2004 CONGRESS POSTER SESSION ABSTRACTS
RÉSUMÉS DES SESSIONS D'AFFICHES - CONGRÈS 2004

The poster session abstracts presented here will be on display in this order in the Winnipeg Convention Centre in Winnipeg, Manitoba from 19h00 - 22h00 on Monday, June 14th. *Les résumés présentés en affiches publiés ci-après seront en montre de 19h00 à 22h00, le lundi, 14 juin dans le Centre de congrès à Winnipeg, Manitoba.*

[MO-POS] CASCA — Monday / *Lundi*

MO-POS-1

The Impact of Canadian Astronomy as Measured by Citations, **Dennis R. Crabtree** *NRC-HIA* — The impact of scientific research is often measured by citation counts. Citations do not measure the quality of the scientific research but are more a measure of the relevance of the research to other researchers. Citation counts are frequently used as once piece of information in tenure decisions and also used to measure the strength of a whole research community (as in the Astronomy Long Range Plan). In this poster I will compare the publication and citation record of Canadian astronomy groups from 1990 onward.

MO-POS-2

"Lets Talk Science Partnership Program" Promotes Science in Canadian Schools, **Vesna Milosevic-Zdjelar**, *University of Winnipeg* — Canadian universities participate in initiative developed to promote science in schools and community. At seventeen universities, graduate students (as well as undergraduate students at the University of Winnipeg), volunteer to share their knowledge, expertise and enthusiasm with elementary and high school students, teachers and wide community. Through partnerships with schools, science and children museums and scout organizations, our program successfully reaches 25 000 children every year. We will describe here our program at the University of Winnipeg and its place in the national picture

MO-POS-3

Doing Science with the Spitzer Space Telescope, **P. Barmby**, S. Laine, M. Lacy, Spitzer/IRAC Team, *Harvard-Smithsonian Center for Astrophysics, Spitzer Science Center* — The Spitzer Space Telescope, launch in August 2003, is well into normal science operations. Here we give an overview of the capabilities of the three science instruments, science operations, and the long-term schedule. Science projects from the Early Release Observations, First Look Survey, and IRAC instrument team's Guaranteed Time will be used to illustrate the power of Spitzer observations for the study of Galactic and extragalactic star formation, high-redshift galaxies, and stellar populations.

MO-POS-4

HIFI: The High Resolution Spectrometer for Herschel*, **Michel Fich**, *University of Waterloo* (on behalf of the HIFI Team) — The Herschel Space Observatory will be a facility-class space observatory operating at wavelengths between 60 and 670 microns. It will be launched, with the Planck satellite, in 2007 to the second Lagrangian point with a minimum lifetime of three years. The Herschel telescope will be 3.5 m in diameter and passively cooled to 80K. HIFI (the Heterodyne Instrument for the Far-Infrared) is a high resolution spectrometer and one of three focal plane science instruments for Herschel. One of the primary purposes of Herschel is to study astrochemistry and HIFI is the main instrument for studying atomic and molecular spectral lines. Together with the Canadian Space Agency, a consortium of approximately 25 Canadian astronomers are contributing a central part of the HIFI instrument (the Local Oscillator Source Unit, or LSU)and, in return, are full partners in the HIFI Science Team. This poster outlines the current status of the instrument development and presents an overview of the science to be carried out with HIFI. It will also describe how interested Canadian scientists can join the Canadian Herschel/HIFI Consortium and become involved in the mission.

* This work is being supported by CSA.

MO-POS-5

Recent Results from the Odin Satellite*, **Michel Fich** [1] and K.A. Woodley [2], [1] *University of Waterloo* and [2] McMaster University — Odin is a mm and submm heterodyne 1.1m radiotelescope mounted on a spacecraft launched on 20 February 2001. It has been developed in a partnership between Sweden, Canada, Finland and France. In this poster we report on recent results from Odin, including a sensitive search for molecular oxygen in interstellar clouds, a survey of the Galactic Plane, and a detailed study of molecular processes in several star forming regions.

* This work is being supported by NSERC and CSA.

MO-POS-6

SPIRE: Herschel's Submillimetre Camera and Spectrometer*, **David Naylor** [1], P. Davis [1], J. DiFrancesco [2], M. Halpern [3], P. Martin [4], D. Scott [3] and C. Wilson [5], [1] *University of Lethbridge*, [2] HIA, [3] University of British Columbia, [4] University of Toronto and [5] McMaster University — The Herschel Space Observatory is an ESA cornerstone mission due for launch in 2007, which will conduct astronomical observations across the far-infrared and submillimetre waveband. It will carry a passively cooled, low-emissivity, 3.5-m telescope and will operate at the Sun-Earth L2 point for three years, providing a large amount of observing time at wavelengths unrestricted by the terrestrial atmosphere. The instrument payload will be cooled with an on-board supply of liquid helium, which determines the lifetime of the mission. Canada is involved in both the SPIRE and HIFI instruments on Herschel. The main scientific goals of SPIRE are deep extragalactic and galactic imaging surveys and spectroscopy of star-forming regions in our own and nearby galaxies. The SPIRE instrument comprises a 3 and imaging photometer at spectral channels at 250, 350, and 500 um, and an imaging Fourier transform spectrometer (FTS) covering the range 200-670um. The FTS employs a dual-beam configuration with broad-band intensity beam dividers. The SPIRE detectors are feedhorn-coupled neutron transmutation doped (NTD) Germanium spider-web bolometers. The Canadian contributions to the SPIRE instrument are (a) a mid-resolution (R » 1000) broadband FTS to test and qualify instrument models, (b) software packages to deglitch the signal stream, correct for the spectral response of the instrument, and process the spectrometer data, and (c) staff effort for the Instrument Test Team and Control Centre. Five Canadian researchers participate in the SPIRE Specialist Astronomy Groups as Associate Scientists. The Canadian involvement in the SPIRE project will be described.

* This work is being supported by CSA, NSERC.

MO-POS-7

Protoplanetary Dust Disk Dynamics*, **Robin Humble** [1], S.T. Maddison [2] and J.R. Murray [2] , [1] *Canadian Institute for Theoretical Astrophysics* and [2] Swinburne Centre for Astro and Supercomputing — With a view to investigating planet formation processes we have developed a code for simulating astrophysical dusty-gas flows in protoplanetary disks. Our parallel three dimensional code incorporates gas hydrodynamics, self-gravity and several gas drag prescriptions to follow the dynamical evolution of a two-phase dusty-gas medium. We present results of some calculations with submillimetre, centimetre and metre sized dust. Dust disk lifetimes and possible gas giant and terrestrial planet formation scenarios are discussed.

MO-POS-8

Neptune's Migration into a Dynamically Hot Kuiper Belt*, **Joseph Hahn** [1] and R. Malhotra [2], [1] *Saint Mary's University* and [2] University of Arizona — The effects of Neptune's orbital expansion into a dynamically hot Kuiper Belt is examined numerically. In the model, a torque is applied to Neptune's orbit causing it to expand 9 AU outwards and into a stirred up Kuiper Belt composed of 10^4 massless particles having initial eccentricities e~0.1. This system is integrated over the age of the Solar System, and our results confirm Chiang *et al.*'s (2003) finding that migration into hot Kuiper Belt allows particles to get trapped at weak mean motion resonances like the 5:2. Indeed, our higher-resolution study of this scenario shows particles getting trapped at many of Neptune's weak resonances, including the 13:6, 9:4, 7:3, 12:5, 8:3, 11:4, 3:1, 7:2, 4:1, all of which reside in the $50<a<80$ AU zone. Many of these trapped particles have such high eccentricities that they also inhabit the domain usually identified as the Scattered Disk. Of course, gravitational scattering by Neptune also produces a Scattered Disk of particles, but most of these particles are removed over the age of the Solar System during subsequent encounters with the planets. Indeed, inspection of all particles with semimajor axes $50<a<80$ AU and $e>0.25$ shows that about 90% were trapped at Neptune's migrating resonances, with only 10% actually being scattered by Neptune. These results may also provide an explanation for the 'extended' scattered disk of Gladman *et. al.* (2002), namely, that some of these KBOs were trapped at an exotic resonance with Neptune rather than scattered.

* This work is being supported by CFI.

M0-POS-9

Evolutionary Models of the roAp star HR 1217: Magnetic Fields and Pulsation Frequencies, **Christopher Cameron** [1], J.M. Matthews [1], M.S. Cunha [2], D.B. Guenther [3] and W. Weiss [4], [1] *University of British Columbia*, [2] Centre for Astrophysics of the University of Port, [3] Saint Mary's University and [4] University of Vienna — Strong magnetic fields measured in the chemically peculiar A stars of the upper main sequence are believed to be intricately linked to to observed abundance anomalies. In addition, a small subset of these stars are unstable to high-overtone pulsations. These stars, known as rapidly oscillating Ap (roAp) stars, show evidence that the magnetic field also has a strong influence on the observed oscillation frequencies. We present evolutionary models for the particular case of the roAp star HR 1217 and estimate the effect of the magnetic field on the calculated oscillation frequencies. We also show how the observed abundances influence calculations of the temperature-optical depth relation for this star.

MO-POS-10

Testing Stellar Evolution Theory: Theoretical Luminosity Functions and M92, **Brian Chaboyer**, S.R. Bjork, N.E.Q. Paust, *Dartmouth College* — A Monte Carlo simulation exploring uncertainties in standard stellar evolution theory on the red giant branch of metal-poor globular clusters has been conducted. The analysis takes into account uncertainties in the primordial helium abundance, abundance of alpha-capture elements, radiative and conductive opacities, nuclear reaction rates, neutrino energy losses, the treatments of diffusion and convection, the surface boundary conditions, and color transformations. These theoretical luminosity functions are compared the observed luminosity function of M92. The M92 luminosity function was obtained from observations which combine wide field (32 x 32 arc-minute) data from the 2.4m telescope at MDM Observatory with HST ACS images of the central 3 arc-minute core of M92. Accurate photometry of over 25,000 stars are used in the construction of the M92 luminosity function.

