - 9.45	49	ION TRANSPORT ACROSS A GAS-LIQUID INTERFACE IN XENON. **L W Mitchell** (Flinders University), M Miyajima and S Sasaki (KEK, Japan).
9.45 - 10.00	50	ON SPONTANEOUS BARYOGENESIS. S A Abel (Rutherford Appleton Laboratory, UK), W N Cottingham (Bristol, UK) and **I B Whittingham** (James Cook University).

Positron production in heavy ion collisions - current status of the problem

R. R. Betts

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For the APEX Collaboration

Argonne, Florida State, Michigan State, Princeton, Queen's, Rochester, Yale, Washington

Abstract

Extremely strong electromagnetic fields are produced in close collisions of high-Z atoms at energies close to the Coulomb barrier. This situation has been predicted to give rise to qualitatively new phenomena associated with the over-critical binding of the inner electron orbits, such as the so-called spontaneous emission of positrons. Experiments motivated by these ideas, carried out over the past decade, have produced some remarkable and unusual results which would seem to signal the appearance of some, certainly interesting and possibly fundamental, new physics. Briefly, sharp peaks are observed in the energy spectra of positrons produced in these collisions and, more remarkably, in the sum-energy spectra of coincident electrons and positrons. This result has been taken to suggest the existence of some hitherto unexpected neutral state which decays into a positron-electron pair. The current status of this field will be reviewed and, in particular, the design, construction and operation of a second-generation experiment at Argonne — the ATLAS Positron EXperiment (APEX) will be discussed, together with some of the first results from this new experiment.

Invited paper presented at the 6th APPC/11th AIP Congress,
4-8 July 1994, Brisbane Australia.

Barriers encountered in fusion - fingerprints of nuclear structure effects in near-barrier reactions

M. Dasgupta

Department of Nuclear Physics, Research School of Physical Sciences and Engineering, The Australian National University, Canberra ACT 0200, Australia

Quantal tunneling of the wavefunction of a particle into classically forbidden regions, is an important process in microscopic physics. The presence of coupling of the relative motion of the particle to other internal degrees of freedom during the tunneling process strongly influences the probability of barrier penetration. Since the process of fusion of heavy nuclei close to the classical barrier is dominated by quantum effects, it is highly sensitive to these coupling effects. Heavy-ion fusion reactions can thus be utilized to obtain an understanding of such coupling effects. Furthermore, one can vary the coupling strengths by using different isotopes, an option perhaps unique to nuclear physics.

As a result of the couplings the classical one-dimensional barrier, between two interacting nuclei, is replaced by a distribution of barriers [1]. It has been shown that the latter can be extracted from accurately measured fusion excitation function [2]. High precision (~1% uncertainty) fusion excitation function measurements have recently been done in this laboratory for a variety of systems [3-5]. The target-projectile combination were chosen such that the fusion is expected to be dominated by the couplings to a small number of channels, with the hope that it would be simple to interpret the resulting barrier distributions. These experiments have revealed in a direct way how the structure of the target and projectile influence the fusion process through coupling effects.

[1] C.H. Dasso *et al.*, Nucl. Phys. **A405** , 381 (1982) ; Nucl. Phys. **A407** , 221 (1983).
[2] N. Rowley *et al.*, Phys. Lett.B **254**, 25 (1991).
[3] J.X. Wei *et al.*, Phys. Rev. Lett. **67**, 3368 (1991).
[4] R.C. Lemmon *et al.*, Phys. Lett.B **316**, 32 (1993).
[5] J.R. Leigh *et al.*, Proc. Int. Workshop on Heavy Ion Reactions with Neutron Rich Beams, RIKEN, World Scientific Press (1993).

Spatial parity and time reversal invariance violations and quantum chaos manifestations in atomic nuclei

O. K. Vorov

School of Physics, University of New South Wales, Sydney 2052, NSW Australia

(April 29, 1994)

Abstract

The spatial parity (P) and time reversal (T) invariance are the fundamental symmetries of Nature, being conserved in most processes in nuclear physics. The weak interaction causes effects of P- and P,T - violations which are subject of extensive experimental and theoretical studyings. The reasons of enhancement of these effects in heavy nuclei are analysed here, especially, in the context of the phenomena observed in slow neutron scattering. These reasons are divided onto two types: a) enhancement due to interplay between the residual strong internucleon interaction and the weak forces, which causes renormalization of symmetry violating forces and b) statistical enhancement arising as a result of complex nature of nuclear compound states at energies close to neutron separation threshold. In fact, the latter effect is a manifestation of general property of enhancement of small perturbations typical for the "chaotic" quantum states. New methods to treat these effects are presented, the obtained numerical results are in good agreement with experimental data. In particular, the effects caused by the π- and ρ-meson exchange interactions are considered, method of calculation of averaged matrix elements between thermalized states with account for exact symmetries (particle number, angular momentum etc).

AU9514699

KEK Research Facilities and their Role in the Asia-Pacific Region

K. Nakai

National Laboratory for High Energy Physics
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Japan

A brief review of present research facilities and future plans at KEK will be presented, including the 12-GeV proton synchrotron(KEK-PS) and the electron-positron collider (TRISTAN). Recently, an asymmetric electron-positron collider(KEK B-factory) has been approved to replace the TRISTAN project within 5 years. For a future high-energy physics project an extensive effort has been carried on at KEK for the development of the electron- positron linear collider(JLC). KEK wishes to carry all these activities under international cooperation, especially among the Asia-Pacific countries, and to develop a user's association in this region of the Pacific rim, so as to build up the third scientific community.

AU9514700

Studies on the Electric Field Distribution in Semi-Insulating GaAs and its Effect on Detector Performance

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The usefulness of GaAs as a detector material for minimum ionizing particles (MIPS) has been the subject of much investigation in recent years. It is thought that it will be particularly suited for use as detectors in the inner region of the Large Hadron Collider (LHC) to be built at CERN, primarily due to it having greater radiation resistance than Si. The luminosities in this region are expected to be around $10^{34}cm^{-2}s^{-1}$.

The research carried out to date has focused on semi-insulating (SI) GaAs which has the advantage that large area wafers of the necessary thickness are readily available. Its SI nature arises from a balance between the concentrations of deep donors (EL2, a native defect), shallow acceptors (usually carbon) and shallow donors, thus giving rise to material which has hitherto been assumed to be at, or very near, full depletion for minimal reverse bias. The charge collection efficiency of detectors made from this material would therefore be expected to be 100%. However, recent studies show that this is not the case, and this is thought to be due to variations in the electric field across the detector [1]. Spatial variations in the electric field affect charge transport in the detector, thus affecting its charge collection efficiency. Trapping of charge due to impurities in the material will also have an effect.

Based on the recent theory of McGregor *et al* [2], a computer code is being developed and used to determine the electric field shape and its dependence on donor levels. Initial results will be reported.

The response of SI GaAs from a number of different suppliers to ionizing particles is being investigated using the charge transient technique (TCT). The shape and amplitude of the current pulses, along with charge collection efficiency measurements and spectroscopy measurements to determine the nature and concentration of the impurities present, will provide information about the electric field across the detector, and from this insight into charge collection processes can be gained. Results from initial experiments will be presented.

[1] Beaumont, S.P *et al*, NIM, A326(1993) : 313-318

[2] Mcgregor, D.S *et al*, NIM, A322(1992) : 487-492

Superconducting Linac Booster at the ANU Progress Report

David C Weisser

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Abstract:

A superconducting linear accelerator is being installed in the Nuclear Physics Department in the ANU as an energy booster to the existing 14 UD tandem accelerator. This accelerator has been obtained from the Daresbury Laboratory in the UK in exchange for guaranteed access to ANU facilities for UK physicists. Installation started immediately after arrival of the first shipment in April 1993. The target date for useful accelerated beam is September, 1995.

The first performance goal is an energy gain of 6 MV/q added to the 15.5 MV capability of the 14 UD. This energy boost will be expanded to 10 MV/q during the following two years. The facility has space for an additional four modules increasing the gain to 18 MV/q. Further improvements resulting from our continuing RF resonator development program should insure even greater enhancement of the linac performance in the future.

The present status of the project will be discussed including progress on Helium refrigeration, beam transport and vacuum systems.

The creation of the light elements: cosmology and cosmic-rays

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The origin and evolution of elements take important keys to the cosmological questions: How massive is our Universe? What is the nature of dark matter? Is it baryonic or non-baryonic? In our recent theoretical study of the inhomogeneous cosmology (Astrophys. J. 422 (1994) 423, and references therein), we found a possibility that all matter observed today is baryonic and the primordial nucleosynthesis of the light elements is consistent with astronomical observations.

Our inhomogeneous cosmological model can even probe the cosmic electroweak (Weinberg-Salam) phase transition as well as the QCD phase transition. Late time baryogenesis in the first order electroweak phase transition is expected today by many particle physicists to be the true site for the creation of baryon asymmetry in the Universe because SU(5) GUTs fails. This theory eventually leads to the inhomogeneous baryon distribution before the onset of explosive nucleosynthesis. In this paper we propose several observational signatures in astronomy of the physical processes operated in the early Universe.

The cosmic-ray induced nuclear spallations are presumed to be the major source for the secondary production and destruction of the light elements after the big-bang. We studied the variation in time of the elemental abundances by constructing a model of chemical evolution of the galaxies and stars. All observed abundance data in our solar neighborhood constrain the upper limits of primordial nuclear abundances. We can predict, in turn, what elements show most clearly the observational signatures of primordial nucleosynthesis.

Nuclear reaction rates including those of unstable nuclei are essential input data for both big-bang and cosmic-ray induced nucleo- syntheses. We make a special note on the significant nuclear reactions the rates of which are unmeasured or poorly known experimentally.

Mass number dependencies and semiclassical descriptions of the nuclear pairing gap

P Schuck and K Taruishi
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Numazu College of Technology, Shizuoka, Japan

It has been found that the nuclear pairing gap Δ follows the relation $12A^{-1/2}$ on the average as a function of mass number A. Let us understand the reason for its dependence from the semiclassical point of view. The pairing gap at the Fermi surface is given by the phase space integral

$$\Delta = \int d^3R\, d^3p\, \Delta(R,p)\, f(R,p)$$

where $\Delta(R,p)$ and $f(R,p)$ is respectively the pairing gap and the distribution function given in the phase space

$$F(R,p)=\{\langle r|F\rangle\langle F|r'\rangle\}.$$

and $|F\rangle$ is the wave function at the Fermi level. Now for $f(R,p)$ there exists a very easy semiclassical approximation

$$F(R,p) = n\delta(\lambda - H(R,p))$$

where the semiclassical Hamiltonian

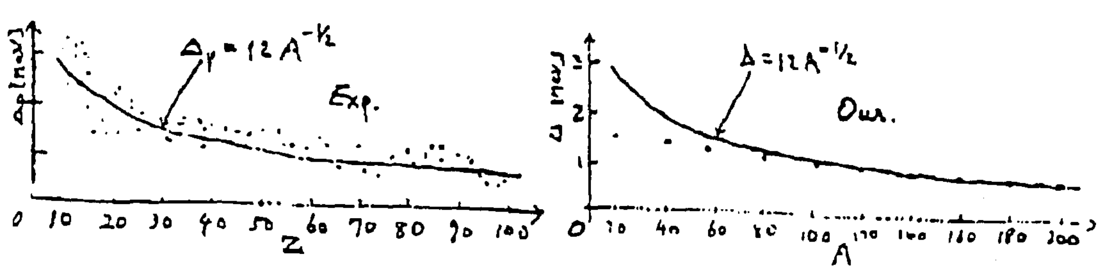
$$H(R,p)=p^*p/\{2m'(R)\}+ V(\text{Woods-Saxon})$$

with the effective mass m'. There are two conditions to indicate the normalization n and the chemical potential λ.

$$1 = \int d^3R d^3p\; n\; \delta(\lambda - H(R,p))$$

$$A = \int d^3R d^3p\; \Theta\,(\lambda - p^*p/(2m) - V(\text{Woods-Saxon}))$$

The result is shown in our figure.



Low Energy Stripping Reactions on Light Nuclei

M.H. Hadizadeh*, H. Miri

Ferdowsi University of Mashhad, Iran

H. Afarideh

Atomic Energy Organization of Iran

Abstract:

Low energy (d,p) reactions on targets of Al, Mg, and S, have been measured using the 3-MeV Van de Graaff accelerator of The A.E.O.I.

Results of the target preparation experimental arrangement and data reduction will be discussed, together with the significance of the results.

* Visiting fellow at the The School of Physics, The University of Melbourne.