MO-POS-11

In Pursuit of the Rotation Rates of Wolf-Rayet Stars, **Andre-Nicolas Chene** and N.S. St-Louis, *Université de Montreal* — Les étoiles chaudes et massives ont un taux de perte de masse très important (jusqu'à 10-5 MSolaire an-1), sous la forme d'un vent stellaire engendré par la pression de radiation (force exercée par la lumière sur la matière). Les étoiles Wolf-Rayet (WR), qui sont les descendantes des étoiles O (les étoiles les plus massives de la Séquence Principale de brûlage d'hydrogène), possèdent les vents stables les plus intenses (voir fig.1). Cette épaisse couche de matière nous empêche de voir l'étoile elle-même, dont il est, par ce fait, difficile d'en déterminer les paramètres. En particulier, le taux de rotation des étoiles WR est pratiquement inconnu. Comme des modèles récents d'évolution stellaire montrent que le taux de rotation est un paramètre crucial dans la vie de ces étoiles (Maeder & Meynet 1996), il est important de le déterminer par des observations. Or, pour certaines étoiles, il est maintenant bien connu que des perturbations à la surface, tel des pulsations stellaires ou des taches magnétiques, se propagent dans le vent en engendrant des structures à grande échelle qui ont une densité inférieure ou supérieure à la moyenne (voir fig.2). La rotation entraîne ces structures, appelées Régions d'Interaction en Co-rotation (CIR en anglais), en générant des spirales dans le vent. Cela se traduit par des variations périodiques dans les raies spectrales d'étoiles apparemment isolées (voir fig.3 tirée de la thèse de T.Morel, 1999). En étudiant ces variations, il est donc possible de déduire le taux de rotation des étoiles WR, tant attendu par les modèles.

MO-POS-12

Defining the Orbit and Distance to WR140, **Sean Dougherty** [1], N.J. Bolingbroke [1], A.J. Beasley [2] and M.J. Claussen [3], [1] *National Research Council*; [2] OVRO and [3] NRAO — Milliarcsecond resolution VLBA observations of the archetype colliding-wind WR+O star binary system WR140 reveal the wind-collision region as a bow-shaped arc of emission that rotates as the highly eccentric orbit progresses from phase 0.74 to 0.95 (Beasley *et al*., in prep). Assuming that the arc is symmetric about the line-of-centres of the two stars and "points" at the WR star, this rotation shows the O star moving from SE to approximately E of the WR star between these orbital phases. In conjunction with orbital parameters derived from radial velocity variations (Marchenko *et al*. 2003, *ApJ* **596**, 1295) and the recent IOTA observation of both stellar components (Monnier *et al*. 2004, *ApJL* **602**, L57), the VLBA observations allow us to constrain, for the first time, the inclination of the orbit plane as $122^\circ \pm 5^\circ$, the longitude of the ascending node as $353^\circ \pm 3^\circ$, and the orbit semi-major axis as 9.0 ± 0.3 mas. This leads to a robust distance estimate to WR 140 of 1.8 ± 0.1 kpc and mass estimates for the components of 20 ± 4 $M_\odot$ for the WR star and 54 ± 10 $M_\odot$ for the O star.

MO-POS-13

Seeking the Progenitors of Magnetic Ap/Bp stars: Detection of a Magnetic Field in Two HAEBE Stars*, **Dominic Drouin** [1], S. Bagnulo [2], J.D. Landstreet [3], E. Mason [2], D.N. Monin [3] and G.A. Wade [1], [1] *Royal Military College of Canada*, [2] ESO Chile and [3] University of Western Ontario — The Herbig Ae/Be (HAeBe) stars are widely thought to be the pre-main sequence progenitors of the magnetic Ap/Bp stars. During a very recent observing run at the ESO VLT, we carried out observations to search for direct evidence of magnetic fields in the envelopes and photospheres of a selected sample of HAeBe stars. The analysis of our data showed a 4σ detection for 2 of the 14 targets observed. These results represent a breakthrough in our understanding of the nature, origin and evolution of magnetic activity in A and B type stars by providing a crucial link between the main sequence magnetic stars and their pre-main sequence counterparts.

* This work is being supported by NSERC.

MO-POS-14

New Insights into Polaris the Cepheid, **David G. Turner**, *Saint Mary's University* — The North Star, Polaris, and the anonymous, poorly populated star cluster in which it lies, have been target objects in a newly initiated campaign of photometric observation using the Burke-Gaffney Observatory at Saint Mary's University. Polaris is one of the most curious, overlooked, and misinterpreted objects in the nighttime sky. Even its presently recognized status as the brightest known classical Cepheid variable is of fairly recent origin. Yet for the last twenty years Polaris has presented an enigma of major concern to variable star specialists: its light amplitude has been decreasing at such an alarming rate that concern was expressed that it might cease to pulsate entirely some time in the mid-1990s. As usual, Polaris stubbornly defies all expectations. Recent photometry indicates that it continues to pulsate at its standard rate of once every 4 days, but at an extremely low, perhaps still decreasing, level. The star also exhibits a rapid rate of period change that raises questions about its evolutionary status and pulsation mode: is it in the first crossing of the instability strip or perhaps the fifth crossing, does it pulsate in the fundamental mode or in an excited harmonic? Such questions are not easy to answer with certainty, and the fact that the star's distance inferred from its Hipparcos parallax is probably inaccurate does not help the situation. Main sequence fitting from its cluster membership and new studies of its period changes provide alternate estimates for its basic parameters that appear to resolve many of the questions posed above. And the North Star is also an exciting object of study for avid variable star enthusiasts with proper equipment. Where else can you see stellar evolution occurring right before your eyes?

PO-MOS-15

Synthetic Flux Spectra of Rotationally Deformed Stars, **C. Ian Short** and Catherine Lovekin, *Institute for Computational Astrophysics and Department of Astronomy and Physics, Saint Mary's University* — Due to geometrical effects and variation of stellar parameters over the surface, the flux spectrum of a star that is deformed by rapid rotation may differ significantly from that of a spherical star of stellar parameters that are fit to the observed flux spectrum. We have used the shape and variation of stellar parameters computed with a fully 2D stellar evolution code and synthetic intensities computed as a function of emergent angle with a NLTE stellar atmosphere and spectrum synthesis code (PHOENIX) to synthesize the flux spectrum of the rapidly rotating star alpha Eridani. We compare the flux spectrum of the rotationally deformed model to that of a spherical model fit to the observed spectrum and investigate the effect on derived stellar parameters of the more realistic modeling.

PO-MOS-16

Rapid Photometry of Variables in the Globular Cluster M55, **Jason Rowe**, C. Cameron, J.M. Matthews and M. Huber, *University of British Columbia* — We present results from photometry obtained with the 8 metre Gemini-South telescope for the core of the globular cluster M55. Over a 6 hour observing run, 2200 images where obtained to measure the light curve shapes of SX Phe type variables. The shape parameters are used to help identify pulsation modes for application to field variables.

MO-POS-17

Spectral Modelisation and Analysis of NGC2363-V1, An Errupting LBV*, **Véronique Petit** [1], L.D. Drissen [1] and P.C. Crowther [2], [1] *Université Laval* and [2] University of Sheffield — I will present the results of a follow up study of the LBV star NGC2363-V1 between the years 1997 and 2003. V1, discoverd in 1994 by Drissen *et al*., is presently undergoing a major outburst, associated with an increase in its mass loss rate. Spectra obtaind by the Hubble Space Telescope were modeled by the non-LTE line-blanketed model CMFGEN (Hillier and Miller 1998) to obtain the evolution in the physical paramaters of this incredible star.

* This work is being supported by Laurent Drissen.

MO-POS-18

Self-Correlation: A Useful New Tool for Analyzing the Photometric Variability of T Tauri Stars*, **John Percy** [1], W.K. Gryc [1], W. Herbst [2] and J.C.Y. Wong [1], [1] *University of Toronto* and [2] Wesleyan University, Middletown CT — T Tauri stars are irregular variable stars in an early phase of evolution where gravitational contraction to the main sequence is still taking place. The (photometric) variability is complex, and takes place on a variety of timescales, due to a variety of physical processes. There is low-level periodic photometric variability, due to the rotation of the star with active regions on its surface. The periodicity is usually investigated by Fourier analysis, but, especially if the active regions are non-permanent, this method may fail. In this paper, we use self-correlation analysis as an adjunct to Fourier analysis. Self-correlation analysis determines the cycle-to-cycle behaviour of the star, averaged over all the data. The data come from an on-line archive of T Tauri photometry, maintained by W. Herbst. Using self-correlation, we have reanalyzed T Tauri stars with known periods, to verify the periods and the applicability of the technique. We have then applied self-correlation to T Tauri stars whose periods (if any) are uncertain or unknown. The results will be described.

* This work is being supported by NSERC Canada.

MO-POS-19

Atomic Data for Resonance Lines, **Donald C. Morton**, *Herzberg Institute of Astrophysics, National Research Council of Canada* — Resonance lines, *i.e.* those transitions involving the ground state or excited levels of the ground term, have a special role in astrophysics because they will dominate the spectra of regions of low particle and radiation densities such as interstellar and intergalactic gas as well as stellar and QSO winds. Thus having reliable data on the wavelengths and transition probabilities of resonance lines is central to many astrophysical investigations. This paper summarizes the present status of the author's efforts to provide critical compilations of these data. Under the general title of "Atomic data for Resonance Absorption Lines" there are three papers:

II . Wavelengths Longward of the Lyman Limit for Heavy Elements (Ge to U), 2000 ApJS 130, 403;
III. Wavelengths Longward of the Lyman Limit for the Elements Hydrogen to Gallium, 2003 ApJS 149, 205 – an update of Paper I published in 1991; and
IV. Wavelengths between the Lyman Limit and 100 Å for the Elements Helium to Gallium, in preparation.

Experimental transition probabilities (A_{ul}) for the extreme ultraviolet region covered in Paper IV are scarce, but fortunately *ab initio* theoretical multiconfiguration calculations now can accurately predict the laboratory energies and give *A*-values consistent with laboratory measurements where checks are possible at longer wavelengths. The data in Paper IV are particularly relevant to the study of absorption lines in high-redshift QSOs.

MO-POS-20

The Degree of Contact and Other Properties of Binary Stars with Common Envelopes*, **Stefan Mochnacki**, *University of Toronto* — A compilation of models fitted using both photometric and spectroscopic data is analysed using the concepts of mean density, minimum period and transfer-corrected primary temperature. The tendency of W UMa systems to have common envelopes close to their inner Roche surfaces is shown to be be a closeness in radius rather than a function of fill-out factor. This allows the use for evolutionary studies of systems for which only spectroscopic mass ratios are available without photometric solutions; the new DDO sample of spectroscopically observed systems is analysed. An analysis of the recent Pribulla-Kreiner-Tremko catalogue is also presented.

* This work is being supported by NSERC.

MO-POS-21

2D-Modelling of the Rotation of a Rapidly Rotating Be star, **C. Lovekin** and R.G. Deupree, *Institue for Computational Astrohpysics, St Mary's Univeristy* — Recent interferometric observations of the Be star Achernar (HD10144) have found it to be extremely oblate, with an axis ratio of 2a/2b = 1.56 ± 0.05, where a and b are the best fit to the semimajor and semiminor axes for the surface shape. This ratio is very close to the limit of 1.5 for a solid body at critical rotation. Based on stellar models, Achernar is a late main sequence star and probably should not be expected to be rotating as a solid body. We have modelled rapidly rotating stars to attempt to reproduce the observed properties of Achernar using a 2D stellar evolution code. The surface of the model is assumed to be an equipotential. Calculated models rotating at critical velocity on the ZAMS have appreciably lower surface velocities when the observed T_{eff} and L of Achernar are reached. These models fail to match the observed oblateness, with ratios of 2a/2b of 1.27 to 1.36, depending on the inclination. We have also calculated models whose rotation rate increases towards the rotation axis and is constant on cylinders. These laws do make the stellar surface more oblate, although the increase in oblateness is insufficient to match the observations

MO-POS-22

The Structure of Close Binaries in 2D, **A.I. Karakas**, and R.G. Deupree, *ICA, Saint Mary's University* — Previous studies of the evolution of close binary systems have assumed that each component is spherically symmetric, even if it fills it's Roche lobe. Rotation and tidal interactions will cause the structure to deviate from spherical symmetry but it was not known in detail how large this distortion will be. Using a state-of-the-art 2D stellar structure code, we study the departure from spherical symmetry on the structure of an zero-age main sequence model of solar composition (Z = 0.02). We assume that the companion is a gravitational point source and in a circular orbit. We present preliminary results of the structure of an 8$M_\odot$ primary with a 5$M_\odot$ point-source secondary companion. We have also begun to study the effect of the primary on the secondary, by calculating the case with 5$M_\odot$ with an 8$M_\odot$ companion. In each case we assume that the separation is 20$R_\odot$. We plan to perform evolutionary calculations on these models, evolving to the point where the primary fills it's Roche lobe. At this point this model may serve as a starting point for a study of mass loss from the primary. Future work will be to study the effect each binary star has on the structure of the other by assuming that neither star is a gravitational point source and calculating the structure of both components simultaneously.

MO-POS-23

The Faint End Of The Luminosity Function In The Core Of The Coma Cluster: A Data Mining Case Study, **Margaret L. Milne** and C.J. Pritchet, *University of Victoria* — We present optical measurements of the faint end of the luminosity function (LF) in the core of the Coma cluster. The archives of the Hubble Space Telescope were mined for images of the Coma cluster and of the field; number counts were determined from these and used with the method of statistical background subtraction to determine the luminosity function to m_R = 25.75. This is the faintest determination of Coma's LF to date, and also marks the first time that HST images have been used to construct Coma's LF. Evidence is found for a steep faint end slope with alpha approximately equal to -2. The process of creating the LF and the implications of the result will be discussed, with an emphasis on the role data mining can play in this field of study.

MO-POS-24

Stellar Atmospheres with Abundance Stratifications, **Dmitry Monin** and F. LeBlanc, *Université de Moncton* — Strong non-uniform distributions of chemical elements as a function of optical depth (*i.e.* chemical stratification) are observed in some chemically peculiar stars. Diffusion processes acting in their atmosphere is most likely responsible for the stratification. Model atmospheres including self-consistent vertical element abundance gradients produced by diffusion are presented here. These models are based on a modified version of the multi-purpose atmospheric code PHOENIX. The changes to the atmospheric structure due to the abundance gradients are shown. Possible applications to different stars are also discussed.

MO-POS-25

Probing Sunspot Magnetic Fields with Solar Oscillations, **Ashley Crouch** [1] and P.S. Cally [2], [1] *Université de Montréal* and [2] Monash University — Sunspots absorb and scatter incident f- and p-modes. Until recently, the responsible absorption mechanism was uncertain. The most promising explanation appears to be conversion to slow magnetoacoustic-gravity waves and Alfven waves, which carry energy down the magnetic field lines into the interior. Assuming uniform vertical magnetic field, this mechanism easily explains f-mode absorption, but cannot fully account for observations of (higher order) p-modes. Recent calculations show that p-mode absorption produced by simple sunspot models with non-vertical magnetic fields is ample to explain the observations. In fact, the resultant p-mode scattering by such models is in remarkable agreement with observations. This excellent agreement allows some degree of probing of subsurface magnetic field strengths (*i.e.*, visualizing the invisible). Here, we present results from the best sunspot models currently available and discuss their implications for subsurface magnetic field structure.

MO-POS-26

Models of Rotating Delta Scuti Stars, **R. Deupree**, *Institute for Computational Astropyhysics and Department of Astronomy and Physics, Saint Mary's University* — Delta Scuti stars are viewed as prime candidates for probing the internal structure of stars by matching multiple pulsation modes. The task is formidable because mode identification is not trivial when there are only a comparatively small number of modes observed and because a number of delta Scuti stars rotate sufficiently rapidly that their structure cannot be modeled with the same degree of confidence as can the structure of nonrotating stars. This work presents a first step with the full 2D calculation of rotating models of delta Scuti stars. It is expected that these models will for the basis of calculating rigorous linear, adiabatic, nonradial pulsation periods using the approach of Clement (ApJS, 116, 57). Pulsation mode results for ZAMS models for presented for several rotation rates.

MO-POS-27

Causality and the Collimation of Astrophysical Jets*, **Heather Cameron** and C.D. Matzner, *University of Toronto* — Collimated jet-like outflows are associated with many astrophysical objects, ranging from protostellar objects to active galactic nuclei. Although magnetic fields are implicated in launching and shaping these flows, and many theoretical models have been offered for them, fundamental questions remain to be resolved. What, for instance, is necessary for collimation — would the Solar wind collimate if there were no heliopause? In both Newtonian and relativistic winds, collimation requires causality: information must cross streamlines. At the same time, information flow is restricted by the acceleration that accompanies collimation. We use the method of characteristics to derive preliminary results on the links between collimation, acceleration, and the causal structure of magnetized winds.

* This work is being supported by University of Toronto.

MO-POS-28

The Relation Between Supermassive Black Holes and their Environments*, **X.Y. Dong** and M.M. De Robertis, *York University* — In order to study the origin and maintenance of activity in galactic nuclei, we consider a sample of 118 spiral galaxies from a variety of morphological stages from Ho *et al.* (1997) to search for correlations among active parameters such as emission-line properties, and parameters associated with the host galaxy. After first calibrating a *K*-band relation between the bulge and central black hole masses: $\mathrm{Log}_{10}[M_{BH} / M_{sun}] = (-0.413 \pm 0.061)\, M_K + (-1.704 \pm 1.442)$, we determine the central black hole masses for these galaxies from *K*-band bulge magnitudes M_K measured from 2MASS data, and using the two-dimensional decomposition routine GALFIT. The parameters that correlate extremely well with black-hole mass include: narrow emission-line width, various emission-line ratios, and the inclination-corrected 21 cm line width for the galactic disk. A list of other pairs of parameters that show good correlations also described. The IRAS 25, 60 and 100 μm luminosities correlate well with the Hα (narrow-line) luminosity. There are also interesting correlations between the IR flux ratios and the

Hα luminosity. We also present the distributions of active and non-active parameters as a function of morphological type, *T*. Bulge luminosities (and black hole masses) are larger in early type spiral galaxies, but with a significant scatter. The absolute *K*-band bulge magnitude is $M_K = (0.3528 \pm 0.1413)\ T + (-22.7378 \pm 0.4277)$. As we discuss, this is undoubtedly a major reason why Seyfert galaxies are discovered primarily in early type spirals. The distributions for Sc galaxies are often markedly different from the distributions in earlier types.

* This work is being supported by NSERC.

MO-POS-29

The Optical And Infrared Emission Of The Magnetar 1E 1048*, **Martin Durant** and M.H. van Kerkwijk, *University of Toronto* — In the magnetar model for anomalous X-ray pulsars (AXPs), the superstrong magnetic field of the neutron star causes currents to traverse the magnetosphere. Optical and infrared emission is produced when ions absorb X-rays from the stellar surface and are promoted into high Landau excitation states, energy which is then released as the ion de-excites. Since the energy of the Landau levels and the radiative timescale both depend on the local magnetic flux density, the magnetic mirroring effect causes a sharp cutoff in the spectrum; and since the current causes the toroidal component of the exterior magnetic field, a relationship between the infrared/optical flux and the X-ray flux and timing torque are expected. I will present photometric data taken with Magellan and the VLT of 1E 1048, and compare these to other AXPs and specifically to the questions raised above.

* This work is being supported by Martin Durant.

MO-POS-30

XMM-Newton Observation of the High Magnetic Field Radio Pulsar B0154+61, **Marjorie Gonzalez** [1], V.M. Kaspi [1], A.G. Lyne [2] and M.J. Pivovaroff [3], [1] *McGill University*, [2] University of Manchester and [3] Space Sciences Laboratoy, UC Berkeley — We present results from a deep X-ray observation of the radio pulsar B0154+61 performed with the XMM-Newton satellite. The pulsar has a characteristic age of 20.5 kyr, a rotation period of 2.3 seconds and an inferred dipole surface magnetic field strength of 2.1×10^{13} G, some of the highest values in the radio pulsar population. Our analysis shows that no X-ray emission is detected from the position of B0154+61 with XMM-Newton. Using a blackbody model, the derived upper limits on the pulsar's temperature and luminosity are <73 eV and $<1.4 \times 10^{32}$ ergs s^{-1}, respectively (assuming a distance of 1.7~kpc and a column density $N_H < 3 \times 10^{21}$ cm^{-2}). When compared to the values predicted by neutron star cooling models, the above limits are found to favor those requiring rapid cooling, especially when corrections for the presence of a light-element atmosphere and relatively high magnetic field on the neutron star are made. However, the uncertainties in distance, column density and atmospheric composition prevent a definite conclusion. In addition, the limits on the temperature and luminosity of B0154+61 are found to be much lower than those exhibited by the "anomalous X-ray pulsars" (AXPs), although their spin characteristics are comparable, thus leaving unanswered the question of a radio pulsar/AXP connection.

MO-POS-31

A Gemini Observation of the Anomalous X-Ray Pulsar 1RXSJ170849 –400910*, **Jennifer West** and S. Safi-Harb, *University of Manitoba* — The anomalous X-ray pulsars (AXPs) represent a growing class of neutron stars discovered at X-ray energies. Unlike the Crab-like pulsars, they are radio-quiet, slow X-ray rotators, and have an X-ray luminosity higher than their rotational spin-down power. The two competing models proposed to explain their anomalous nature invoke either accretion from a low-mass companion or a disk, or an ultra-magnetized neutron star (magnetar). In the past few years, evidence has been accumulating in favor of the magnetar model, making AXPs and the Soft Gamma-Ray Repeaters among the strongest magnets in the Universe. Infrared observations offer a tool to test these models and study the variability of these objects. 1RXSJ170849-400910 is a relatively bright AXP which was discovered with the ROSAT X-ray satellite, and later found to be an 11 s X-ray pulsar by the ASCA X-ray satellite. Recently, Israel *et al*. (2003) reported the detection of the likely IR counterpart to 1RXSJ170849-400910 using a deep observation the ESO and CFHT telescopes. We will here present a Gemini observation of 1RXSJ170849-400910 obtained with Flamingos, the Gemini-South near-IR imager, in J (1.25 um), H (1.65 um), and K (short) (2.15 um), and compare our result with that of Israel *et al*.