POSITIVE PHOTOPION PRODUCTION FROM $^{12,13}C$ USING TAGGED PHOTONS

H. Choi[1], K. Min[1], T. Kobayashi[1], P.F Yergin[1], L.Y. Murphy[1], J. Shaw[1], H. Tsubota[2], K. Shoda[3], H.T. Chung[4], J.C. Kim[4] J.M. Vogt[5], E.L. Hallin[5], H.S. Caplan[5], J.C. Bergstrom[5] and D.M. Skopik[5]

1) *Department of Physics, Rensselaer Polytechnic Institute, Troy, New York 12181, U.S.A*
2) *Department of Physics, College of General Education, Tohoku University, Kawauchi, Sendai 982, Japan*
3) *Laboratory of Nuclear Science, Tohoku University, Kawauchi, Sendai 982, Japan*
4) *Department of Physics, Seoul National University, Seoul 151-742, Korea*
5) *Saskatchewan Accelerator Laboratory, University of Saskatchewan, Saskatoon, Saskatchewan S7NOWO, Canada*

Angular distributions of positive pions to residual states in ^{12}B and ^{13}B at excitation energies up to 20 MeV were measured using tagged photon facility at SAL. Strong spin-isospin flip($\Delta S = \Delta T = 1$) states are clearly observed in the excitation spectra of both ^{12}B and ^{13}B. Data were found to be in good agreement with existing data at excitation energies below 10 MeV.

The Entropy in Ultrarelativistic Heavy Ion Collisions

LI PANLIN LI ZHILIANG* SHI XINHUI**

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** Department of Mathematics, Qing Tao University of Seas & Oceans, Qing Tao 266033, China

Abstract:

It is known that an entropy is a Lorentz invariable in relativistic thermodynamics. The entropy of the system is also related to the complete equation of state and is reflected in the ratios of different particle species emitted in the collisions of heavy ions at ultrarelativistic energy. Thus the entropy is chosen as an evolution parameter of the system of an expansion quarkgluon plasma and an entropy equation of including expansion and irreversible flavour kinetics is set up. From hydrodynamic equations with source terms and the thermal grand canonical ensemble relation, the entropy equation with an entropy generation terms is derived identically, $T\partial_\mu S^\mu = u_\nu \Sigma^\nu - \mu\sigma$. In the source terms Σ^ν and σ, for our purpose they are sufficient to include all particles, i.e. besides small produced hadronic particles in the primary collisions, a main part of the contribution will be provided by the transition of the quark-gluon plasma phase to the hadronic phase during the expansion of the system. A string phenomenology is used to describe the evolution of the quark-gluon phase towards the hadronic phase. The source region, where $\Sigma^\nu \neq 0$ and $\sigma \neq 0$, lies over a hyperbola $t^2 - x^2 = \tau_0 = 1$ (fm/c). Outside the solurce region $T\partial_\mu S^\mu = 0$ and the system expands adiabatically. Then one sees explicitly that how the entropy is generated in the source region by matter and baryon number production. The evolution of the entropy density of the process of the phase transition was calculated by numerically integrating the entropy equation. The results can be used to assess the possibility of attaining the quark-gluon plasma phase as well as to discuss its diagnosis.

Radioactive nuclear beams

W Gelletly

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Abstract

All of the science based on accelerated ion beams has been developed using the 283 stable or long-lived nuclides found on Earth, a small fraction of the ~ 7000 species lying between the nucleon drip-lines. Two methods for producing beams of unstable, radioactive ion species have emerged. The first is based on the fragmentation of high energy heavy ions. The second requires one accelerator to produce the radioactive species and a second to accelerate the ions produced.

The science which can be addressed with radioactive ion beams (RIBs) will be explored, and the status of major RIB projects discussed. In particular the status of RIST, the radioactive ion source test facility, at the Rutherford-Appleton Laboratory, which is aimed at determining whether an ion source/target can be developed to withstand 100 μA of 800 MeV protons, will be reported. RIST may pave the way for a full scale RIB facility based on an intense, high energy proton beam.

AU9514707

RESOLUTION OF ANOMALOUS FISSION ANISOTROPIES FOR THE REACTION OF $^{16}O + ^{208}Pb$

D. J. Hinde, C. R. Morton, M. Dasgupta, J. R. Leigh, J. P. Lestone, R. C. Lemmon, J. C. Mein, J. O. Newton, and H. Timmers

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Models describing fusion are tested by comparing their predictions with measured fusion excitation functions and with deduced properties of the fusion angular momentum ($\ell\hbar$) distribution. For heavy compound nuclei, which decay by fission, the value of $<\ell^2>$ can in principle be deduced from the measured anisotropy of the fission angular distribution $W(0^0)/W(90^0)$. However, at near-barrier energies, predicted values of $W(0^0)/W(90^0)$ based on ℓ-distributions calculated by fusion models are substantially smaller than those measured[1]. This anomaly is particularly significant for the system $^{16}O + ^{208}Pb$ [2], where transfer induced fission and quasi-fission reactions are not expected to influence the result, as they may for heavier targets.

To investigate this problem, we have measured at the ANU the evaporation residue and fission excitation functions for $^{16}O + ^{208}Pb$ to high precision. The former cross-sections are substantially higher than published values[3], whilst the latter are in agreement[3]. The deduced values of the anisotropy obtained by fitting the measured fission angular distributions are shown in Fig. 1 as a function of energy; they are slightly lower on average than those of Ref. 2.

To calculate $W(0^0)/W(90^0)$ within the statistical model, the angular momentum ℓ, the effective moment of inertia at the saddle point $\mathcal{J}_{eff}$, and the temperature at the saddle point T for each nucleus passing the fission saddle-point should be known. The ℓ-distributions were determined from a calculation fitting the fusion excitation function. Angular momentum dependent values of $\mathcal{J}_{eff}$ were used.

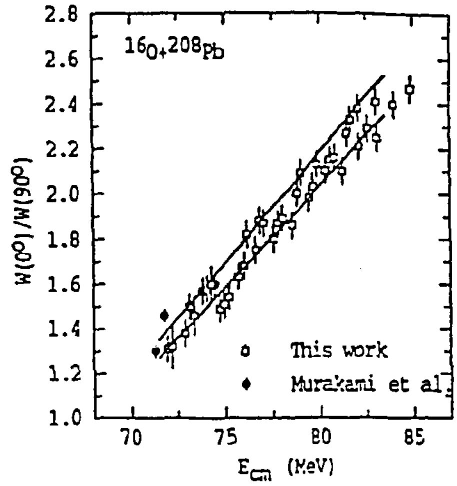

FIG. 1. Calculated anisotropies including the effect of pre-fission neutrons lie between the lines, the range reflecting the uncertainty in the experimental multiplicities.

The temperature at the saddle-point is constrained by the experimental pre-fission neutron multiplicity[3], however instead of taking an average value, the Monte-Carlo decay simulation code JOANNE[4] was used to obtain the *distribution* of saddle-point T values. These extend down to very low values for "last-chance" fission. The calculated anisotropies are in good agreement with the experimental data. The anomaly in the fission anisotropies for the system $^{16}O + ^{208}Pb$ appears to have been resolved.

[1] R. Vandenbosch, Annu. Rev. Nucl. Part. Sci. 42(1992)447
[2] T. Murakami *et al.*, Phys. Rev. C34(1986)1353
[3] H. Rossner *et al.*, Phys. Rev. C45(1992)719 and ref. therein
[4] J. P. Lestone *et al.*, Nucl. Phys. A559(1993)277

Determination of the Quadrupole Moment of the Proton $i_{13/2}$ Orbital

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Abstract:

An understanding of the behaviour of complex nuclei requires the knowledge of the properties of constituent orbitals. In the trans-lead region the $i_{13/2}$ orbital plays a key role in the formation of high spin isomeric states. While the quadrupole moments for many of these isomers have been measured, the quadrupole moment for the $i_{13/2}$ orbital cannot be measured directly, but must be inferred from lifetime measurements on nuclei near the doubly magic ^{208}Pb core. For one of these nuclei, ^{211}At, previous measurements of the lifetimes of isomeric states have give widely disparate values resulting in an uncertainty in the derived $i_{13/2}$ moment.

Lifetime measurements have been performed using the $\gamma\gamma$-time technique with the CAESAR detector array. This technique allows the isolation of the lifetimes of particular states and provides definitive results. The present work has determined the meanlives of the $21/2^-$ and $29/2^+$ states in ^{211}At as 50.7(10) ns and 73.3(10) ns respectively. The features of this measurement and the implication of the results in terms of effective charges in the trans-lead region will be discussed.

AU9514709

Sensitivity of quasi-elastic excitation functions to barrier distributions

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Heavy-ion fusion excitation functions at bombarding energies above the Coulomb barrier can be characterised by a fusion barrier B_0. At energies below B_0, fusion cross-sections invariably exceed those calculated using this single barrier [1]. Such sub-barrier fusion enhancement has been understood to be caused by the coupling of the relative motion of the two nuclei to inelastic and transfer channels of the system. This results in a distribution of fusion barriers around B_0.

It has been shown [2], that the distribution of fusion barriers can be extracted directly from fusion excitation functions. Barrier distributions have now been measured for a range of reactions and the effects of rotational and vibrational excitations and neutron transfer have been identified [3,4]. Experimentally, the barrier distribution becomes increasingly difficult to determine from fusion data as the energy increases. An alternative method at high energies would therefore be extremely useful. It has been suggested that, information about the barrier distribution of a reaction might be contained in the elastic and quasi-elastic scattering excitation function at backward angles. Calculations have been performed[5] for ^{154}Sm + ^{16}O and ^{92}Zr + ^{16}O which indicate that the scattering would depend on deformation in the former case and multi-phonon coupling in the latter.

In order to determine the sensitivity of scattering data to the barrier distribution, we have measured [6] back-scattered quasi-elastic (elastic + inelastic + transfer) excitation functions, at energies spanning the Coulomb barrier, for these two reactions. In addition, the scattering of ^{16}O projectiles from targets of ^{144}Sm and ^{186}W was studied. The first differential with respect to energy of these excitation function qualitatively reflects the distribution of barriers for each reaction, displaying features which depend on the structure of the target nucleus. The extracted distributions are qualitatively similar to those from fusion data, but they are distorted by the diffractive nature of the scattering and perhaps by the effects of transfer. It appears, that the best method of experimentally determining the distribution of barrier strength is measuring fusion, not the relatively simple measurement of quasi-elastic scattering.

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[1] M. Beckerman, Rep. Prog. Phys. 51, 1047 (1988).
[2] N. Rowley et al., Phys. Lett. B 254, 25 (1991); J. X. Wei et al., Phys. Rev. Lett. 67, 3368 (1991).
[3] R. C. Lemmon, Phys. Lett. B 316, 32 (1993).
[4] C. R. Morton et al., submitted to Phys. Rev. Lett.; J. C. Mein et al., to be published.
[5] M. V. Andres et al., Phys. Lett. B 202 (1988); A. T. Kruppa et al., Nucl. Phys. A 560 (1993).
[6] H. Timmers et al., to be submitted to Nucl. Phys. A.

Electron Laboratory for Europe

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Abstract

ELFE is the acronym for Electron Laboratory for Europe. It is a 15 to 30 GeV, continuous beam, high intensity superconducting accelerator for nuclear and hadronic physics. The physics issue of this facility is to understand the quark and gluon structure of matter in the non perturbative domain of Quantum Chromodynamics. I will review the main ideas of the research program and the most important experimental proposals,. The technical project and the recent progress on superconducting RF cavities will also be presented as well as the political and financial aspects of the project.

K^+ Nucleus Interactions at Low Momentum

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The K^+meson is the weakest hadronic probe of the nucleus. Unlike other hadronic probes the K^+ has a long mean free path in nuclear matter (5-7fm) at low momentum. There is also a very smooth energy dependence in that region. Single scattering of the K^+ with a nucleon in the nucleus will dominate the nuclear scattering. However, the cross sections for K^+-^{12}C and K^+-^{40}Ca scattering at 800 MeV/c cannot be explained in conventional approaches.

It is suggested that the discrepancy can be removed by considering the "swelling" of nucleons in the nucleus. The swelling may be seen in the ratio of the K^+ total cross section on nuclei to that on deuterium.

$$R_t=\frac{\sigma_{tot}(K^+\text{-}A)/A}{\sigma_{tot}(K^+\text{-}d)/2}$$

This is inspired by some interpretations of the EMC effect. Recently, the ratios R_T are measured for nuclei with mass numbers A=6, 12, 28 and 40 having Z=N, in the momentum range of $480 \leq P_L \leq 714$MeV/c.

An alternative suggestion is that the effect of the nuclear medium is to decrease the masses of vector mesons which form the meson-cloud of the nucleus and whose exchange dominates the K^+N interaction. However the change of vector meson masses in the normal nuclear medium is not certain.

It should be noted that there is a large ambiguity for K^+N phase shifts based on scarce data, since the real part of the amplitude cannot be constrained with the total K^+N cross section through the optical theorem. In the present paper, the K^+N phase shifts derived from the Bonn meson exchange potential are used in the Glauber approach to calculate R_T.

The nuclear cross section contributed from single and double scattering is

$$\sigma_{tot}(K^+\text{-}A)=A\sigma[1-\alpha\sigma(1-\varepsilon^2)A^{1/3}],$$

where σ is the total K^+N cross section, α is a constant, and ε is the real to imaginary part of the K^+N amplitude. If the mean free path is very long, single and double scattering are sufficient to account for nuclear scattering. When $|\varepsilon|>1$, the antishadowing occurs, and hence $R_T>1$. This is the case for K^+-A scattering at very low momentum.