* This work is being supported by NSERC and URGP.

MO-POS-32

Near InfraRed Detection of the Anomalous X-Ray Pulsar 1E 2259+586, **Cindy Tam** [1], V.M. Kaspi [1], M.H. van Kerkwijk [2] and M. Durant [2], [1] *McGill University* and [2] University of Toronto — On June 18 2002, the Anomalous X-ray Pulsar AXP 1E 2259+586 underwent a major X-ray outburst that lasted several hours and consequently linked AXP's to another class of high-energy bursting objects, called Soft Gamma-ray Repeaters (SGR). This was predicted uniquely by the "magnetar" model, in which these two classes are ultrahigh magnetic field, isolated young neutron stars. A few days after this outburst, Target of Opportunity observations were obtained with the Gemini North Near-InfraRed Imager (NIRI), followed by a longer term monitoring program of the IR variability that spanned nearly one and a half years. It was observed that shortly after the burst, the pulsar's Ks band flux dramatically increased relative to its pre-burst flux level, prompting the question "does the IR luminosity of 1E 2259+586 constantly undergo fluctuations, or can this brightening be undeniably associated with the X-ray outburst?" We present the results of our IR analysis, and relate them to the results of previous X-ray studies. There was no evidence for variability apart from that seen immediately after the outburst, implying the IR fluctuation was definitely associated with the outburst. Also, we discuss the effect that our findings might have on current AXP theoretical models.

MO-POS-33

The Study of a Puzzling Galactic Supernova Remnant and The Discovery of an Active Galactic Nucleus in its background yard*, **Samar Safi-Harb** [1], U. Hwang [2], R. Petre [2], S.S. Holt [3] and P. Durouchoux [4], [1] *University of Manitoba*, [2] NASA/GSFC, [3] Olin College and [4] Saclay, France — G41.1-0.3 is an intriguing supernova remnant with an unusual morphology and properties. In our previous X-ray study of this remnant, we suggested that it is the result of a type II supernova explosion; however no pulsar has been yet found to be associated with it. We report on our Chandra spatially resolved spectroscopic study of the remnant, and correlate its X-ray emission with the radio and millimeter observations. We then address its unusual morphology and discuss its properties in the light of a shock wave interacting with an inhomogeneous medium. The burning question about G41.1-0.3 remains: where is its compact stellar remnant? While searching for a compact object, we discovered an X-ray pointsource just outside the remnant. We discuss the nature of this new source andargue that it is a nearby Seyfert II Active Galactic Nucleus.

* This work is being supported by NSERC, NASA.

MO-POS-34

Long Term Timing Observations of the Young, Energetic Pulsar PSR B1509-58, **Margaret Livingstone** [1], V.M. Kaspi [1] and R.N. Manchester [2], [1] McGill University and [2] ATNF - We present results from the long-term timing observations of the young, energetic pulsar PSR B1509-58. We present a phase-coherent analysis of 21 years of timing data from the Molonglo and Parkes Radio Observatories and the Rossi X-Ray Timing Explorer. We have measured the frequency derivative as well as higher order frequency derivatives to test the conventional model of pulsar spin-down given by $\dot{\nu} = K\nu^n$, where ν is the frequency of the pulsar, is the frequency derivative, $\dot{\nu}$ is a constant related to the magnetic field of the pulsar and n is the 'braking index'. Using a partially phase-coherent timing analysis, we have measured a braking index consistent with previous measurements. We also measure the value of the third frequency derivative to be inconsistent with the simple spin-down law for pulsars, possibly indicating a time-dependent magnetic field.

MO-POS-35

PSR J1740-5340 Promises and Surprises*, **Fernando Pena** and M.H. van Kerkwijk, *University of Toronto* — Bright stars which are binary systems where the other component is a neutron star are very useful as a tool to constraint pulsar's masses. Different equations of state (EOS) will give different values slightly grater then the current 1.35 $M_\odot$ depending in the type of interactions between particles at the core and depending in the mass accreted. In the particular case of the binary system PSR J1740-5340 the companion is a bright (V~17) Non-MS star (we called it "red straggler") which partially fills its Roche lobe ($R/R_{RocheLobe} \leq 1$), the orbital period is 1.35 days. The system is in the globular cluster NGC 6397 (mean velocity ~ 18 km/s) and the pulsar has a period of 3.5 ms (MSP). I will present high resolution VLT/UVES spectra (~24 nights covering different orbital phases). From these I will show the radial and rotational velocities of the companion star, and assuming some models I will present the mass ratio (already done, $M_{PULSAR}/M_{COMP} \sim 5.7$), the inclination angle of the orbit (in progress but will be finished by the time of the congress), and finally the mass of the binary components (MSP and companion). Together with the mass measurement I will discuss some interesting puzzles of this system, most of them related to the lack of heating showed by companion's light curve (which is purely sinusoidal, because of its tidal deformation), strange because we expect some influence of the pulsar's irradiation on the –very close- companion's atmosphere.

* This work is being supported by University of Toronto.

MO-POS-36

A Chandra Observation of the W50 Nebula Associated with SS433, **A. Moldowan** and S. Safi-Harb, *University of Manitoba* — The X-ray binary system SS433/W50 has baffled astrophysicists since its discovery in 1979. W50 has been classified as a Galactic supernova remnant that harbors SS433, an X-ray binary consisting of a compact object accreting matter from a companion star at a super-Eddington rate. The nature of the compact object is still unknown, but it is expelling relativistic jets that interact with W50, causing it to elongate along the jets axis and forming the X-ray lobes. We have studied this system with ROSAT, ASCA, RXTE and, most recently, Chandra. A 75 ksec Chandra observation will be presented for the western lobe of W50. This observation and the corresponding analysis will be compared to the observations made by ASCA and ROSAT of the western lobe, as well as the eastern lobe of W50. The Chandra data will also allow a spatial resolution of thermal and non-thermal emission from the shock-excited regions in the remnant.

MO-POS-37

The Plerionic Supernova Remnant G21.5-0.9: In and Out*, **H. Matheson** and S. Safi-Harb, *University of Manitoba* — The Crab nebula has been viewed as the prototype for a pulsar-wind nebula or a plerion. Today, we know of about a dozen Galactic plerions. The absence of a supernova remnant (SNR) shell surrounding the Crab and other plerions is still a mystery. G21.5-0.9 is an intriguing plerionic SNR. Early Chandra observations revealed a faint extended X-ray halo, which was suggested to be the missing shell of the

SNR. Safi-Harb *et al*. (2001) show however that the X-ray emission from this extended halo is non-thermal, unlike what would be expected from an SNR shell. They suggested that the extension could be indicative of a larger than previously thought plerion and/or due to a dust scattering X-ray halo. In the former scenario, G21.5-0.9 would be the only plerion which has a larger size in X-rays than in the radio. Since G21.5-0.9 is a calibration target for Chandra, there is a large amount of data available. We will present our analysis of 207 ksec of data obtained with the High-Resolution Camera and 450 ksec of data acquired with the Advanced CCD Imaging Spectrometer. We will show the results of our deep search for thermal emission and discuss the nature of the X-ray halo in the light of the proposed models. We will also put further constraints on the parameters of the putative pulsar powering G21.5-0.9.

* This work is being supported by NSERC.

MO-POS-38

X-Ray Aurora in Magnetosphere of Accreting Neutron Stars*, Vahid Rezania, John C. Samson and **Peter Dobias**, *Theoretical Physics Institute* — In this study we propose a new generic model for quasi periodic oscillations (QPOs) based on oscillation modes of neutron star magnetospheres. We argue that the interaction of the accretion disk with the magnetosphere can excite resonant shear Alfven waves in a region of enhanced density gradients. We demonstrate that depending on the distance of this enhanced density region from the star and the magnetic field strength, the frequency of the field line resonance can range from several Hz (weaker field, farther from star), to approximately kHz frequencies (stronger field, ~ 6-10 star radii from the star). We show that such oscillations are able to significantly modulate inflow of matter from the high density region toward the star surface, and possibly produce the observed X-ray spectrum. In addition, we show that the observed 2:3 frequency ratio of QPOs is a natural result of our model.

* This work is being supported by NSERC.

MO-POS-39

The Search for Supernova Remnants Using the International Galactic Plane Survey Data*, **Ashish Asgekar** [1], Samar Safi-Harb [2] and Roland Kothes [2], [1] *University of Manitoba* and [2] Dominion Radio Astrophysical Observatory, NRC — The International Galactic Plane Survey (IGPS) has in the past few years demonstrated its remarkable sensitivity towards low-surface brightness, extended structures, like supernova remnants (SNRs). We are searching for new SNRs targeting the positions of already-known pulsars in the IGPS data. Two candidates were identified by comparing the IGPS 20-cm images with the archival images from other surveys, such as the NVSS and IRAS. We will present their polarized intensity and spectral index maps obtained with the archival VLA data, and search for their X-ray counterparts.

* This work is being supported by IGPS.

MO-POS-40

Correlating Dust Properties with Star Formation and the ISM in the BIMA SONG Survey, **Scott Brooks** and C. Wilson, *McMaster University* — We present preliminary results from the analysis of 450 and 850 micron SCUBA jiggle maps of a selection of galaxies from the BIMA SONG catalog. Our observations are sensitive to the continuum emission due to cool dust, which can be correlated with the gas emission to determine empirically what the relative importance is to the continuum emission of changes in the dust mass versus changes in the dust heating due to nearby star formation.

MO-POS-41

The Spatial Distribution and Extraordinary Extinction Law in Optical Nebulae of the 2nd Quadrant, **Tyler Foster** [1] and R. Kothes [2], [1] *Herzberg Institute of Astrophysics, National Research Council*, [2] University of Calgary, HIA/NRC — We have constructed a new map of the Galactic Plane Region $90° \leq \ell \leq 180°$, $-3.5° \leq b \leq 5.5°$ using new non-photometric distances to ~70 HII regions, from the technique of Foster & Routledge (2003). We present new radial velocity measurements for each region using Canadian Galactic Plane Survey HI and ^{12}CO data, as well as published Ha line surveys. The most noticeable result is that the clear majority of these optically catalogued nebulae (c.f. Sharpless 1959) are residents are the Perseus Arm, the nearest major spiral arm to the Sun. Many of these regions form a striking "chain" that follows the Arm's inner edge. Some others are Local Arm inhabitants, while Sh-127 (d = 6.2 kpc) is likely an Outer Spiral Arm member. Published photometric distances to many HII regions (particularly those near the Galactic anticentre, $150° \leq \ell \leq 180°$ suggest that they are scattered irregularly throughout the disk, a picture inconsistent with the accepted model of their formation in "chains" along Spiral Arms. We show that most of these HII regions are surrounded by layers of dust, and that the value of total-to-selective extinction $R_V = A_V /E(B - V)$ in the involved dust is greater than the canonical ISM value of R_V = 3.1. The anomalous photometric distances of these HII regions are likely the result of observing their exciting star(s) through these dense shells of dust, where we measure R_V to range from 3.2 to more than 7. This abnormal extinction law particularly affects the distance modulii of those regions toward the anticentre, where extinction due to associated dust equals or exceeds that due to foreground material.

MO-POS-42

Pulsar-Based Galactic Magnetic Field Mapping: A Small Annulus With An Anti-Clockwise Magnetic Field, In A Large Disk With A Clockwise Magnetic Field, **Jacques P. Vallee**, *National Research Council Canada - Herzberg Institute of Astrophysics* — A new pulsar-based model for the structure of the Milky Way's magnetic field is obtained, by using both the rotation measure and the dispersion measure of over 350 pulsars in the Milky Way. The model holds true separately for pulsars above the galactic plane, and for pulsars below the plane. In this pulsar-based model, an overall clockwise-going magnetic field (as seen from the North Galactic Pole) extends radially at least from 1 to 12 kpc from the Galactic Center, except for a 2-kpc wide anti-clockwise magnetic field located in a radial annulus between 4 and 6 kpc from the Galactic Centre. Here the magnetic field is not attached to any specific spiral arm. The origin of this unique anti-clockwise annulus could be due to a number of factors (internal or external) or could be primordial (regular or chaotic). The new model has a very special feature in the form of a string of HII regions located in the anti-clockwise annulus, and it may be a new class of "axisymmetric (ASS) magnetic field" models. The new model disagrees with recent pulsar studies that employed several magnetic reversals in the inner Galaxy, and some more in the outer Galaxy [the "bisymmetric (BSS) field" model].

MO-POS-43

Fourier Transform Spectroscopy of Orion Molecular Cloud, D.A. Naylor [1], **M.K. Tahic** [1], B.G. Gom [1], G.R. Davis [2] and D. Johnstone [3], [1] *University of Lethbridge*, [2] JAC and [3] Herzberg Institute of Astrophysics — The Orion molecular cloud is the most studied region of star formation in our galaxy. Recent SCUBA images at 450 & 850 mm reveal a variety of structures including candidate pre-stellar cores, cores containing Class 0 protostars, shocks and PDR fronts. In the last few years, we have been using a Fourier transform spectrometer (FTS) at the James Clerk Maxwell Telescope (JCMT) to separate the line and continuum components of emission in the two brightest sources of the Orion Molecular Cloud: KL and S. In December 2000 we obtained complete spectral scans of the 850 mm band of Orion KL and S with the JCMT heterodyne receiver B3. In October 2002 and April 2003 we obtained spectral scans of the 850 mm band of Orion KL with the University of Lethbridge Fourier Transform Spectrometer. These spectra will be compared to determine the potential for measuring, simultaneously, both the line and continuum emission components of galactic sources using the FTS currently under development for use with the SCUBA-2 detector.

MO-POS-44

A Galactic Chimney Over the W47 HII Region Complex, **Jeroen Stil**, R. Ouyed and A.R. Taylor, *University of Calgary* — We present new 21-cm line and 21-cm continuum from the VLA Galactic Plane Survey (VGPS; Taylor *et al*. 2002) of the Galactic star formation region W47 and the associated worm GW 38.0+1.6. The edge of this region is a 200 pc long vertical filament observed in the 21-cm line and 21-cm continuum. The location of this filament and the radio recombination line velocity of the ionized gas associate the filament with the W47 complex at V_LSR = 50 km/s. The shape of the filament can be represented by a Kompaneets model with W47 as the source that encloses the GW 38.0+1.6 area. However, the HI filament is detected at V_LSR = 0 km/s. The location and velocity of the HI suggest a velocity component of 50 km/s perpendicular to the expansion velocity of the super bubble. We have initiated 3-dimensional magnetohydrodynamic simulations of a superbubble bursting out of the Galactic disk to obtain insight into the physics of this surprising result.

MO-POS-45

Imaging Cold Dust in the Galactc Plane, **Henry Matthews** [1], B. Weferling [2], A. Evans [3], M. Cohen [4], J. Jackson [5], R. Simon [5], D. Johnstone [6], G. Davis [2], T. Jenness [2], D. Pierce-Price [2], W. Dent [7], J. Richer [8] and G. Fuller [9], [1] *National Research Council of Canada*, [2] JAC Hawaii, [3] Keele University, UK, [4] Berkeley University, [5] Boston University, [6] HIA/NRC, [7] UKATC, UK, [8] MRAO, UK, [9] UMIST, UK — We present images of continuuum emission at 850 and 1200 microns wavelength from a section of the Galactic Plane centered near longitude 44 degrees. These data were obtained from complementary observations made with the JCMT and SEST bolometer array receivers, with beamwidths of about 14 and 22 arcsec respectively. The features seen arise principally from cold dust in two spiral arms at about 1.5 and 8kpc distant from Earth; dust is optically thin at mm/submm wavelengths. These data are compared with existing spectral line data having similar angular resolution, which allow kinematic distances to be assigned to individual features. Comparison with images at mid-infrared wavelengths is also revealing. These data presage the potential of large-scale survey observations with forthcoming instrumentation such as SCUBA2 and HARP/ACSIS at the JCMT.

MO-POS-46

HI Shells Surrounding The Cygnus Loop*, **Denis Leahy**, *University of Calgary* — The Cygnus Loop supernova remnant has been observed in the 21 cm neutral hydrogen (HI) line with the Dominion Radio Astrophysical Observatory's (DRAO) Synthesis Telescope and 26 m Telescope. A search through the dataset reveals large structures associated with the Cygnus Loop in position and velocity. A large ring feature extends from the southeast rim into the center of the Cygnus Loop. Another large structure is found which wraps around the southern and western limb of the southern extension of the Cygnus Loop. Both structures have been identified in the IRAS all-sky survey maps of the region, allowing both HI and dust column densities to be determined as a function of position. The velocity structure of the HI is studied and used to constrain the origin of the HI.

* This work is being supported by NSERC.

MO-POS-47

A Huge Magnetic Bubble In The Anti-Centre Region Of The Milky Way, **Roland Kothes**, and T.L. Landecker, *Dominion Radio Astrophysical Observatory*, *University of Calgary* — We present the discovery of a large magnetic bubble in the data of the Canadian Galactic Plane Survey. This structure is revealed by rotating the polarization angle of the smooth Galactic background polarization. The magnetic bubble is surrounded by an HI bubble with a systemic velocity of about -20 km/s implying a Perseus arm location. At this distance the bubble has a diameter of about 300 pc. At the northern edge of the bubble is the SNR VRO 42.05.01, which is the remnant of a supernova that happened just outside the edge of the bubble. This is not only the first time a Faraday screen can be related to an HI structure, but also gives us the opportunity to directly study the interaction of the supernova shock wave with the HI bubble and the embedded magnetic field.

MO-POS-48

Propagating Star Formation Around Single O-star HII Regions, **Charles Kerton** [1], Lewis Knee [2] and Christopher Brunt [3], [1] *Iowa State University,* [2] *HIA* and [3] *UMass/FCRAO* — The vast majority of stars of all masses form in regions in which rare but prominent high mass O stars are born. It is thus important to understand the processes and modes of star formation in the harsh environment of HII regions and PDRs around O stars. We present the initial results of our sub-mm (JCMT SCUBA) observations of small angular size HII regions designed to examine how star formation propagates through a molecular cloud surrounding an HII region. Our targets are a carefully chosen sample of eight small (~10 arcmin in diameter) HII regions each excited by a single O star. The SCUBA observations are being combined with near-IR (2MASS), mid-IR (MSX), mm (FCRAO) and cm (DRAO) observations to determine the spatial distribution of molecular cores and the embedded stellar population throughout the surrounding molecular cloud. The small size of the HII regions permits easier acquisition of the multiwavelength data needed to trace all of the relevant physical components (HI, HII, molecular gas, and stars) which enables the entire physical chain from triggering source to emerging stellar population to be investigated.

MO-POS-49

The Kinematics of Massive Star-Forming Region NGC 7538*, **Michael Reid** [1], C. Wilson [1] and B. Matthews [2], [1] *McMaster University* and [2] University of California at Berkeley — Progress in understanding star formation increasingly comes through an understanding of the kinematics of star-forming regions and cores. Much is known about the kinematics of low-mass regions and cores, but less about their higher mass counterparts. One such region in our galaxy, NGC 7538, is the home of a spectacular class 0 core candidate, NGC 7538, which has a young outflow and disk of several hundred solar masses (Sandell, Wright, & Forster 2003, ApJ, 590L, 45). We are studying the massive young cores of NGC 7538, with an eye toward their kinematic properties. We have acquired SCUBA continuum maps at 850 and 450 microns of the entire region, as well as high-resolution BIMA and VLA line maps of select cores in up to seven different molecular kinematic probes. Analysis of this data is proving complex, but we present some preliminary results here.

* This work is being supported by NSERC.

MO-POS-50

Characterizing the Outflow of W28A2, **Pamela Klaassen** [1], R. Plume [1], R. Ouyed [1] and J. DiFrancesco [2], [1] *University of Calgary* and [2] Herzberg Institute of Astrophysics — The formation of high mass stars is less well understood than that of lower mass stars due to the shorter time scales and larger distances involved. One of the earliest stages of high mass star formation consists of a period of outflow which can be studied through its impact on its environment. We present observations of W28A2, a shell like Ultracompact HII region associated with one of the youngest and most energetic outflows in the Galaxy (O6 star). Using the James Clerk Maxwell Telescope, we have observed the outflow in a number of transitions and have derived the age, mass, extent, and velocity of the outflow. In order to better constrain the driving mechanism of the outflow, we have conducted magneto-hydrodynamic simulations (using Zeus-MP and Jetget) of a high-velocity jet impacting on a surrounding molecular envelope.