For larger A, triple and higher multiple scattering take part in the K^+-A scattering. Hence the p_L-dependence of R_T varies with A. As p_L increases, R_T decreases monotonically. The decrease becomes rapid with increasing A.

The ratios R_T are fairly reproduced in the Glauber approach with the K^+N phase shifts derived from the meson exchange potential. The differential cross sections for K^+-^{12}C and K^+-^{40}Ca scattering at 800MeV/c are also reproduced. The magnitude of the real part of K^+N amplitude is essential to reproduce the A and p_L-dependence of R_T, and the differential cross sections. The real part of the K^+N amplitude should be fixed before considering the swelling of nucleons and medium corrections for the K^+N interaction in the nucleus.

A Search for Signatures of Scalar Top Quark at *ep* Collider HERA — Case of R-parity Breaking Coupling —

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Abstract

The supersymmetry (SUSY) seems to be a most promising approach to beyond the standard model. The existence of the light scalar top quark (stop) lighter than other squarks is a natural consequence of the minimal supersymmetric standard model (MSSM). In the framework of the MSSM with an R-parity breaking coupling of the stop we investigate production processes and decay properties of the stop at *ep* collider HERA energies. We show that the stop could be singly produced not only in the neutral current processes but also in associated processes whose final states contain some heavy flavour quarks, bottom and top. These signals would be useful to discriminate the stop from leptoquarks.

MEASUREMENT OF BACKGROUND NEUTRON FLUX AT A DEPTH OF 1230 m BELOW GROUND

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Abstract:

Measurements of the background neutron flux at a depth of 1230 meters below the surface, in a silver, lead and zinc mine at Broken Hill, New South Wales are reported. Using ^{3}He neutron counters, the thermal neutron flux and epithermal neutron flux as a function of neutron energy were determined.

The effect of background gamma radiation on the resultant neutron spectra is discussed and a procedure is given for the correction of the obtained spectra for the effects of this gamma background. Also the internal counts originating from the radioactive trace elements in the construction material of the detectors are discussed and appropriate corrections are determined.

Using Monte Carlo calculations the response of ^{3}He detector for neutrons of different energies was examined. The upper energy limit for detection of neutrons using ^{3}He detectors directly (in absence of any moderator) is calculated.

The resulting fluxes are in good agreement with the fluxes calculated on the basis of nuclear reactions that takes place in the mine environment.

Aspects of Nuclear Fission.

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Our understanding of how, hot fissioning nuclei propagate from the ground state to the scission configuration has improved considerably in recent years. Statistical model analysis of U(n,f) cross sections at neutron energies up to ~20 MeV has enabled the first experimental determination of the magnitude of the γ deformation of the first saddle point of U isotopes. The properties of the pre-scission particle emission from heavy-ion fusion-fission reactions has conclusively proven that fission deviates markedly from the exponential decay law on time scales less than a few 10^{-20} s. This deviation from simple exponential decay is due to the time it takes the collective degrees of freedom to equilibriate with the single particle degrees of freedom and the time it takes nuclei to transit from the saddle point to the scission configuration. These two times can be used to estimate the viscosity of hot nuclei matter.

AU9517715

Inelastic and Transfer Channels in Heavy-Ion Fusion for ^{144}Sm + ^{16,17}O.

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In the fusion of heavy nuclei, the coupling between the relative motion and internal degrees of freedom of the interacting nuclei causes a splitting in energy of the uncoupled fusion barrier. The resultant distribution of fusion barriers has a shape indicative of the relevant couplings, and is directly manifested as an enhancement of the fusion cross-section at energies below the uncoupled barrier. Fusion excitation functions can be transformed to reveal directly the distribution of barriers [1].

Fusion excitation functions for ^{144}Sm + ^{16,17}O have been measured to high precision and the extracted distribution of barriers reveal unambiguous experimental signatures of the effects of specific inelastic and transfer reaction channels on fusion. The experiments were performed with the 14UD tandem accelerator at the ANU. Excitation functions for evaporation residues were measured using a compact velocity filter [2]. The quantity $d^2(E\sigma)/dE^2$, which is directly related to the distribution of barriers, was extracted from the excitation functions for each reaction.

Figure 1 shows the experimental barrier distribution for the ^{144}Sm+^{16}O reaction (squares). The dotted line is the distribution for a single barrier obtained by fitting the cross-sections in the high energy region. The measured distribution shows that the single barrier is split into two discrete barriers. This is due to inelastic excitation of the target. The dashed line in Fig. 1 is the theoretical distribution from a calculation performed with the coupled-channels code CCMOD which couples between the 0^+ and 3^- states of ^{144}Sm with a coupling strength evaluated from *accepted* values. The agreement between experiment and the coupled-channels calculation is remarkable, and confirms the assignment of the second peak to inelastic excitation of single-phonon states in ^{144}Sm.

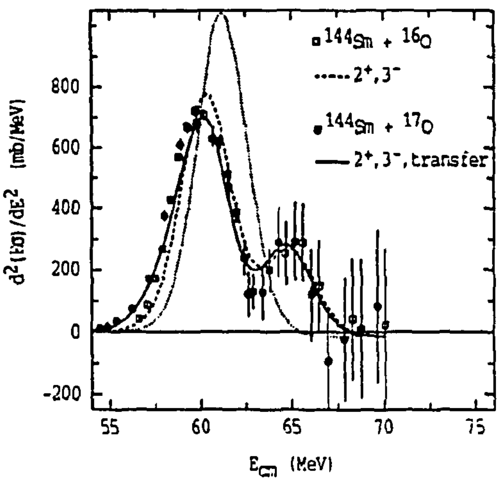

FIG. 1. The experimental results compared with CCMOD calculations.

The barrier distribution for ^{144}Sm+^{17}O is also shown in Fig. 1 (circles). At the higher energies the two distributions are in excellent agreement. However, at lower energies the two distributions differ significantly and this can be explained by coupling to a *positive* Q-value transfer reaction (solid line with the single stripping channel $Q = +2.6$ MeV). The inclusion of the transfer channel gives very good agreement in the low energy region.

In conclusion, precisely determined fusion excitation functions for the reactions ^{144}Sm+^{16,17}O have enabled the identification of specific inelastic and transfer channels influencing the fusion process.

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[1] N. Rowley *et al.*, P.L. B **254**, 25 (1991).

[2] J. Wei *et al.*, NIM Sect. A **306**, 557 (1991).

Barrier Distribution for the Fusion of ^{16}O and ^{92}Zr

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Coupling to the intrinsic degrees of freedom in a heavy-ion collision can result in an enhancement of the fusion cross-sections over that expected for a single barrier [1]. The barrier can be replaced by a distribution of barriers [2] as a result of couplings to the inelastic excitation channels of the reaction. Previous detailed measurements [3] of the fusion cross-sections σ for the reactions $^{16}O + {}^{144}Sm$, ^{154}Sm and ^{186}W demonstrated that the curvature of $E\sigma$, at each energy E, is related to the barrier distribution of the fusing system. The distributions revealed that the effects of coupling to the low-lying rotational and vibrational states in the target nucleus are important in the fusion process.

Calculations for the fusion reaction $^{16}O + {}^{92}Zr$ by Rowley *et al.* [4] included couplings to the low-lying vibrational states of ^{92}Zr. The series of calculations included only couplings to the dominant single-phonon quadrupole 2^+ and octupole 3^- states, and then couplings to the double-phonon $(2^+, 3^-)$, $(2^+)^2$ and $(3^-)^2$ states. In all cases, the single barrier is redistributed to become a broad distribution of barriers with a weighted mean centered on the original barrier, and, in the case of double-phonon coupling, a significant fraction of the barrier strength lies at high energy. These calculations inspired a measurement of the fusion cross-sections over a large energy range near the Coulomb barrier.

The barrier distribution extracted from the experimental data is broad, but the clear high energy signature of the double-phonon coupling is not observed. The potential parameters that best fit the experimental data at high energies, well-above the mean barrier, provide for a more diffuse nuclear potential than that used in Ref. [4]. Theoretical calculations using our parameters reveal a barrier distribution for double-phonon coupling that has no high energy barriers, but simply a broad barrier distribution similar to the experimental data. The theoretical distributions for single-phonon couplings are not sufficiently broad to account for the width of the experimental distribution, and double-phonon couplings need to be included to reproduce the breadth and structure of the distribution. This is possibly the first experimental observation of multiphonon coupling in sub-barrier fusion reactions.

1. C. H. Dasso, S. Landowne and A. Winther, Nucl. Phys. **A405** (1983) 381; *ibid*, **A432** (1985) 495.
2. N. Rowley, P.H. Stelson and G.R. Satchler, Phys. Lett. B **254** (1991) 25.
3. J.X. Wei, *et al.*, Phys. Rev. Lett. **67** (1991) 3368; J.R. Leigh *et al.*, Phys. Rev. C **47** (1993) R437; R.C. Lemmon *et al.*, Phys. Lett. B **316** (1993) 32; C.R. Morton *et al.*, Phys. Rev. Lett. (submitted).
4. N. Rowley, Nucl. Phys. **A538** (1992) 205c; A.T. Kruppa, P. Romain, M.A. Nagarajan and N. Rowley, Nucl. Phys. **A560** (1993) 845.

A STUDY OF ULTRA-RELATIVISTIC HEAVY ION COLLISIONS USING AN AUTOMATED VIDEO SCANNER SYSTEM

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Ultra-relativistic heavy ion collisions are studied in order to probe nuclear matter at high baryon densities. QCD, the theory of strong interaction predicts the existence of a new state of matter, the Quark-Gluon Plasma (QGP) where quarks and gluons, which are normally confined within hadrons, become unconfined and chiral symmetry is restored. QGP is believed to have existed shortly after Big Bang and may still exist in neutron stars.

For the first time, experiments with truly heavy ions are possible in Brookhaven National Laboratory. As part of EMU01 collaboration, emulsion chambers, which contained thin gold target foils in the upstream, were exposed to 10.7 A GeV Au beams. Central Au-Au events in which all the projectile and target nucleons are participants, provide the highest energy densities available and therefore are of considerable interest. These events are selected on the basis of their high shower multiplicities and the absence of charged fragments. Measurements are done on an automated video scanner which has been developed by the Sydney group.

In this paper, important features of Sydney's automated microscope scanner will be described and some preliminary results of Au-Au collisions will be presented.

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Shape coexistence in ^{185}Tl and ^{187}Tl - investigation of the deformed minima

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The coexistence of bands built upon both prolate and oblate shape in the neutron-deficient even-even mercury isotopes is now well established[1]. The neighbouring odd nuclei provide a possibility to probe the microscopic structure of the even-even core via the effects of the odd particle. To investigate the proton structure of the even-even mercury isotopes, a comprehensive series of experiments have been performed to look for high-spin states in the odd-proton nuclei, ^{185}Tl and ^{187}Tl[2]. These studies have been run in conjunction with that of ^{183}Hg, where the effects of the odd neutron can be seen.

Gamma-gamma coincidence measurements have been performed with the CAESAR array and level schemes for ^{185}Tl and ^{187}Tl constructed. Strongly coupled rotational bands built upon oblate $\frac{9}{2}^-[505]$ and $\frac{13}{2}^+[606]$ states were observed, along with decoupled bands due to the $i_{13/2}$, $h_{9/2}$ and $f_{7/2}$ protons coupled to the prolate shape, thus establishing a shape coexistence in ^{185}Tl and ^{187}Tl.

The results of equilibrium deformation calculations reproduce the experimental trends with mass number, but fail to reproduce the absolute excitation energies of the intrinsic states. In particular, the energy difference between the prolate and oblate states does not agree with experiment, continuing the persistent discrepancy between theory and experiment found in the mercury region[3].

While early calculations[4] suggested simple two proton excitations for the prolate deformed mercury nuclei, recent calculations[5,6] indicate that the coexisting prolate and oblate states have very different configurations. It is suggested that the oblate states are primarily due to the excitation of a pair of protons into the $\frac{9}{2}^-[505]$ orbital, while the prolate states are due to more complicated 4 particle - 4 hole configurations, where the excitations are into the low-K orbitals from the $i_{13/2}$, $h_{9/2}$ and $f_{7/2}$ proton shells. The prolate deformed rotational bands we observe in ^{185}Tl and ^{187}Tl are due to precisely these states, and are well deformed, despite the fact that the prolate core configurations are blocked. From this we deduce that the prolate mercury core nuclei are formed from the more complicated configuration.

1) J.L. Wood *et al.*, Phys. Rep. **215** (1992) 101.
2) G.J. Lane *et al.*, Phys. Lett. **B**, in press.
3) G.D. Dracoulis, Proc. of Int. Conf. on the Future of Nuclear Spectroscopy, 1993, Crete, (National Technical University Press, Athens)
4) R. Bengtsson *et al.*, Phys. Lett. **B183** (1987) 1.
5) R. Bengtsson and W. Nazarewicz, Z. Phys. **A334** (1989) 269.
6) W. Nazarewicz, Phys. Lett. **B305** (1993) 195.

Nuclear clusters

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Abstract

The idea that clusters of nucleons might exist in the nucleus has a long history and dates back to the earliest days of nuclear physics. These ideas arose initially from the observation of alpha particles emitted as products from radioactive decays and were later supported by the observations of selective population of particular nuclear states in nuclear reactions where clusters of nucleons were transferred between two colliding nuclei. More recently the observation of resonances in the collision of even heavier nuclei (for example $^{12}C + ^{12}C$) suggested that even larger clusters might occur.

The earliest theoretical models developed for alpha clusters in the nucleus presented a geometrical (almost crystalline) picture of light nuclei built from alpha particles. These models were further developed in a more rigorous quantum mechanical description and in particular the model of a nucleus as a core plus orbiting alpha particle was shown to be able to describe many of the static and dynamic properties of certain nuclei.

More recently the cluster model has been developed extensively and has predicted that cluster nuclei can be excited to many highly deformed shapes. At the same time new experimental approaches hade been developed which can probe cluster structures by observing the breakup of the nucleus into the cluster components. These developments have led to a renewed interest in clustering in the nucleus.

In this talk I will briefly review the early ideas on clustering before describing the results of the more recent theoretical and experimental work. The wide variety of highly deformed cluster structures which have been revealed will be discussed, ranging from the simple alpha cluster states, to the extremes of orbiting nuclei (nuclear molecules) and the evidence of even more spectacular linear chains of alpha particles (alpha chain states). Finally, a comparison will be made between these structures seen in the nucleus and examples of clustering in atoms.

RESONANT STRUCTURES IN THE $^{16}O+^{20}Ne$ SYSTEM

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Abstract:

Resonant structures have been observed in the excitation functions for the scattering of 4N-type nuclei. Such structures are particularly pronounced[1,2] for the system $^{16}O+^{20}Ne$ in the energy range $20 < E_{c.m.} < 40$ MeV and these data have been well described within the frameworks of the extended optical model[3] and coupled-channel techniques[4] using shallow potentials. However, the double-folding model[5] suggests and analysis[6] of the non-local nucleus-nucleus interaction obtained by the resonating group method indicates that the equivalent local interaction should be described by a deep potential, which can support wave functions with a proper number of radial nodes, consistent with the Pauli principle. More recently, the resonant structures in the elastic scattering excitation functions for the system $^{16}O+^{20}Ne$ have been analysed using a deep potential and the LCNO model[7,8]. Unfortunately, this model is unable to describe the inelastic scattering excitation functions.

In the present work the correlated gross resonant structures observed in both elastic and inelastic scattering for the $^{16}O+^{20}Ne$ system have been studied using a coupled-channel approach. In particular, the analysis has employed a deep real potential consistent with the resonating group work. The real potential is also assumed to have a squared Woods-Saxon form factor, compatible with predictions of the double-folding model.

The results of the coupled-channel calculations and the interpretation of the resonant structures for the $^{16}O+^{20}Ne$ system will be discussed.

1) J. Schimizu *et. al.*, Phys. Lett. **B112**(1983) and private communication
2) D.F. Hebbard *et. al.*, Nucl. Phys. **A481** (1988) 161
3) Y. Kondo, B.A. Robson and R. Smith, Nucl. Phys. **A410** (1983) 289
4) Y. Kondo, B.A. Robson and R. Smith, Nucl. Phys. **A437** (1985)117
5) G.R. Satchler and W.G. Love, Phys. Reports **55** (1979) 183
6) T. Wada and H. Horiuchi, Prog. Theor. Phys. **80** (1988) 488
7) C. Gao, Y. Kondo and B.A. Robson, Nucl. Phys. **A529** (1991) 234
8) Chengqun Gao and Guozhu He, Phys. Lett. **B282** (1992) 16

Channel Selection in Heavy-ion Reactions by Charged Particle Detection

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Abstract:

Nuclei near the line of stability can readily be produced using heavy-ion fusion reactions in which a small number of neutrons are evaporated. As one moves away from stability the ability to produce nuclei selectively is decreased. This occurs because charged particle evapouration becomes more pronounced, with a resulting increase in the diversity of nuclei produced. Gamma-ray spectroscopic studies of nuclei far from stability are therefore difficult, both in the small absolute cross sections for production and in the contamination from other reaction products. While a number of devices are available for the identification of a particular nucleus following a reaction are available, these tend to have very low efficiencies. An alternative approach is to detect, in coincidence, the charged particles emitted in the reaction and thereby infer the identity of the nucleus.

A compact detector system has been developed for this purpose for use with the CAESAR γ-ray detector array. Charged particles are detected in a ball of 14 plastic phoswich scintillation detectors which have been designed to provide high efficiency for detection without impeding the performance of the γ-ray detectors.

The operation of this detector and its use in a number of recent spectroscopic studies will be discussed.

First Observation of a $K^{\pi}=8^{-}$ Band for N=74.

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Abstract:

For more than twenty years, low lying, isomeric states for nuclei with neutron number 74 have been known to exist in the light rare earth region around mass 130. These isomers are thought to be due to a high-K structure built from the coupling of the $[404]\frac{7}{2}^{+}$ and $[514]\frac{9}{2}^{-}$ orbitals to a $K^{\pi}=8^{-}$ state which is hindered in its decay to the K=0 ground band. However, in order to test this assignment, it is important to measure the characteristics of the bands built upon these states. Since their lifetimes are in the millisecond region, measurement of the transitions above the N=74 isomers are very difficult, indeed, no information exists on bands built upon the previously observed isomers in $^{130}_{56}$Ba [1], $^{132}_{58}$Ce [2] and ^{134}Nd [3].

To extend the systematic, we have studied the N=74 nucleus, ^{136}Sm, using the reaction ^{32}S(^{107}Ag,p2n) with a pulsed, 140 MeV beam provided by the ANU 14UD accelerator. Emitted γ-rays were detected using the ANU CAESAR Compton suppressed detector array. A new isomer with a half life of 15 ± 1 μs was observed.

In an attempt to detect states above this new isomer, a second experiment was performed with the particle detector ball (PDB) in conjunction with the CAESAR array. The PDB enabled clean selection of 1-proton events, substantially reducing the background due to Coulomb excitation of the ^{107}Ag target. It was possible to observe discrete transitions populating the isomer, including the rotational band built on it. Its in-band decay properties will be used to test the proposed configuration.

1. H. Rotter *et al.* Nucl. Phys. **A133** (1969) 648
2. D.G. Parkinson *et al. et al.* Nucl. Phys. **A194** (1972) 443
3. D. Ward *et al.* Nucl. Phys. **A117** (1968) 309

Confronting nuclear structure and magnetic moments

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The present status of theory and experiment for magnetic moments of short-lived (lifetimes less than 1 ns) excited states in rare-earth nuclei will be reviewed. The focus will be on the implications of these data for nuclear structure physics, with a view to the experimental and theoretical challenges for the future.

One challenge for experimenters is to extend the g-factor data to include short-lived states in *unstable* nuclei. Novel experiments on the neutron deficient Pt isotopes are described in an accompanying abstract [1]. The possibilities and limitations for future measurements in unstable, heavy nuclei will be reviewed.

On the theoretical side, there has continued to be interest in g-factors of low-lying states in rare-earth and transitional nuclei, to test the assumptions and parameters of nuclear structure models, particularly the Interacting Boson Model and the Cranked Hartree Fock Bogoliubov Model. Of considerable current interest, the g-factor data have implications for the physics of nuclear moments of inertia [2], and, in deformed odd-A nuclei, may be used to test the validity of the pseudo-Nilsson approximation [3].

After about a decade of confrontation between theoretical and experimental g-factors in the transitional osmium and platinum nuclei, a resolution, through F-spin breaking mechanisms in the Interacting Boson Model, is now in sight. The new calculations and supporting experimental data will be discussed.

[1] S.S. Anderssen, *et al.*, abstract in these proceedings

[2] A.E. Stuchbery, abstract in these proceedings

[3] A.E. Stuchbery, abstract in these proceedings

Evidence for Pre-equilibrium Effects Following Implantation of Pt into Fe

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The static hyperfine magnetic field acts on the nuclei of impurities in a polarized ferromagnetic medium. For a number of impurity-host combinations there have been conflicts between the field strengths measured following ion-implantation and those obtained by other experimental methods.

We have remeasured the static hyperfine field for Pt in Fe using the ion-implantation perturbed angular correlation technique (IMPAC) following Coulomb excitation. Our data are in agreement with those obtained in earlier experiments, except that more recent information on the transient field correction leads us to infer a significantly smaller static field strength. The field strength is about 75% of the field obtained in experiments that do not employ implantation. We suggest the observed reduction of the static field is an inherent feature of the implantation process.

A survey of the static fields measured for the neighbouring $_{76}$Os, $_{77}$Ir, $_{78}$Pt, and $_{79}$Au impurities in ferromagnetic Fe shows that the reduced static fields observed in IMPAC measurements can be correlated with the lifetimes of the nuclear states used to sample the field strength. From these comparisons, we suggest that the IMPAC data are consistent with there being a period of about 10 ps following ion-implantation during which the static field is quenched due to dynamic structural damage caused by pre-equilibrium processes. Once equilibrium is reached, a large fraction ($\sim$ 90%) of the implanted ions have final positions on unique lattice sites within the Fe host.

Examining Shape Coexistence with a Simple Collective Potential

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Abstract:

The occurrence of multiple minima in calculated nuclear potential energy surfaces is often used to illustrate shape coexistence. This phenomenon is clear in nuclei where a large potential barrier exists between the minima but the situation becomes ambiguous where the barrier is small or not present. In such cases the deformations of the 'shape coexisting' states may not be easily distinguishable.

An alternative viewpoint is that the observed states are mixtures of two intrinsic states of different deformation. This approach has been used with success in phenomenological models of the low-spin structure of light Os and Pt nuclei [1]. Quite large mixing is given by these models, consistent with the small or non-existent potential barriers calculated between coexisting states.

To examine how well such admixed states approximate the wave functions of a dual-minimum potential, a one-dimensional potential model has been studied, consisting of two joined harmonic oscillator potentials. The first two wave functions and eigenvalues are determined numerically and compared to linear combinations of two 'intrinsic state' wave functions. Where the potential barrier between the wells is large, the mixed states are good representations of the solutions to the potential, and the mixed states approach is a useful way to interpret the structure.

For small barriers, the approximation does not describe the excited state well. However, the inclusion of an additional state of vibrational character improves the agreement significantly. It appears that such vibrational states must be taken into account, in addition to any shape coexisting states, when considering the low-lying structure of nuclei with soft potential surfaces.

1) T. Kibédi, G.D. Dracoulis, A.P. Byrne, P.M. Davidson and S. Kuyucak, Nuclear Physics A567 (1994) 183;
P.M. Davidson, G.D. Dracoulis, T. Kibédi, A.P. Byrne, S.S. Anderssen, A.M. Baxter, B. Fabricius, G.J. Lane and A.E. Stuchbery, Nuclear Physics A568 (1994) 90;
P.M. Davidson, G.D. Dracoulis, T. Kibédi, A.P. Byrne, S.S. Anderssen, A.M. Baxter, B. Fabricius, G.J. Lane and A.E. Stuchbery, to be published.

High-spin states and intrinsic structure in ^{175}Ta and ^{176}Ta

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Abstract:

The existence of high-spin isomers is a well established feature of many nuclei in the Hf-W-Os region. The investigation of such states can reveal some interesting aspects of nuclear structure, such as the effects of blocking, configuration dependent pairing, nucleon-nucleon residual interactions and K-violation. In this context, the tantalum isotopes are of special interest, because the proton orbitals near the Fermi surface are isolated by sub-shell gaps.

States in ^{175}Ta and ^{176}Ta were populated using ^{170}Er(^{10}B,5n) and ^{170}Er(^{11}B,5n) reactions at beam energies of 64 and 66 MeV respectively. In both experiments the beam was bunched and chopped - 1 ns wide with 1712 ns separation. Gamma-rays were detected using the CAESAR array, which comprised for these experiments of six Compton-suppressed Ge detectors and one LEPS detector. Coincidence pairs, with time differences up to $\mp$856 ns, were recorded in event-by-event mode for subsequent off-line analysis. In addition, angular anisotropy was obtained during prompt gated singles experiments performed for both reactions.

The analysis of the experimental data has revealed a number of multi-quasiparticle states some of them long-lived, and their associated rotational bands. Proposed multi-particle configurations, deduced from the in-band decay properties will be presented. The excitation energies of the intrinsic states and the moments-of-inertia of the rotational bands based on them will be evaluated in the light of configuration-dependent pairing reductions, predicted by blocked BCS calculations.