MO-POS-51

Mapping the Sprial Structure of the Milky Way Galaxy*,**Saul Davis** [1], H.B. Richer [1], J.S. Kalirai [1], G. Fahlman [1], G. Bono [2] and M. Cignoni [3], [1] *Universtiy of British Columbia*, [2] Osservatorio di Roma and [3] Universita degli Studi di Pisa — The details of the spiral structure of the Milky Way remain poorly understood. This project attempts to provide us with a more complete picture of our own Galaxy - We have obtained images of 19 open clusters in the disk of the Milky Way. These clusters are predominantly in the quadrant of the Galaxy opposite to the Galactic center ($135° < l < 225°$), and over half are at low latitude ($b < 5°$). The images were obtained with CFH12k, for the CFHT Open Star Cluster Survey, and represent a unique data set in terms of area (0.22 square degrees per image) and depth (V~23) in this region of the sky. The colour-magnitude diagrams (CMDs) of the various lines of sight look markedly different. Most obvious, is the difference between the lines of sight with $b > 5°$ and those with $b < 5°$, yet more subtle distinctions appear between the low-latitude lines of sight with are presumably attributable to the presence of spiral arms. By simulating CMDs we hope to be able to constrain various parameters that describe the Galaxy, such as scale-length and scale height of the disk, star formation history of the disk, initial-mass function of the halo, and finally, the precise location and extent of the spiral arms. Early results will be presented.

* This work is being supported by UBC.

MO-POS-52

Infrared Imaging of Protoclusters in the Orion B Molecular Cloud, **Ashley J. Ruiter** and George F. Mitchell, *Saint Mary's University* — Sub-millimetre mapping of Orion B using SCUBA (Mitchell *et al*. 2001, ApJ, 556, 215) has revealed a large population of compact cores, most of which are clustered in well-separated regions. In three nights in January 2003, we obtained near-infrared images of two of these regions. Using the CFHT-IR camera on the Canada-France-Hawaii telescope, we imaged NGC 2068 and NGC 2071 in a narrow band K-continuum filter, and in a narrow band filter centred on the 2.122 μm line of H_2. This vibrational H_2 line is a well-known diagnostic for shocked gas and radiatively excited gas. When it is observed in regions of active star formation, the exciting mechanism is often shock excitation by an outflow. The IR images show continuum point sources (stars), and regions of extended molecular hydrogen emission. Some cores show a coincident infrared source, while others show no sign of an associated IR source. The latter situation is an indication that the core in question, if containing a forming star, is deeply embedded. Since deeply embedded pre-stellar cores will have no obvious associated K narrow band emission, the H_2 map and a CO map of high-velocity gas are useful probes of the physical processes which are taking place in the vicinity of each core. We will present the H_2 and K continuum images, comparing the emission with the SCUBA map and with a previously obtained map of CO. In particular, we will discuss the implications of these new observations for the evolutionary state of the SCUBA cores.

MO-POS-53

Starlight Excitation Of Permitted Lines In The Orion Nebula*, **Kevin Blagrave** and P.G. Martin, *CITA, University of Toronto* — Robust abundance calculations for gaseous nebulae require knowledge of line formation mechanisms for a multitude of lines, encompassing both permitted and forbidden. Permitted lines are usually associated with cascades after recombination. However, there is often a sizeable (or even overwhelming) contribution from fluorescence processes (*e.g.*, excitation by starlight). Here, using data from deep optical echelle spectroscopy, we confirm (and extend the analysis of) the line formation mechanisms which had been predicted for permitted lines of several ions. We develop a completely independent method based on the ionization and velocity structure of the Orion Nebula as determined from forbidden lines in the context of photoionization models.

* This work is being supported by NSERC.

MO-POS-54

Molecular Hydrogen in a Sample of Cooling Flow Clusters **Louise Edwards** [1], C. Robert [1] and F. Marleau [2], [1] *Université Laval* and [2] SIRTF Science Centre — We present imaging data of the cooling flow clusters Abell 644, Abell 400 and Abell 1795 taken with CFHT-IR in the infrared. These clusters are all cooling flows of moderate mass deposition rates (200, 100 and 10 solar masses per year, respectively). With proper data reduction, the use of narrow band filters can provide the 1-0 S(1) emission line of molecular hydrogen. For Abell 1795, we report the molecular hydrogen flux of the central dominant galaxy, as well as discuss the first detections of molecular hydrogen emission found in cooling flow cluster galaxy other than the CDG. We describe the emission morphology of the CDG emission found for Abell 1795 and relate it to possible emission mechanisms. We compare our measurements with Donahue et al. (2000) who have published similar work for three other cooling flow clusters. For Abell 400 and Abell 644 we present the preliminary results of our data analysis.

MO-POS-55

Studies of an Intergalactic Neutral Hydrogen Cloud, **Jayanne English** [1], B. Koribalski [2] and K.C. Freeman [3], [1] *University of Manitoba*, [2] Australia Telescope National Facility and [3] RSAA, Australian National University — An intergalactic HI cloud of a few billion solar masses, previously detected using the Parkes Radio Telescope and the Australia Telescope Compact Array (ATCA) (English 1994; Freeman *et al*. 1996), has been confirmed in further ATCA observations of the NGC 3256 galaxy group. The group contains the prominent merging galaxy NGC 3256, which is surrounded by a number of HI fragments (English *et al*. 2003), the tidally disturbed galaxy NGC 3263 (Koribalski *et al*., in prep.), and several other galaxies. Using ATCA HI data we examine the nature of this massive gas cloud and its relationship to the neighbouring galaxies. This could be a primordial "galaxy building block". However the cloud's properties, in conjunction with the spatial extents and velocity behaviours of the group's major galaxies, may indicate that it originated out of tidal debris.

MO-POS-56

A Gallery of Galaxies in the Hubble Deep Field South, **Theresa Wiegert** [1,2], D.F. de Mello [3] and C. Horellou [2], [1] *University of Manitoba*, [2] *Onsala Space Observatory*; and [3] Goddard Space Flight Center — We have applied a photometric redshift technique using spectral energy distribution templates to the WFPC2 images of the Hubble Deep Field South. As a result, a catalogue of 1142 objects with photometric redshifts and spectral types was produced, showing the redshift distribution of galaxy spectral types. There is a

decrease in early-type galaxies for higher redshifts (z>1), while the amount of irregular and starburst galaxies increases. A subsample of the galaxies is displayed in a gallery, showing the reliability of using spectral energy distributions for calculating photometric redshifts. The work was done as part of a master's thesis project at Onsala Space Observatory.

MO-POS-57

The NOAO Fundamental Plane Survey, **Russell Smith** [1], M.J. Hudson [1], R.L. Davies [2], J.R. Lucey [3], J.E. Nelan [4], D. Schade [5], N.B. Suntzeff [6] and G.A. Wegner [4], [1] *University of Waterloo*, [2] Oxford University, [3] University of Durham, [4] Dartmouth College, [5] HIA/CADC and [6] CTIO/NOAO — The NOAO Fundamental Plane Survey (NFPS) is a wide field imaging and spectroscopic survey of the ~100 nearest X-ray luminous galaxy clusters, with two principal science goals: (1) to measure distances and peculiar velocities through the Fundamental Plane relation, to probe large-scale flows to ~200h^{-1}, Mpc; and (2) to study the structural, morphological and star-formation properties of the cluster galaxy population. Here, I present some preliminary results in each of these categories, and discuss some multi-wavelength follow-up studies based upon the NFPS sample.

MO-POS-58

Changes in the Radio Image of Quasar 3C454.3 and their Possible Effect on the VLBI Astrometry for the Guide Star of the Gravity Probe B Mission*, **Ryan Ransom** [1], J.I. Lederman [1], N. Bartel [1], M.F. Bietenholz [1], D.E. Lebach [2], M.I. Ratner [2], I.I. Shapiro [2] and J.-F. Lestrade [3], [1] *York University*, [2] Harvard-Smithsonian Center for Astrophysics and [3] Observatoire de Paris-DEMIRM — Since 1997 we have observed the quasar 3C454.3 at 3.6 cm with a VLBI array of 12 or more stations about four times per year in support of the NASA-Stanford relativity gyroscope experiment, Gravity Probe B (GP-B). This quasar is a phase reference source for the imaging and astrometry of the mission guide star, HR 8703, which we observed during the same sessions. We present a selection of VLBI images of 3C454.3 produced from observations between January 1997 and December 2003. The images show changes in the region within 1.5 mas of the radio core of the quasar. We also examine the effect of these changes on our astrometric results for HR 8703.

* This work is being supported by NASA, NSERC.

MO-POS-59

A Step Closer to the Detection of the Reionization Epoch, **Sasa Nedeljkovic**, C.B. Netterfield and U. Pen, *University of Toronto* — Approximatively a billion years after the Big Bang, the first stars reionized the universe and ended the so-called Dark Ages. In many models, the reionization occurs rapidly making a sharp step in the spectra from the quenching of the redshifted 21cm line. The step is expected to be visible between 70-240MHz for Z_reion = 5 to 20. The step is expected to be around 15mK, which is easily detectable from a signal to noise point of view. However, the signal is 5 orders of magnitude smaller than the forgrounds, complicating the task of detection. With large radio instruments such as PAST, CLAR, LOFAR and ultimately SKA on the way, we give the update of the small instrument built primary for the detection of the reionization step: TREX (21cm Reionization EXperiment). This poster will give an overview of the latest instrument specification.

MO-POS-60

Visualizing the CMB through the Dust : A New Generation of IRAS Maps*, **Marc-Antoine Miville-Deschenes** [1] and G. Lagache [2], [1] *Canadian Institute for Theoretical Astrophysics* and [2] Institut d'Astrophysique Spatiale — Twenty years ago the IRAS satellite made an all-sky survey in the mid/far-infrared that had a tremendous impact on modern astrophysics. In this contribution I will show that IRAS will still be a crucial element for cosmological missions to come like Planck, an European satellite (with Canadian contribution) that will be launched in 2007 and that will map the whole sky in the submm/mm range. The main scientific goal of Planck is to study the cosmic microwave background but one of the biggest challenge of Planck is to be able to separate the numerous emission components in that frequency range (dust emission, synchrotron, free-free). To tackle this problem, external data sets, which probe specific components, are needed. With its full-sky coverage and arcminute resolution, the IRAS data, that probe the dust emission of the interstellar medium, will be a key player in the analysis of the Planck data. Unfortunately, the available IRAS product suffers from several instrumental effects that prevent its use for detailed CMB analysis. In this context we have performed a totally new reprocessing of the IRAS data, based on the knowledge acquired recently on the behavior of photoconductors and using modern data analysis techniques. In this contribution I will present the image processing techniques we used to improve significantly the quality and reliability of the IRAS data. This new generation of IRAS data opens very exctinging new perspectives on the study of the interstellar meidum but it will also be essential for the analysis of CMB data.

* This work is being supported by Canadian Space Agency.