AU9514727

Multiplets and Collective Structures in ^{202}Po

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Abstract:

The coexistence of different shapes in the same nucleus is a well established feature for many nuclei. The $Hg-Pb$ region is of particular interest in this respect because a variety of shapes - spherical oblate, prolate and superdeformed prolate - have been observed, in close proximity to the Z = 82 closed shell. In recent studies, cascades of magnetic dipole transitions in ^{199,200}Pb[1] have been identified with rather regular energy spacings. They have been characterised as bands of weak oblate collectivity, with angular momentum provided largely by alignment of the $h_{9/2}$ and $i_{13/2}$ proton orbitals and the $i_{13/2}^{-2}$ neutron holes. In these cases, the proton orbitals above the Z=82 gap must be populated by excitation of protons, leaving proton holes below. We have initiated a study of ^{202}Po, the isotone of ^{200}Pb, in which the two valence protons ($Z = 84$) can occupy the same orbitals without involving holes.

Excited states in ^{202}Po have been populated using the ^{194}Pt(^{12}C,4n) reaction and a variety of γ-ray and conversion electron techniques, using pulsed beams from the ANU 14UD Pelletron accelerator, giving sensitivity to isomeric states.

Many new transitions have been assigned depopulating states up to $\sim 25\,\hbar$. The recently published level scheme of the ^{202}Po[2] has been extended including observation of the $10, 12^-$ states of the $\pi h_{9/2}\,\nu f_{5/2}^{-1} i_{13/2}^{-1}$ configuration. At least three cascades of involving sequences of magnetic dipole transitions feeding states with spins 14 to 17 $\hbar$ states have been observed, The most prominent one feeds the 15^- isomeric state. The cascades are irregularly spaced.

The results will be discussed within the alternative approaches involving the multi-particle states and multiplets predicted by empirical shell model calculations using ^{208}Pb as a core, or as quasi-collective bands.

References

[1] G. Baldsiefen, et al., Phys. Lett. B275 (1992) 252.
[2] B. Fant, et al., Phys. Script. 41 (1990) 652.

Kaon-nucleon scattering and kaon condensation

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Abstract

The s-wave $K^{\pm}N$ scattering amplitude is computed up to one-loop order corresponding to next-to-next-to-leading order with a heavy-baryon effective chiral Lagrangian. Constraining the low-energy constants by on-shell scattering lengths, we obtain contributions of each chiral order and find that the chiral corrections are "natural" in the sense of viable effective field theories. We have also calculated off-shell s-wave $K^{-}N$ scattering amplitudes relevant to kaonic atoms and K^{-} condensation in "nuclear star' matter including the effect of Λ(1405). The critical density for kaon condensation in "nuclear star" matter is also computed up to two-loop order *in medium* with parameters determined from *KN* scattering and kaonic atom data.

Dynamical generation of the Sigma Model

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Abstract:

It is shown how to generate the linear sigma model dynamically by imposing vanishing renormalization constants on the meson fields, regarded as quark composites. All quantities are related to the fundamental mass scale f_π associated with weak pion decay and, consistent with the chiral symmetry, we find $m_\sigma = 2m_q$, $m_\pi = 0$. After gauging the model it is also feasible to generate the vector and axial vector masses dynamically, with reasonable results.

AU9514730

CHARGE SYMMETRY BREAKING IN THE NN INTERACTION FROM A QUARK-PION COUPLING MODEL

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Using a constituent quark model which incorporates chiral symmetry, a model has been developed for the short range part of the NN interaction[1]. This model has been used to calculate the NN interaction arising from both one gluon exchange and one pion exchange[3].

We present the results from a study of the charge symmetry breaking (CSB) effects, due to the up-down quark mass difference, in the one pion exchange interaction. These effects are interesting because they might give some insight into the relationship between high energy (quark-gluon) and low energy (nucleon) theories and the relative contributions to the CSB piece of the strong nuclear force.

1. K. Holinde, Phys.Lett. 118B (1982) 266
2. K. Holinde, Nucl.Phys. A415 (1984) 477
3. G.Q. Liu et al., Nucl.Phys.A. 556 (1993) 331

Rho-omega mixing

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Abstract

The pion electromagnetic form factor gives a clear indication of the violation of isospin symmetry in the time-like region, in particular a small bump around the rho mass that is attributed to rho-omega mixing. A great deal has been extracted from this rather specific data, inducing the mass difference of the up and down quarks. The amplitude for the rho-omega mixing obtained at the rho mass point is also extrapolated back to the space-like region where it is of significance to nuclear physics (in the charge symmetry breaking of the nucleon-nucleon interaction). We comment on the validity of the assumptions used in these calculations.

TREATMENT OF MESON-NUCLEUS ELASTIC SCATTERING USING THE KDP FORMALISM

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For some time we have been studying meson-nucleus scattering using a relativistic description similar to that employed in the successful analysis of proton-nucleus elastic and inelastic scattering. In this paper we discuss a treatment of K^+–nucleus elastic scattering using the work of Dirac phenomenology and the Relativistic Impulse Approximation (RIA) as a guide. In this work we employ the Kemmer-Duffin-Petiau (KDP) equation as the relevant one-body scattering equation.[1]

Following the same procedure in constructing the optical model potentials as in the RIA, we express the meson-nucleon amplitudes in invariant form. The optical potentials are constructed by folding these amplitudes with the scalar and vector neutron and proton densities, obtained from relativistic Hartree mean field calculations. In constructing RIA optical potentials consistent with Eq. (3) we have several choices for the invariant form of the meson–nucleon t matrix. The details of the t matrix construction and calculation of the scattering amplitude are given in Ref. (1), where this folding procedure was applied to pion and kaon scattering at 800 MeV/c beam momentum. Here we consider applications to other beam energies which is is motivated by the availability of new experientlal data.

This work was supported by the U. S. National Science Foundation, The U. S. Department of Energy and The Ohio Supercomputer Center. One of us (B. C. Clark) thanks the National Institute for Nuclear Theory for their kind hospitality.

REFERENCE

1. B.C. Clark, S. Hama, G.R. Kälbermann, R.L. Mercer, and L. Ray, Phys. Rev. Lett., 55, 592 (1985) and references therein.

The Sudbury Neutrino Observatory

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Abstract

The SNO Collaboration is now constructing a solar and supernova neutrino detector at a depth of 6800 feet in the Creighton mine near Sudbury, Ontario in Canada. The target will consist of 1000 tonnes of D_2O contained in an acrylic vessel. Surrounding the target will be an array of approximately 9500 photomultiplier tubes to detect the Cherenkov radiation produced by neutrino interactions in the D_2O. Measurements of the charged-current reaction, $\nu_e + d \rightarrow p + p + e^-$, will allow the flux and shape of the ν_e spectrum above about 5 MeV to be determined. By also measuring the neutral-current reaction, $\nu_x + d \rightarrow p + n + \nu_x'$, to total flux above 2.2 MeV of all neutrino species will be determined. A status report on the Sudbury Neutrino Observatory project will be presented.

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† HC Evans, GT Ewan, A Hallin, HW Lee, JR Leslie, JD MacArthur, HB Mak, AB McDonald, W McLatchie, BC Robertson, P Skensved, B Sur, E Bonvin, ED Earle, D Hepburn, GM Milton, I Blevis, WF Davidson, CK Hargrove, H Mes, M Shatkay, D Sinclair, AL Carter, B Hollebone, D Kessler, P Jagam, J Law, JJ Simpson, J-X Wang, J Bigu, ED Hallman, RU Haq, S Gil, C Waltham, MM Lowry, EW Beier, W Frati, M Newcomer, R Van Berg, TJ Bowles, P Doe, MM Fowler, A Hime, F McGirt, RGH Robertson, TC Spencer, DJ Vieira, JB Wilhemy, JF Wilkerson, JM Wouters, YD Chan, A Garcia, KT Lesko, EB Norman, AR Smith, RG Stokstad, I Zlimen, NW Tanner, NA Jelley, JC Barton, G Doucas, EW Hooper, AB Knox, ME Moorhead, M Omori, PT Trent, DL Wark

Search for Neutrino Oscillations

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Abstract

Experimental high energy physics groups from the Universities of Melbourne and Sydney, and from ANSTO, are involved in an experiment code-named NOMAD (Neutrino Oscillation Magnetic Detector) located at the European Centre for Nuclear Research (CERN) near Geneva. The aim of the experiment is to search for oscillations between muon neutrinos, produced in copious quantities by beams derived from the CERN Super Proton Synchrotron (SPS), and tau neutrinos. Observations of a positive signal for tau neutrino interactions above background would have far-reaching consequences in both particle physics and cosmology. In the event of no signal being observed, experimental limits on neutrino oscillations will be improved by an order of magnitude.

A brief description of the NOMAD experiment is given, with emphasis on the role played by the Australian groups involved. The technique to be used for the oscillation search is outlined, and the expected limits on oscillations that can be obtained are quoted. Consequences of a positive signal are explored. Finally, the current status of the experiment, which commenced data-taking in April 1994, is given.

INVISIBLE SUPERNOVA DIRECTION ESTIMATION

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Abstract:

If another supernova ever occurs in our galaxy, it would most likely be optically invisible because of the opacity of the galaxy. However, it would be observable through neutrino detection. The determination of its direction is of primary interest, not only for mapping purposes but also as a crucial parameter for physics. For a single detector, the only way to estimate its direction is to deal with the ν_e elastic scattering by use of a large Cherenkov imaging detector. Estimation in this way has a relatively large error due to the nature of the scattering and poor statistic for a vortex reconstruction. An alternative and more direct method of direction estimation is considered here. In the near future, some very large detectors (Super Kamiokande, SNO, Borexino or LVD) will be in operation. Each detector has its own detection method and will work independently. If, however they are used in co-operation, it could be possible to measure the arrival time of the burst frontline in order to estimate the direction with better accuracy. The method requires at least three detectors with large time bases to find the direction. This alternative method could not only reduce the estimation error but is also independent from any other uncertain parameter such as a neutrino energy. The largest estimation error seems to be due to low statistics to identify the burst peak as well as the relative incident direction to a detector array and the time base. The ultimate lower limit of the error is set by the duration of the ν_e burst at the neutronization stage of a star collapse. Nevertheless, the estimation error based on the timing measurement could be as low as a few degrees. The argument is on the assumption of a massless neutrino.

A1/9514736

A quark-meson coupling model and charge symmetry breaking in nuclear matter

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Charge symmetry breaking (CSB) effects have attracted notice for a long time in nuclear physics. Although the effect is rather small compared with typical hadronic masses, one can see it in the neutron-proton mass difference, n-p scattering and so on. The atomic mass difference between light-to-medium mirror nuclei and the Coulomb displacement energies of analog states in large mass nuclei also show CSB (the Okamoto-Nolen-Schiffer , ONS, anomaly). It is well known that conventional nuclear contributions to the ONS anomaly are thought to be at the few per cent level and that they cannot explain the experimental findings [1,2]. The effects of CBS in the nuclear force, especially ρ-ω mixing, are expected to reduce the anomaly. However, recent investigations of the off-shell variation of the ρ-ω mixing amplitude have put this explanation into question [3,4]. In an alternate approach, using the Nambu–Jona-Lasinio (NJL) model, it is proposed that the anomaly might be related to the partial restoration of chiral symmetry in nuclear matter [5].

Recently, we have developed an explicit quark model, based on a mean field description of non-overlapping nucleon bags bound by the self-consistent exchange of σ, ω, ρ and δ mesons (all mesons whose masses lie below 1 GeV) [6]. It has then been used to study nuclear matter (including asymmetric matter) properties up to a few times normal nuclear density, the ONS anomaly and isospin symmetry breaking in the quark condensates. For the ONS anomaly, we find that, in combination with the u-d mass difference, the difference between quark scalar densities in protons and neutrons generates the anomaly. Furthermore, we find that isospin symmetry breaking in the quark condensates can be directly related to the δ meson field.

[1] S. Shlomo, Rep. Prog. Phys. vol.41 (1978) 957.
[2] G. A. Miller, B. M. K. Nefkens and I. Šlaus, Phys. Rep. **194** (1990) 1.
[3] T. Goldman, J. A. Henderson and A. W. Thomas, Few Body Systems **12** (1992) 123;
G. Krein, A. W. Thomas and A. G. Williams, Phys. Lett. **B317** (1993) 293.
[4] J. Piekarewicz and A. G. Williams, Phys. Rev. **47** (1993) R2461;
T. Hatsuda, E. M. Henley, Th. Meissner and G. Krein, Phys. Rev. **C49** (1994) 452.
[5] E. M. Henley and G. Krein, Phys. Rev. Lett. **62** (1989) 2586.
[6] K. Saito and A. W. Thomas, Phys. Lett. **B** in press;
K. Saito and A. W. Thomas, University of Adelaide preprint, ADP-94-4/T146.

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Pion Exchange Force and Meson vs. Quark Dynamics in the Nucleon-Nucleon Interaction

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ABSTRACT:

To distinguish explicit quark effects from meson exchange in the NN interaction, it is needed to splice the long-range meson exchange forces and short distance dynamics due to quarks. However, in most quark-model studies the short-range part of the pion exchange is usually treated differently, which makes it difficult to get a uniform picture of the short-range dynamics. We make a comparison between meson exchange and quark-gluon dynamics using the same pion exchange potential based on a quark-pion coupling model. The roles of vector meson exchange and gluon exchange in the NN interaction are compared by calculating NN phase parameters. It is shown that, with this consistent one pion exchange force, the vector meson exchange gives a better fit to the data. This may suggest that non-perturbative mechanisms responsible for meson exchange need more careful handling to supplement the usual one gluon exchange mechanism in describing the NN interaction[1].

[1] G.Q.Liu and A.W.Thomas. Aust. J. Phys. 1993, 46 737.

Weak Decays of Charmed and Bottomed Hadrons and Heavy Quark Symmetries

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Abstract:

Matrix elements for exclusive decays of charmed and bottomed hadrons are investigated in the framework of Bethe-Salpeter approach, incorporating heavy quark flavor and spin symmetries. The Bethe-Salpeter amplitude consists of a spin-parity projector representing the Lorentz property of the hadron and a wave function of the relative motion. It is the former that determines the general covariant structure of hadronic matrix elements, whilst the latter always enters in the guise of form factors. Besides demonstrating the equivalence of several methods of the heavy quark effective theory with Bethe-Salpeter approach in the decays between heavy flavoured hadrons, we establish relations between form factors in weak decays of heavy hadrons into light flavoured resonances of arbitrary spin. Thus we may evaluate rates for various exclusive channels in terms of a set of common form factors. Phenomenological consequences of our results on semileptonic, non-leptonic, and rare decays of charmed and bottomed hadrons are discussed.

Modelling deuteron photodisintegration up to 200 MeV and testing nucleon-nucleon potentials

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Abstract:

It is now known that deuteron photodisintegration up to 200 MeV is dominated by the impulse approximation, one pion exchange in leading order, and the contributions of one pion exchange with a Δ intermediate state and of one rho exchange to the $M^{(1)}$ amplitudes with a singlet final state. The model is now sufficiently well understood, and the experimental data is now sufficiently reliable, for it to be possible to test any nucleon-nucleon potential which is used to generate the deuteron and continuum wavefunctions.

AU9514740

Pion-Nucleon Scattering Requires a Soft πNN Form Factor

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Abstract:

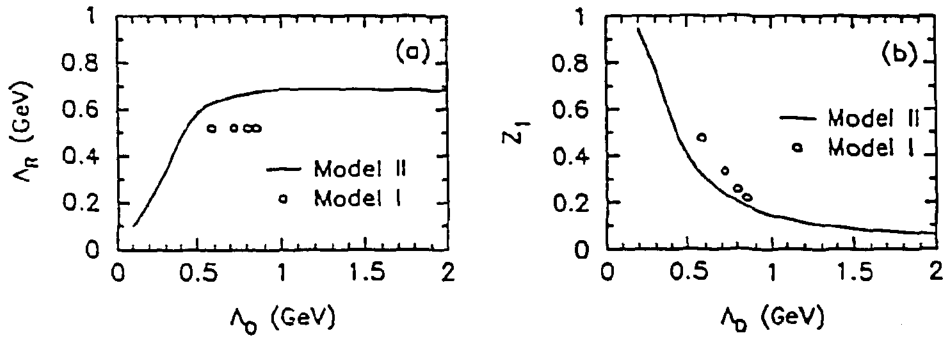
The dressed πNN form factor is extracted from two models of πN scattering in which the nucleon is correctly renormalised and the low energy phase shifts fitted. The range of the dressed form factor is found to be independent of the bare form factor in both cases. In the first model, based on meson exchange, the dressed form factor is has a monopole range $\Lambda = 0.5GeV$. The second model, where the 2-particle irreducible $\pi N \rightarrow \pi N$ amplitude is approximated by a separable potential, yields $\Lambda = 0.68GeV$.

By classifying all diagrams contributing to $\pi N \rightarrow \pi N$ according to their irreducibility, the t-matrix can be written in the form[1]

$$t = t^{(1)} + f^{(1)\dagger} d f^{(1)}; \qquad t^{(1)} = t^{(2)} + t^{(2)} g t^{(1)} \tag{1}$$

$$f^{(1)} = f^{(2)} + f^{(2)} g t^{(1)}; \qquad d^{-1} = d_0^{-1} - \Sigma^{(1)}; \qquad \Sigma^{(1)} = f^{(1)} g f^{(2)\dagger} \tag{2}$$

(see [1] for more details). The input to a phenomenological calculation based on this approach will be the bare nucleon mass m_0 appearing in d_0, the bare coupling constant g_0 and cutoff mass Λ_0 appearing in the bare vertex $f^{(2)}$ and whatever other parameters are needed to specify the non-pole potential $t^{(2)}$. The bare parameters m_0 and g_0 are fixed by the usual renormalisation procedure.



The figure shows the dependence of the dressed cutoff Λ_R (extracted from $f^{(1)}$) on the bare cutoff Λ_0 for two models. In Model I, $t^{(2)}$ is constructed from an effective Lagrangian describing mesons and baryons[2], while in Model II it arises from a separable potential in each partial wave. In both cases, Λ_R saturates for Λ_0 greater than about 0.5 GeV. The maximum value attained by Λ_R is about 0.52 GeV for Model I and 0.68 GeV for Model II. These values are much lower than is conventionally used in meson exchange models of the NN potential[3] but is much more in line with that deduced from deep inelastic scattering[4]

Also shown is the vertex renormalisation constant Z_1 which is given by the ratio $f^{(2)}/f^{(1)}$ evaluated with all legs on-shell. This measures the contribution of the bare vertex to the total vertex. For large cutoffs, this becomes small, meaning that Λ_R is dominated by the non-pole potential $t^{(2)}$ which appears to be well constrained by the data.

References

[1] B. C. Pearce and I. R. Afnan, Phys. Rev. C **34**, 991 (1986).
[2] B. C. Pearce and B. K. Jennings, Nucl. Phys. **A528**, 655 (1991).
[3] R. Machleidt, K. Holinde, and C. Elster, Phys. Rep. **149**, 1 (1987).
[4] A. W. Thomas, Phys. Lett. B **126**, 97 (1983); L. L. Frankfurt, L. Mankiewicz, and M. I. Strikman, Z. Phys. **A334**, 343 (1989).

Neutrinos and Dark Matter from Nuclear Spectroscopy

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A brief review is given of recent studies of neutrinos and dark matter by means of high precision nuclear spectroscopy. It includes neutrino studies by means of double beta ($\beta\beta$) and γ spectroscopy and dark matter (DM) studies by means of nuclear recoil and γ spectroscopy. The highly sensitive spectrometer ELEGANT (ELectron GAmma-ray Neutrino Telescope), developed at Osaka University, has been shown to be very powerful for these studies.

Two neutrino $\beta\beta$ decays of ^{100}Mo and ^{116}Cd were observed. They give the nuclear matrix elements, which are used to evaluate matrix elements of neutrino-less $\beta\beta$ decays.

Neutrino-less $\beta\beta$ are very useful for studying a possible Majorana neutrino mass, a right-handed weak current, a SUSY-particle contribution, and so on, which are beyond the minimal standard theory. The present upper limits give upper limits of a few eV on the Majorana neutrino mass.

Large NaI(*Tl*) scintillators in ELEGANTV are used to search for spin-coupled DM. Nuclear recoils of I by elastic scattering of DM and nuclear de-exciting gamma rays of I by inelastic scattering were studied. CaF_2 scintillators are now being used for futher studies of spin- coupled DM.

Ion transport in zenon gas: applications to double beta decay

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Abstract:

One method of detecting double beta decay involves the collection and counting of the daughter ions of the process. For the double beta candidate ^{136}Xe the detection of the daughter ion $^{136}Ba^{++}$ provides a potentially unique signature that double beta decay has occurred. Due to the long half-life of the process (in excess of 10^{20} years for the allowed two-neutrino decay) a substantial quantity of ^{136}Xe must be assembled in order to produce a countable number of daughter ions: $1m^3$ of ^{136}Xe gas at 1 atm might produce about 1000 ^{136}Ba ions a year. This leads to an all important question: Can a single ion be transported distances of order 1 m through the parent gas without loss, and collected onto a substrate for later counting?

To answer this question we have investigated the transport of $^{208}Tl^{+}$ ions in 99.999% pure xenon gas. The ionisation potential and size of the thallium ion is similar to that of the barium ion, hence the ^{208}Tl-xenon system should prove to be a good model of the ^{136}Ba-xenon system. A linear drift tube was used to measure the yield of ions as a function of electric field, pressure and source-collector distance. No loss of ions was observed for drift distances up to 23 cm in gaseous xenon at pressures up to 3 atmospheres and fields as low as 5 V cm^{-1}. Attenuation lengths in excess of 8.8 m for xenon at atmospheric pressure with a field of 100 V cm^{-1} can be inferred from our measurements.

The mobility of ^{208}Tl ions in xenon at 1 atm was also measured using a parallel plate configuration. This result for the zero-field reduced mobility, $K_0=0.55\pm0.02$ cm^2V^{-1} s^{-1}, allows us to deduce a lifetime for the ions against neutralisation in excess of 16 sec.

These results give hope that an experiment can indeed be designed to collect, with high efficiency, $^{136}Ba^{++}$ ions produced from the double beta decay of ^{136}Xe. Once collected the ions could then be counted using one of several surface atom counting techniques available today. Thus a measurement of the double beta decay half-life of ^{136}Xe could be made.

Ion transport across a gas-liquid interface in xenon

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Abstract:

Neutrinoless double beta decay ($0\nu\beta\beta$), if observed, would signal the violation of lepton number conservation and the existence of massive Majorana neutrinos. Substantial improvements in the sensitivity of double beta decay searches will require the construction of very large, very low background experiments. Moe (Phys. Rev. C 44 (1991) R931) has discussed the possibility of a large-volume liquid xenon time projection chamber, with the signal derived primarily from the ionization of the emitted electrons but confirmed by the detection of the ^{136}Ba ion which accompanies the decay, to probe effective Majorana mass of the neutrino down to ~ 0.01 eV. The success of such a detector rests on the ability to identify a single molecular ion $(BaXe)^+$ isolated in the xenon matrix, an exceedingly difficult task. If, however, the daughter ion could be transported through the liquid, and perhaps into the gas phase, identification may become possible.

Since no previous measurements exist of diffusion coefficients or mobilities of dissimilar ions in liquid rare gases, we have studied the transport of ions in liquid xenon. ^{208}Tl ions are chosen for this study because they can be both produced and detected by radioactive decay, and the first ionization potential of thallium (6.0108 eV) is higher than that of barium (5.212 eV) suggesting that if the Tl^+ ion retains its net charge during the transport process, then Ba^+ will also.

We show that individual, thermalised $T\ell$ ions can be transported over distances of several cm through liquid xenon at fields of several kV cm^{-1}. In addition, we show that the ions can be transported across the interface from gaseous xenon into liquid xenon, under the influence of an applied electric field. The lifetime of the ions in liquid xenon is discussed, as are applications of this technique to searches for double beta decay in xenon.

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On Spontaneous Baryogenesis

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Abstract

Generation of the observed matter-antimatter asymmetry of the universe at the electroweak phase transition seems possible in two-Higgs doublet extended or supersymmetric electroweak models which contain CP-violating phases in the Higgs sector. We address recent claims that such spontaneous baryogenesis is suppressed by chirality-breaking transitions due to strong sphalerons.

The following papers were submitted to the secretariat but have not been scheduled for oral presentation

AU9514745

Why are the g-factors of 2_1^+ states in the even $^{184-198}$Pt nuclei constant?

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The g-factors of the 2_1^+ states in ^{184,186,188}Pt have been measured using a novel experimental technique developed in the ANU 14UD Pelletron laboratory for measuring the magnetic moments of short-lived excited states in *unstable* nuclei. The Pt nuclei of interest were populated by β-decay of parent nuclei following formation of the parent in a heavy-ion induced reaction. The recoil energy produced by the heavy-ion bombardment caused implantation of the parent nuclei into a polarized Fe backing foil, where they subsequently decayed. The large hyperfine field present at the site of Pt impurities in Fe caused precession of the excited Pt nuclei, which was measured as a perturbation of de-exciting γ-radiation. A similar measurement on the ^{192}Pt nucleus allowed a calibration of the internal field strength since the g-factor of its 2_1^+ state is known independently. A separate measurement of the $g(2_1^+)$ in ^{190}Pt has been made using the thin-foil transient field technique.

This work significantly extends the mass-dependent systematics of the first-excited state g-factors in the even-even Pt nuclei. In fact the $^{184-198}$Pt isotopes span nearly all of the upper half of the valence neutron shell.

The $g(2_1^+)$ values in the $^{184-198}$Pt isotopes remain almost constant. This is in marked contrast with the behaviour observed in the neighbouring W and Os nuclei and is in clear disagreement with the general predictions of the proton-neutron interacting boson model (e.g. ref. [1]). Also, the microscopic calculations of Kumar and Baranger [2] fail to predict the constant $g(2_1^+)$ for the lighter ^{184,186,188}Pt isotopes.