MO-POS-61

Distribution of the Submillimetre Population of Galaxies, **Vjera Miovic** and C.B. Netterfield, *University of Toronto* — The sources detected by the ground-based sub-mm surveys are understood to be dusty galaxies experiencing massive bursts of star-formation. The lack of the precise redshift determination of these sources and of the counterpart identification in radio and other wavebands, prevents a reliable estimate of the evolutionary history of these galaxies. Previous studies have investigated finding the photometric redshifts of identified point sources above the confusion limit [1]. We investigate the possibility of constraining the luminosity and density evolution of sub-mm galaxies using a different approach – extracting information from the statistics of the unresolved sources detected beyond the "confusion limit". The results from our simulations can be used to analyse the data from sub-mm surveys, such as Spitzer, BLAST or Herschel.

1. Hughes *et al*, 2002

MO-POS-62

A Deep Near-IR Look At Dusty Submillimetre Galaxies*, **Alexandra Pope** [1], D. Scott [1] and C. Borys [2], [1] *University of British Columbia* and [2] Caltech — The study of sub-mm galaxies at optical wavelengths is difficult given that the optical images are highly obscured by dust and there are often several possible counterparts. We have been forced to characterize the entire population of sub-mm galaxies by the sub-sample of sources that have radio counterparts. There is a need for deep near-IR images of these dusty galaxies in order to study the radio-undetected sub-sample and thus understand the entire sub-mm population. We have been compiling a sub-mm map of the Great Observatories Origins Deep Survey (GOODS) North field. GOODS is a huge multi-wavelength campaign to unite the deepest observations from NASA's big three space observatories: HST, Chandra and Spitzer, to study galaxy formation and evolution. We have used the ACS HST images from GOODS to study a large sample of 850 micron sources. With the depth achieved by this survey, near-IR counterparts have been found for the majority of the radio-detected sub-mm sources. The colours, morphologies and photometric redshifts of these secure identifications can be used to characterize the optical properties of dusty sub-mm galaxies to help identify counterparts to the blank- field sources. Certain combinations of near-IR properties can be used to successfully identify the counterpart to a sub-mm source.

* This work is being supported by NSERC/NRC.

MO-POS-63

Results from the BOOMERANG 2003 Antarctic LDB Flight, **Carrie MacTavish**, *University of Toronto* / *BOOMERANG collaboration* — BOOMERANG is a balloon-borne, microwave telescope with polarisation sensitive bolometric detectors. It is designed to measure the polarization, as well as the small scale temperature anisotropies of the cosmic microwave background. In January of 2003 the experiment mapped over 2000 square degrees of the sky at an angular resolution of approximately 10 arcminutes. The most recent results from the analysis of the data obtained from this flight will be presented.

MO-POS-64

Metallicity Distribution Function of Galaxies Through Infrared Colors, **Waldemar Okon** [1], W.E. Harris [1] and D. Crabtree [2], [1] *McMaster University* and [2] HIA/NRC — Globular clusters around galaxies provide unique tracers of their merger and formation history as well as the cluster formation itself. The key quantity which is related to the galaxy enrichment history is the metallicity distribution function (MDF). The MDF is of much interest and debate in current literature, and its fine structure, which contains the sequential starburst history of a galaxy, is sketchily known. This is because most of the current MDF work is based on the fundamentally insensitive (V-I) color index. We have undertaken a project which uses the (V-K) color index, which is more than four times more sensitive to metallicity than (V-I), to considerably improve on the current state of the quality of MDFs. This new data will allow us to study the MDFs of galaxies in much greater detail than previously possible, and hence will increase the understanding of galaxy formation. We have been using the CFHT-IR camera on the Canada-France-Hawaii Telescope to obtain deep K-band photometry of globular clusters in the interesting S0 galaxy NGC 1023 (which may have an unusually wide mixture of cluster ages), the giant elliptical M87, NGC 3377, 3379, 3608, M60, M86, M89 and NGC 2768 during three observing runs. Results from data analysis completed to date are presented here. These include the color distribution (which clearly shows bimodality for M87), color-magnitude and color-color diagrams.

MO-POS-65

Dynamical Masses of Galaxy Clusters, **Kris Blindert** [1], H.K.C. Yee [1], M.D. Gladders [2] and E. Ellingson [3], [1] University of Toronto, [2] Carnegie Observatories and [3] University of Colorado — Cosmological simulations predict a universal density profile for galaxy clusters. In order to test this prediction one requires a large sample of galaxy clusters in a wide range of masses. To this end, we are completing a follow-up survey of about forty galaxy clusters selected from the Red-Sequence Cluster Survey (RCS), with redshifts from 0.15 to 0.6, in a wide range of cluster richness. I will present some preliminary results for a subset of the clusters, including the correlation of optical richness with mass, and the mass-to-light ratio as a function of cluster mass.

MO-POS-66

A Peculiar Probe of the Dark Matter Distribution of Large Scale Structure*, **Robbi Pike**, *University of Waterloo* — Quantifying peculiar motions of galaxies and clusters provides a fundamental tool for probing the mass distribution of large scale structure. It is believed that light traces mass (at least within some biasing scheme), permitting the use galaxies as tracers for the underlying dark matter distribution. Within the confines of linear theory, peculiar motions, due to coherent gravitational pulls from overdense regions can lead to

valuable information pertaining to the cosmological density parameter, Ω_m. The primary goal of this research was to place constraints on Ω_m by modelling the galactic density and velocity fields in the local universe (cz ~ 8000 km/s). When comparing observed peculiar velocities to that which is predicted for a given density model (v-v comparisons), the aim is actually to measure the parameter $\beta = \Omega^{0.6} / b$, which depending on how well mass traces light is a degenerate combination of Ω_m and the biasing parameter, b. We have computed the density field from galaxy distributions for both the 2MASS and NOG all sky redshift surveys (magnitude and volume limited samples). These are transformed into real space density fields through an iterative procedure outlined by Yahil *et al*. (1991). We use the VELMOD maximum likelihood technique (Willick *et al*. 1997b), making v-v comparisons with several peculiar velocity datasets (SFI, SBF and SNIa) to constrain β. I will report on our findings and discuss how they fit in the current literature, as well as shed some insight into the morphological dependences for both elliptical and spiral galaxies.

* This work has been supported by Hudson for the completion of a Masters program at the University of Waterloo.

MO-POS-67

SCUBA-2: A Submillimeter Bolometer Array Camera for the JCMT*, **Michel Fich**, (on behalf of the SCUBA-2 Team), *University of Waterloo* — Canadian astronomers have played a large role in the success of SCUBA on the JCMT. SCUBA has had a major impact in many areas of astronomy from solar system research out to large scale cosmology studies. SCUBA has been declared to be the "most successful ground-based instrument" in a recent study. Now Canadian astronomers have an opportunity to participate in the construction of a replacement for SCUBA. SCUBA-2 will be many hundred of times faster than SCUBA. This will generate a new explosion in submillimeter research and discoveries as revolutionary as those found with SCUBA. This poster will discuss the current state of the development of SCUBA-2 and describe a few of the exciting science programs that various groups have proposed for the new instrument.

* This work is being supported by CFA.

MO-POS-68

Initial Observations with the Arecibo Signal Processor, **Robert D. Ferdman** [1], I.H. Stairs [1], D.J. Nice [2], D.C. Backer [3], R. Ramachandran [3] and P. Demorest [3], [1] *University of British Columbia*, [2] Princeton University and [3] U.C. Berkeley — The Arecibo Signal Processor (ASP) is a flexible, state-of-the-art wide-bandwidth observing system, for the acquisition and analysis of radio telescope signals. The primary application driving the development of this instrument is high-precision long-term timing of predominantly millisecond pulsars. This is attained through coherent removal of dispersion introduced into pulsar signals as they traverse the interstellar medium. The system will be able to process the incoming data stream in near-real time, through a network of personal computers, over a bandwidth of 64 MHz, in each of two polarisations. This initial implementation of ASP is at the 300-m Arecibo telescope in Puerto Rico, in order to take advantage of its enormous sensitivity. We present preliminary results of timing and flux calibrations with ASP for several pulsars. Comparisons have been made, and are shown, between ASP results and those of several existing pulsar instruments ranging from narrow to wide bandwidths, and which use coherent as well as incoherent de-dispersion. In particular, we show results of parallel timing observations with the Princeton Mark IV instrument, a narrow-bandwidth coherent de-dispersion instrument, and the precursor timing system to ASP. We briefly discuss several upcoming observations with ASP, as well as plans for installation of a twin instrument at the 100-m Green Bank Telescope.

[MO-POS] ATMOSPHERIC AND SPACE PHYSICS / *PHYSIQUE ATMOSPHÉRIQUE ET DE L'ESPACE* — Monday / *Lundi*

MOPOS-69

Trends in Relative Humidity in Canada from 1953-2003, **W.A. van Wijngaarden** [1] and L.A. Vincent [2], [1] *York University* and [2] Meteorological Service of Canada — This study reports the analysis of relative humidity data collected at 75 stations throughout Canada. For data at each station, a best fit linear trend estimated the change during 1953-2003 and a statistical t test determined whether the trend was significant. Large decreases in relative humidity occur throughout Canada in winter and spring. These results correlate closely to changes in dew point, temperature and precipitation. This study shows that relative humidity is a potentially useful indicator of climate change

MO-POS-70

A Quantitative Analysis on the Effects of Physical Sputtering in Meteoroid Ablation*, **Kyle A. Hill**, *Mount Allison University* — Conventional meteor ablation theory assumes that during atmospheric flight, a meteoroid undergoes intensive heating and meteoric atoms evaporate from its surface. Light is then produced as the ablated (evaporated) constituents undergo collisions with the atmospheric molecules and become excited. Our research has investigated whether another process, physical sputtering, could play a significant role as an alternative disintegration process. Using a 4th order Runge-Kutta numerical integration technique, we ran computer simulations which simultaneously solved the ablation and sputtering equations during the atmospheric flight for these meteoroids. We modeled asteroidal, cometary, and porous meteoroids with masses ranging from 10^{-3} kg to 10^{-13} kg and velocities ranging from 11.2 km/s to 71 km/s. We find that while in many cases (particularly at low velocities and for relatively large meteoroid masses) sputtering contributes only a small amount of mass loss during atmospheric flight, in some cases sputtering is responsible for a large fraction of the mass loss. The impact of this work will be most dramatic for the very small meteoroids observed with large aperture radars, whose ablation process may possibly be dominated by sputtering. The heights of ablation and decelerations observed using these systems may provide evidence in the future for the importance of sputtering.

* This work is being supported by NSERC.