It will be shown that the phenomenon of shape-coexistence in the lighter ^{184,186}Pt nuclei may be incorporated in simple IBM calculations to account for the observed g-factors. However, an understanding of the $g(2_1^+)$ in the heavier $^{188-198}$Pt isotopes in terms of the IBM is still an open theoretical problem. A recent phenomenological analysis of the $^{192-198}$Pt data highlights the discrepancy between the empirical boson g-factors and those expected nominally [1]. The reasons for this disparity are the subject of current theoretical research, which includes (i) microscopic calculations of the boson g-factors [3], and (ii) the influence of significant non-maximal F-spin admixtures in 2_1^+ states [4].

1. A.E. Stuchbery *et al.*, Nucl. Phys. **A528** (1991) 447.

2. K. Kumar and M. Baranger, Nucl. Phys. **A110** (1968) 529.

3. B.R. Barrett *et al.*, Phys. Lett. **B 295** (1992) 5.

4. A. Wolf *et al.*, Phys. Lett. **B 312** (1993) 372.

Do Light Nuclei Exhibit Deformation Effects In Sub-Barrier Fusion?

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The importance of internal nuclear degrees of freedom in sub-barrier fusion of heavy ions was shown for the first time in the reactions of ^{16}O with different isotopes of Sm [1]. Sub-barrier fusion cross-sections were found to be enhanced for ^{154}Sm as compared with the spherical ^{144}Sm. The experimental cross-sections were consistent with calculations which treated ^{154}Sm as a classically deformed object. This approach implicitly assumes coupling to all states of a rotational band. The sub-barrier cross-section rapidly saturates with successive inclusion of the first five or six states of the rotational band. Hence, the classical approach may still be valid in those cases where the rotational states are low lying and can couple strongly to the incoming channel, as in the case of ^{154}Sm. In several instances, the calculations performed to explain the sub-barrier enhancement in reactions involving projectiles in the mass range $12 \leq A \leq 40$ have treated them as being classically deformed [2 – 4]. Although these nuclei (e.g. ^{27}Al, ^{28}Si) have large $B(E2)$ values their first rotational level is far removed (>1 MeV) from the ground state. This approach may not be valid in these cases. Since deformation effects lead to a large enhancement in fusion cross-sections, an incorrect assumption can easily lead to masking of the effects of other channels or other erroneous conclusions. Thus, in order to have a proper understanding of the effects of other channels it is crucial to know the behaviour of such nuclei during the fusion process. Precisely measured fusion excitation functions, represented in terms of the distribution of barriers, can best address this question by showing the nature of couplings in an obvious manner [5].

To investigate this issue, fusion excitation functions for the systems ^{16}O,^{28}Si+ ^{92}Zr and ^{16}O,^{28}Si+^{144}Sm have been measured to high precision using the 14UD Pelletron accelerator at the ANU. For ^{28}Si+^{144}Sm, the fission contribution was measured to obtain the total fusion cross-section (σ). The quantity $d^2(E\sigma)/dE^2$, which is directly related to the distribution of barriers was then determined. For both the systems, comparison of the calculated and experimental barrier distribution shows that the latter is not consistent with the assumption that ^{28}Si can be treated as a classically deformed nucleus. This is clearly in contradiction with the assumptions made in some earlier analyses.

These results show that *precise* measurement of the fusion excitation function is necessary to obtain a correct understanding of the relevant couplings in a particular reaction. Further theoretical analysis in terms of a more exact coupled channel calculation is necessary to understand the experimentally observed distribution of barriers.

[1] R.G. Stokstad *et al.*, Phys. Rev. Lett. 41, 465 (1978).
[2] E.F. Aguilera *et al.*, Phys. Rev.C 41, 910 (1990).
[3] H. Funaki and E. Arai, Nucl. Phys. **A556**, 307 (1993).
[4] M. Dasgupta *et al.*, Nucl.Phys. **A539**, 351 (1992).
[5] N. Rowley *et al.*, Phys. Lett.B **254**, 25 (1991).

Very Long-Lived Yrast Isomers, Multi-Quasiparticle States and Blocking in ^{177}Ta

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Abstract:

High-angular momentum intrinsic states, with lifetimes ranging from nanoseconds to years occur at low excitation energies in the Z≈72, N≈106 region. Apart from the exotic character of such states, their observation allows in principle the determination of basic nuclear properties, such as the pairing strength and nucleon nucleon residual interactions. Although, the decline in pairing as a function of angular momentum has been extensively studied [1], its behaviour as a function of seniority has been largely neglected, partly due to paucity of experimental data. A spectroscopic study of $^{177}_{73}Ta_{104}$ nucleus has been carried out, partly to complement the comprehensive results obtained for the odd-neutron nucleus $^{179}_{74}W_{105}$ [2].

States in ^{177}Ta (and ^{176}Ta) were populated using a chopped and bunched beam of 55 MeV ^{11}B, incident on a ^{170}Er target. Measurements of γ-ray singles, $\gamma - \gamma$ and $\gamma - X$ coincidences were made using the CAESAR array. Conversion coefficients were determined from intensity balances and also from electron and γ-ray singles measured in a separate run using the SUPER-e electron spectrometer. The level scheme deduced reveals many new bands and intrinsic states and also extend the previously known bands to higher spins.

Several isomers have been identified, most notable being $K^\pi = 20^-$ and $49/2^-$ yrast isomers in ^{176}Ta and ^{177}Ta, with meanlives of 1.4 ms and 0.19 ms, respectively. The long meanlives arise from substantial K-hindrance in the ^{176}Ta case but from spin-trapping in the ^{177}Ta case. Quasiparticle calculations, which treat the Fermi and pairing energies self-consistently [2, 3], reproduce the excitation energies of these isomers and the other multi-quasiparticle high-K states observed. Due to blocking, pairing is significantly reduced in the 3-quasiparticle states, the extent depending on the specific configurations. It is completely quenched for both protons and neutrons in the highest seniority states which involve up to seven quasi-particles. The calculations predict the existence of yrast traps of even higher spins.

[1] Y.R. Shimizu *et al.*, Rev. Mod. Phys. **61** (1989) 131.
[2] P.M. Walker *et al.*, Nucl. Phys. **A568** (1994) 397.
[3] B. Fabricius *et al.*, Int. Conf. on the Future of Nucl. Spectroscopy, Crete (June 1993)

AU9514748

Changes in Nuclear Structure in the new, very deficient isotopes of Hafnium, Tantalum and Tungsten

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Abstract:

Heavy Ion, fusion evaporation reactions have been used to populate states in the very neutron-deficient isotopes of Hafnium ($Z = 72$) and Tungsten ($Z = 74$). As the neutron number reduces below $N = 90$, the prevailing prolate deformation is expected to fall, making the nuclei susceptible to shape changes, dependent on the population of specific proton and neutron orbitals. Octupole susceptibilty is predicted for the Hafnium cases.

Our previous measurements [1] (carried out in collaboration with the group at Lawrence Berkeley Laboratory) used ^{58}Ni and ^{54}Fe beams incident on thin ^{107}Ag targets which form the compound nuclei ^{165}Re* and ^{161}Ta*. These subsequentl evaporate 3 or 4 particles (p, n or α) and study of the associated in-beam γ-decays allowed identification of excited states in the new isotopes, ^{162}W,^{163}W,^{162}Ta ^{163}Ta,^{158}Hf and ^{159}Hf as well as isotopes of lutetium. However, ambiguities remained in the level schemes because of many overlapping γ-ray transitions caused by the complexity introduced by the large number of competing evaporation channels. The measurements have been extended using beams from the ANU 14UD Pelletron accelerator and the Particle Detector Ball, a compact array of particle detectors inserted inside the Compton-Suppressed γ- detector array, CAESAR. Particle-γ - γ coincidence studies allow distinction between evaporation channels, involving one, two or three protons, or α-particles. The new results remove many of the earlier ambiguities.

1. G D Dracoulis *et al* Proceedings of the International Conference on Nuclear Structure at High Angular Momentum, Ottawa, 1992 AECL-10613 Vol 2 p92

Test of the photonuclear rection mechanism near 100 MeV.

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Abstract:

The Quasi-Deuteron Model modified by Shier and Schoch (Nucl. Phys. **A229**, 93, 1974)) treats the nucleons as correlated proton-neutron pairs, coupled to S=1, T=0 within the nucleus. In a recent high resolution measurement of $^{16}O(\gamma,p)$ reaction cross section (Hoorbeke *et al* (Phys. Rev. C, **42** R1179, 1990)) it was observed that proton emission from ^{16}O not only populated the ground state (GS) and 6.3 MeV negative states parity states of ^{15}N as expected, but significantly populated the positive parity doublet of 1p-2h (one particle - two holes) states near 5.3 MeV. The importance of this observation is that, if a two-step reaction process is discounted (as van Hoorbeke *et al.* show), the 5.3 MeV doublet cannot be populated if the generally accepted form of the quasi-deuteron mechanism is involved. They solve the dilemma by proposing a modification of the QDM model to include a significant component of quasi-deuterons with isospin T=1.
By measuring the decay gamma-rays from the residual states in ^{15}N following the $^{16}O(\gamma,p)$ reaction one could resolve the relative population of the residual states using the immediate γ-ray decay following the proton emission whereas the resolution in the direct proton detection is marginal. In order to limit the detection of de-excitation γ-rays to those reactions where a proton is emitted, we trigger the data acquisition system only when a proton is detected from the target using an efficient proton detector placed near ^{16}O target. The proton trigger also allows to reject any de-excitation γ-rays that follows a decay of higher energy residual state. An experiment to test this method of measurement of de-excitation γ-rays from residing nucleus in the $^{12}C(\gamma,p)$ reaction will be performed at Lund University, Sweden. A 105 MeV microtron with duty factor of 100% will be used with the intensity of electron beam on bremsstrahlung target about 10^7 electrons per second. A 10" NaI γ-ray detector for detection of de-excitation γ-rays and 3 CsI proton detectors with thin deltaE detectors will be used in the data aqcuisition system.

The time evolution of the fission decay rate of hot nuclear systems.

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In recent years it has become clear that it takes a finite period of time for the fission decay rate of a newly formed hot compound nucleus to change from its initial value of zero to its quasi-stationary value of $R(t{=}\infty)$. Bhatt et al in the mid 80's derived an analytical expression for the time dependence of the fission decay rate by making several simplifying assumptions. This analytical expression is now widely used by authors trying to understand the properties of particle and gamma-ray emission in coincidence with the fission of hot nuclei. It is shown that this simple analytical expression for the time dependence of the fission decay rate is in disagreement with results obtained by numerical solving the appropriate equations. This disagreement is due to assumptions made about nuclear potential energy surfaces which are inappropriate to real nuclei. Excellent agreement is, however, obtained between numerically calculated fission decay rates and a modified version of Bhatt et al's expression.

A simple and fast method of calculating finite range corrected liquid drop model potential energy surfaces.

J. P. Lestone

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In recent years the measurement of pre-scission neutrons, charged particles and GDR gamma-rays have conclusively proven that nuclear dissipation plays a crucial role in determining the time evolution of hot fissioning systems. Given the magnitude and nature of the dissipation processes and the shape of the nuclear potential energy surface one can then calculate both the pre and post-saddle time evolution of hot fissioning systems by either numerically solving the Fokker-Planck equation or by making some simplifying assumption which leads to analytical expressions. In either case one needs to determine the properties of nuclear potential energy surfaces as a function of mass A, atomic number Z, and spin J and to do this as rapidly as possible.

With this in mind, I have developed a simple, yet accurate method of obtaining finite range droplet model potential energy surfaces. I call this new model the "modified liquid drop model". The beauty of this model is its simplicity and thus its speed. I have written a Fortran subroutine which calculates MLDM potential energy surfaces from $r/R_0 = 0.5$ to 2.38 in steps of 0.01 where r is the distance between mass centres and R_0 is the nuclear radius, determines the height of the fission barrier, the curvatures around the equilibrium position and the saddle point and the curvature beyond the saddle point. 10^3 calls to this subroutine take ~1 second of CPU time on a VAX station 4000.

Determination of the deformation dependence of nuclear viscosity from particle emission.

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Recently measured properties of the pre-scission particle emission from heavy-ion induced fission of systems with A ~ 200 were analysed using the statistical model of nuclear reactions. Simultaneous fits to pre-scission neutron, proton and α-particle multiplicities and mean kinetic energies can be obtained when the deformation dependence of both the particle transmission coefficients and particle binding energies are taken into account. The experimental data are consistent with a pre-saddle fission delay of $\sim 10^{-20}$ s and a saddle to scission transition time of $\sim 2 \times 10^{-20}$ s. These times imply that at large deformations nuclear viscosity is full one body, while at more compact configurations the viscosity is significantly less than full one body.

Statistical model analysis of fast-neutron-induced fission of U isotopes.

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We have obtained the first experimental evidence of the washing out of the collective level density enhancement associated with the γ deformation of the triaxial first barrier in the U isotopes. In order to fit U(n,f) cross sections at neutron energies up to ~ 20 MeV, with a statistical model which uses level densities obtained from Nilsson model single particle levels, we find that it is necessary to (1) wash out the triaxial level density enhancement at an excitation energy of ~ 7 MeV above the triaxial barriers with a width of ~ 1 MeV, and (2) incorporate the effects of preequilibrium emission. These results imply a γ deformation of the first barriers in the range 10° – 20°. Above an incoming neutron energy of ~ 20 MeV where insufficient data exist to constrain optical model potentials, our statistical model U(n,f) cross sections increasingly overestimate the experimental data. A satisfactory reproduction of all the available U(n,f) cross sections is obtained by scaling our calculated compound nucleus formation cross sections. This scaling factor falls from 1.0 at ~ 20 MeV to 0.82 at 100 MeV.

AU9514954

Deformed Band Crossings in Cadmium Nuclei.

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Abstract:

Due to their close proximity to the Z=50 shell gap, at low excitations, the cadmium isotopes (Z=48) are near spherical in shape. However, at higher spins, weakly deformed collective states exist, associated with the occupation of the prolate driving, low-Ω $h_{\frac{11}{2}}$ neutron orbitals. We have studied the high spin states in ^{105,106}Cd using (HI,xn) reactions at the ANU 14UD tandem accelerator and the Tandem Accelerator and Super-Conducting Cyclotron facility at Chalk River Canada. In ^{105}Cd, we have extended the $\nu h_{\frac{11}{2}}$ band through a band crossing for the first time. The increase in alignment through the band crossing in ^{105}Cd is approximately 5 $\hbar$, which contrasts with the heavier odd-A Cd isotopes [1], where the increase of $\sim 8 \rightarrow 9$ $\hbar$ is explained by a $(h_{\frac{11}{2}})^2$ neutron alignment, The ^{105}Cd value is comparable to the expected increase for the $g_{\frac{7}{2}}$ neutrons and is the first time such an alignment has been observed in an odd-A cadmium isotope [2].

In ^{106}Cd a new rotational band is observed from a 10^+ bandhead, to spin 28 $\hbar$ and over 15 MeV in excitation energy. We propose that this is the $(\nu h_{\frac{11}{2}})^2$ structure. This new band has a very similar alignment pattern to the $h_{\frac{11}{2}}$ band in ^{105}Cd, again implying a $(\nu g_{\frac{7}{2}})^2$ crossing. Using a delayed $\gamma - \gamma$ coicidence technique, new states above the yrast 12^+ isomer in ^{106}Cd, have been observed ^{106}Cd for the first time. These include a strongly coupled collective structure, which has measured branching ratios consistent with a six quasi-particle, 2-proton-4-neutron configuration.

1. P.H. Regan *et al.* Phys. Rev. C49 (1994)
2. P.H. Regan *et al.* J. Phys. G19 (1993) L157

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AU9514755

Deformation, pairing and $g(2^+)$ values in rare-earth nuclei

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The discovery of "identical bands" in nuclei at both superdeformation and normal deformation has renewed interest in the theory of moments of inertia in rotational nuclei. In these nuclei, the g-factors of the excited states reflect the ratio of the proton moment of inertia to the total moment of inertia and so provide a means of separating the behaviour of the proton and neutron fluids. Consequently, experimental and theoretical studies of magnetic moments could illuminate the identical bands problem.

Zhang *et al.* [1] performed an empirical survey of ground-state rotational bands in even-even rare-earth nuclei, finding that changes in the moments of inertia are correlated with changes in the ratio of deformation to pairing gap (ϵ/Δ). Recently, Halbert and Nazarewicz [2] have shown that the global features of this empirical study can be understood theoretically using the Migdal estimate of the moment of inertia [3].

The present work uses the same approach as Halbert and Nazarewicz [2] to calculate $g(2^+)$ values in rare-earth nuclei and compare them with experiment. The Migdal formula treats the average behaviour of the nucleon superfluid approximately. Like the moment of inertia, the g-factor depends on the A and Z of the nucleus, its deformation, and the pairing gaps for protons and neutrons. The underlying single-particle motion is taken into account only through microscopic calculations of the deformations and pair gaps.

With some clear exceptions, the agreement between the experimental and theoretical $g(2^+)$ values for nuclei between ^{146}Nd and ^{192}Os is good. The implications, both theoretical and experimental, will be discussed.

[1] J.-Y. Zhang *et al.*, Phys. Rev. Lett. 69 (1992) 1160

[2] E.C. Halbert and W. Nazarewicz, Phys. Rev. C48 (1993) R2158

[3] A.B. Migdal, Nucl. Phys. **13** (1959) 655

Magnetic moments of excited states in the pseudo-Nilsson model

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The pseudo-Nilsson model is attractive for studying heavy, deformed nuclei with odd-A because the pseudo-spin-orbit splitting is so reduced compared with the normal spin-orbit splitting that it may be neglected. (For an extensive list of references, see [1,2].) As magnetic moments of odd-A deformed nuclei are sensitive to the wavefunction of the odd nucleon, they provide a useful test of the pseudo-Nilsson wavefunctions. Calculations for ground-state magnetic moments in odd-A deformed rare-earth nuclei have been reported by Ratna Raju *et al.* [1] and Troltenier *et al.* [2].

We have measured magnetic moments of excited states in several odd-A nuclei using the transient field technique. To make comparisons between these data and the pseudo-Nilsson model, the general formula for the g-factors of excited states has been derived and a computer code developed to calculate them in the case of a pure pseudo-Nilsson band.

In the present paper, the magnetic moment predictions of the pseudo-Nilsson model and the conventional Nilsson model are compared with each other and with experiment.

[1] R.D. Ratna-Raju, Draayer and K.T. Hecht, Nucl. Phys. **A202** (1973) 433

[2] D. Troltenier, W. Nazarewicz, Z. Szymanski and J.P. Draayer, Nucl. Phys. **A567** (1994) 591

Beam optics design for the ANU booster accelerator

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A superconducting heavy-ion linear accelerator is being installed to boost the energies of beams from the ANU Pelletron accelerator.

This poster will show how the beam optics has been designed to transport pulsed beams from the Pelletron to the linac and then return them (boosted in energy) to the experimental areas. The system design employs 8 dipoles and 12 quadrupoles (operating as singlets, doublets and triplets).

Emphasis will be on features such as the compact 90° achromat [1], required because of space constraints; and on aspects of the design which allow for the installation of further accelerating modules in future.

[1] B.A. MacKinnon, A.E. Stuchbery and D.C. Weisser, Nucl. Inst. Meth., *in press*

LOOPS AND GRAVITY

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Abstract:

Non-perturbative quantum gravity provides an alternate (but a possibly more satisfactory) way of understanding the micro-structure of space-time. In the loop representation theory of non-perturbative quantum gravity, gravitational states are described by functionals on the loop space of a 3-manifold. In order to gain a deeper insight into the physical interpretation of loop states, a natural question arises: to wit, how are gravitons related to loops? Some light will be shed on this question by establishing a definite relationship between loops and 3-geometries of the 3-manifold.

Typeset by $\mathcal{AMS}$-TEX

The following papers have been incorporated into the Mathematical Physics sessions of the Congress

Exact electropoles and vertices in gauge theories coupled to gravity

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Abstract

Explicit exact solutions of Einstein Yang Mills Chern Simons (EYMCS) theory in 4+1 dimensions corresponding to topological soliton multiplets carrying non-Abelian topological electric charge are obtained. The mechanism used to find the solutions is then applied to the case of the self-dual Abelian Higgs model with Chern-Simons interactions coupled to gravity in 3 dimensions. Exact solutions with long range electric fields but peculiar gravitational properties are found. Flat space versions of our results in theories with a dilaton are also discussed.

Modelling the vertex in gauge field theories

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Abstract

Schwinger-Dyson equations provide a promising non-perturbative approach for understanding both confining and non-confining field theories. In CD the Schwinger-Dyson approach allows for a study of the origin of dynamical chiral symmetry breaking and quark confinement and may, one day, compete with lattice simulations. A common procedure for gauge field theories in general entails making an ansatz for the fermion-gauge boson vertex function, and solving the remaining finite set of equations for single particle propagators. The main drawback of this procedure is the difficulty of ensuring that gauge covariance is maintained. We examine how the vertex may be restricted by this requirement in the cases of quantum electrodynamics in 3 and 4 space-time dimensions. The three dimensional theory, which displays both confinement and chiral symmetry breaking, is a useful test case for understanding the mechanisms driving the non-perturbative behaviour of QCD.

Extensions in local current algebras in 4D

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Abstract

Kac-Moody algebras play a significant role in the integrability of 2D field theories. However it is not clear in what way such extensions in local current algebras carry over to field theories in 4D, and what possible consequences such terms will have in the standard model. In this paper, we show on general grounds that charge density algebras in 4D must necessarily contain operator extensions whose explicit forms are critically dependent on the details of the underlying dynamics. We estimate, within the standard model, the matrix elements of these operators between hadrons, and show that their presence provides a quantitative resolution to a long-standing discrepancy in the Gerasimov-Drell-Hearn sum rule involving total photoabsorption cross sections off nucleons.

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Quantum group approach to mass splitting of hadrons

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Abstract

The problem of internal symmetry breaking in theory of elementary particles is treated in the framework of quantum group concepts. We take under consideration the underlying SU(3) unitary symmetry. In using the q-deformed harmonic oscillator description we consider a symmetry breaking mechanism to derive the mass split sum rules for hadron multiplets.

Relativistic quantum mechanics of bosons

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Abstract

It is usually argued that there is no natural definition of a positive probability current density for relativistic bosons, particularly in strong external fields. Recently Ghose, Home and Sinha Roy [1] have shown how to construct such a current. One defines the current four-vector $s_\mu = \theta_{\mu o} / E$ where $\theta_{\mu\nu}$ is the conserved, symmetrical energy-momentum tensor of a Klein-Gordan boson and E its total energy which is positive. Then $\partial\mu s_\mu = 0$ and $s_0 = \theta_{oo} / E > 0$. Thus s_0 can be interpreted as a probability density. Moreover, one can express $s_0 = (m / E)\phi\dagger\phi$ where ϕ is a five-component wavefunction. Interestingly, ϕ can be seen to satisfy the first-order Kemmer-Duffin equation analogous to the Dirac equation.

A similar programme fails for fermions because θ_{oo} for fermions is not non-negative. So one has the counterpart of the spin-statistics theorem in relativistic quantum mechanics - the probability density corresponds to the charge density for fermions and the energy-density θ_{oo} for bosons.

In the context of a Bohm-type hidden-variable model it has so far been argued that there are trajectories for fermions, the particles of mater, but not for bosons, the quanta of fields. The existence of a conserved positive probability current s_μ shows that bosons, too, have trajectories.

Reference

P Ghose, D Home and M N Sinha Roy, Phys. Lett. A **183** (1993) 267-271

Symmetry properties of superstring ghosts

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Abstract

We elaborate on the symmetry properties of superstring ghosts. The supersymmetry transformation of ghost fields and the corresponding current are given, the generalised ghost energy-momentum tensor is introduced; the condition for conformal anomaly cancellation as well as for nilpotency of BRST charge are found on their structure.

Magnetic charges and 3-cocycles

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Abstract

One of the interesting properties of Dirac's monopole is that it produces a 'representation' of the canonical commutation relations which does not satisfy the Jacobi identity. This is a feature which is appearing more frequently in quantum field theory, and possibly indicates some deep seated inconsistencies even in renormalized field theories. A way of interpreting these so-called obstructions has been developed, and as expected, the magnetic charge provides an interesting test case. Two extreme cases can be considered – a single charge and a uniform distribution of charges. In this paper some of the properties of these two and the intermediate case of a uniform finite ball are discussed.

Supermultiplet decay constants

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Abstract

Using several simplistic assumptions about the dynamics of quarks in hadrons, we use relativistic meson wavefunctions to determine the coupling constant g associated with various strong interaction and radiative decays. Surprisingly, although we consider many different processes, the coupling constant is very similar.

Loops and Gravity

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Abstract

Non-perturbative quantum gravity provides an alternate (but a possibly more satisfactory) way of understanding the micro-structure of space-time. In the loop representation theory of non-perturbative quantum gravity, gravitational states are described by functionals on the loop space of a 3-manifold. In order to gain a deeper insight into the physical interpretation of loop states, a natural question arises: to wit, how are gravitons related to loops? Some light will be shed on this question by establishing a definite relationship between loops and 3-metrics of the 3-manifold.

Regularisation and mass generation in odd dimensional theories

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Abstract

Gauge theories in an odd number of space-time dimensions permit an extra, parity-violating Chern-Simons term in the Lagrangian. We investigate the behaviour of this Chern-Simons theory, primarily in (2+1)D, and see the new ideas necessary to permit the use of dimensional to solve UV divergent integrals. We then investigate the dynamical generation of masses in such a theory, seeing that the presence of either a fermion or photon mass will result in the generation of the other. These ideas are then generalised to arbitrary (odd) dimensions.