[MO-POS] ATOMIC AND MOLECULAR PHYSICS / *PHYSIQUE ATOMIQUE ET MOLÉCULAIRE* — Monday / *Lundi*

MO-POS-71

Torsion-Vibration, Torsion-Rotation, and Vibration-Rotation Interaction Constants for CH_3OH from *Ab Inito* Calculations, **Li-Hong Xu** [1], J.T. Hougen [2] and R.M. Lees [1], [1] *University of New Brunswick* and [2] National Institute of Standards and Technology — This is a progress report on our effort to investigate the possibility of obtaining useful spectroscopic information from *ab initio* calculations. Previously, we have shown [1] that quantum chemistry results for methanol at the top and bottom of the torsional barrier could be used to determine the $\cos 3\gamma$ dependence of the torsional potential energy (*i.e*., the barrier height) to better than 0.5 %, and the $\cos 3\gamma$ dependence of the rotational constants (three diagonal and one off-diagonal) to accuracies ranging from 7 % to 40 %. Results for acetaldehyde were about ten times worse, though these large discrepancies could be improved significantly by an empirical adjustment procedure. We then have shown [2] that G98 delivered very smooth force constant plots as a function of angle along the internal rotation coordinate (defined to be 0° at the bottom and 60° at the top of the barrier), and that when symmetrized coordinates (in the permutation inversion group G_6) were used, these plots exhibited the $\sin 3\gamma$ or $\cos 3\gamma$ behavior expected from the symmetry species of the pair of vibrational coordinates multiplied by the force constant. In the present paper we investigate algebraically the meaning of various off-diagonal elements occurring in a Hessian matrix obtained by rotating the Cartesian Hessian matrix (containing second derivatives of the potential surface) to a coordinate system consisting of $3N-7$ small-amplitude vibrations (where N is the number of atoms in the molecule), one large-amplitude vibration (the torsion), three overall rotations of the molecule, and three translations of the molecule. We then compute these elements numerically using quantum chemistry methods. Finally we discuss how these elements can be applied to analyses of vibration-torsion-rotation bands of methanol.

1. L.-H. Xu, R.M. Lees, and J.T. Hougen, *J. Chem. Phys*. **110**, 3835-3841 (1999).
2. L.-H. Xu, J.T. Hougen, R.M. Lees, and M.A. Mekhtiev, *J. Mol. Spectrosc*. **214**, 175-187 (2002).

MO-POS-72

Progress Report on the Measurement of Cesium Electron-Impact Cross Sections Using a Magneto-Optical Trap*, **T.J. Reddish** [1], J.A. MacAskill [1], C. McGrath [1], D.P. Seccombe [1], M. Lukomski [1], J. Teeuwen [1], S. Sutton [1], W. Kedzierski [1], J.W. McConkey [1], W.A. van Wijngaarden [2], I. Bray [3], [1] *University of Windsor*, [2] York University and [3] Murdoch University, Australia — A trapped Cesium atom target, prepared using a magneto-optical trap (MOT), is exposed to a broad monochromatic beam of electrons. Since the infrared fluorescence from the trap is directly proportional to the number of atoms in the trap, the measurement of the decrease in the fluorescence signal, due to the interaction of the electron beam, provides a straightforward method of determining electron-impact cross sections. This technique, pioneered by Lin and co-workers [1], does require knowledge of the absolute target density. The choice of an appropriate pulsing scheme enables one to obtain either the ground state (Cs 6 $^2S_{1/2}$) total cross section or that for the 6 $^2P_{1/2}$ excited state; ionisation cross sections may also be determined. The first results (100-400 eV) showed good agreement with convergent close coupling calculations [2]. Improvements to the experimental setup and new results at lower electron energies will be presented at the conference.

1. R.S. Schapp, *et al* Phys. Rev. Lett. **76** (1996) 4328.
2. J.A. MacAskill *et al* J. Elec. Spec. Rel. Phen, **123** (2002) 173.

* We gratefully acknowledge CFI and NSERC for their support.

MO-POS-73

Modeling of Collision-Induced Light Scattering using Mathematica/Programme Mathematica pour le calcul de l'intensité de la diffusion de la lumière induite par les chocs*, **Andrew Senchuk** and George Tabisz, *University of Manitoba* — Collision-induced light scattering has been of great interest for many years due to the insights it gives on the physics of molecular interactions and dynamics. Calculation of the scattered intensities usually involves the manipulation and coupling of Cartesian tensors describing the multipole polarizability of the atoms or molecules together with tensors describing their interaction. As more complicated effects between the atoms and the field and/or higher order interactions between the atoms themselves are considered, the ranks of the resulting tensors become large. Consequently the resulting complexity, arising from the sheer number of terms that need to be considered, makes the calculation impractical in all but the lowest order cases. However, the effect of the higher order interactions cannot necessarily be dismissed as being negligible. To make the problem more tractable, one can re-express the theory in terms of irreducible spherical tensors, whose symmetry properties allow only a limited number of terms for a particular polarizability, and couple according to the Wigner coefficients. This is advantageous, as software packages, like Mathematica, exist which are able to calculate these very quickly. Thus we present results of modeling collision-induced light scattering using Mathematica in spherical tensor formalism. Our program handles arbitrary order polarizability tensors and can calculate interactions up to second-order.

* This work is being supported by CIPI.

MO-POS-74

Variational Calculations of Four-Body Molecular Systems, **Z.-C. Yan**, *University of New Brunswick* — Fully nonadiabatic calculations are performed for various four-body two-center molecular systems, using variational method in Hylleraas coordinates. The systems under study include H_2, HeH^+, MuH, and their isotopes. Our studies demonstrate that the traditional Hylleraas coordinates, which has been used widely for one-center atomic systems, can be equally well applied to two-center molecular systems. High-precision energy eigenvalues will be reported.

MO-POS-75

Intensity-Dependent Optical Rotation by Molecules/ Rotation Optique par les Molécules Dépendante sur l'Intensité de la Lumière*, **R. Cameron** and G.C. Tabisz, *University of Manitoba* — Chiral molecules rotate light through a forward scattering event. Single photon scattering, which is known as ordinary optical rotation, is independent of the light intensity I. We used a polarimeter in a heterodyne experiment to measure the optical rotation of solutions at 308 nm with high-intensity laser pulses. In three of the molecules that we studied (uridine, thymidine and cytidine) we found an intensity-dependent effect. The effect only appeared in molecules that had an absorption line near 308 nm; in other molecules that had no absorption line near 308 nm, such as sucrose, no intensity-dependent effect was observed. The intensity-dependent optical rotation in the three molecules was cumulative with each laser pulse and persisted with a time constant that was on the order of seconds and characteristic of the molecule.

* This work is being supported by NSERC.

MO-POS-76

Atomic Metastable Production Following Fragmentation of S-Containing Molecules*, **W. Kedzierski**, S. Amlin, X. Liao, R.J. Murray, J. Mutus, and J.W. McConkey, *University of Windsor* — A special xenon-matrix detector which is selectively sensitive to $S(^1S)$ atoms has been used to monitor dissociation of sulfur containing molecules into this fragment following controlled electron impact over an incident energy range from threshold to 400eV. A crossed-beam apparatus with a pulsed electron beam is used to obtain time-of-flight, and hence energy, spectra of metastable S fragments. Cross sections have been made absolute by comparison with previously obtained data from COS targets [1].

1. Kedzierski *et al, J. Phys. B*, **34**, 4027 (2001)].

* Research supported by the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Canadian Foundation for Innovation (CFI).

MO-POS-77

Trace Gas Detection Using Cavity Enhanced Absorption*, **Jeff Seabrook** and D. Tokaryk, *University of New Brunswick* — This presentation describes our application of an integrated cavity output spectrometer (ICOS) to trace gas detection. The principles behind cavity enhanced absorption and details of our implementation will be presented. In addition, we will discuss this technique's potential for determining number densities of the trace gases we hope to monitor. This technique also shows promise as an easy to use, and highly sensitive absorption spectroscopy tool. The near infrared region offers us the opportunity to detect weak vibrational transitions in many atmospheric species such as CO, CO_2 and H_2S. We will present our preliminary investigations into the detection of the pollutant hydrogen sulfide, and of our spectroscopy of the extremely weak and highly perturbed (012) vibrational transition of this molecule.

* This work is being supported by CIPI, NSERC.

MO-POS-78

An Atomic Source for Degenerate Fermi Gas Experiments*, **Swati Singh** [1], S. Aubin [2], P. Scrutton [2], M. Extavour [2], S. Myrskog [2] and J.H. Thywissen [2], [1] *McMaster University and* [2] *University of Toronto* — Even though all the constituents (electrons, protons, neutrons) of an atom are fermions, fermionic atoms are much less abundant in nature than bosonic atoms. In order to make a degenerate Fermi gas of Potassium 40 (40K) atoms, we had to make our own atomic source using potassium enriched to 3% 40K, instead of the natural 0.01% abundance. We present the experimental challenges faced in building and testing of a "dispenser" source for K-40 that can be used for the experiment. We also present recent progress in other areas of the experiment, towards magneto-optical trapping and pure magnetic trapping of potassium.

* This work is being supported by NSERC, CFI, OIT, PRO.

MO-POS-79

Mixed Sample Ion Trapping: Analysis and Evolution of Trapped Species*, **Jérémie J. Choquette** [1] and R.I. Thompson [2], [1] *University of Calgary* and [2] NSERC — Sympathetic laser cooling of trapped ions shows promise as a tool for low temperature studies of atoms and molecules. However, by its very nature it requires the generation and storage of mixtures of ions. Our work is currently focused on some of the issues and challenges of generating, storing, and analysing mixed samples involving magnesium, noble gas, nitrogen, and carbon monoxide ions. This presentation will outline our techniques for loading and buffer gas cooling of atomic and molecular ions from solid and gas phase sources. It will outline the 'q-scan' ion trap mass spectrometric technique that we use to analyse our trapped samples, and will provide a detailed discussion of the temporal evolution of these mixed samples which results from charge transfer reactions involving the trapped species and background gases in the vacuum system.

* This work is being supported by NSERC.

MO-POS-80

Spectral Clustering in the NMR Spectrum of a Gaseous System*, **Geoffrey Archibald**, Simon, E. Brief and M.E. Hayden, *Simon Fraser University* — We have observed unanticipated spectral clustering effects in the NMR spectrum of room temperature thermally polarized ^3He gas at 1.5 Tesla. At least three distinct lines form when ^3He is adulterated with the highly paramagnetic gases NO or O_2. These lines shift in frequency yet remain remarkably narrow when linear field gradients are applied. Unlike previous reports of spectral clustering, this behaviour cannot be explained solely in terms of the dipolar fields of the ^3He atoms. Instead, the effects we observe appear to be mediated by electronic spins associated with the paramagnetic adulterants.

* This work is being supported by NSERC.

[MO-POS] CONDENSED MATTER AND MATERIALS PHYSICS / PHYSIQUE DES MATIÈRES CONDENSÉE ET MATÉRIAUX — Monday / *Lundi*

MO-POS-81

Effect of Chain Unsaturation on Bilayer Response to Pressure: A Deuterium NMR Study*, **Michael R. Morrow**, I.D. Skanes, J. Stewart and K.M.W. Keough, *Memorial University of Newfoundland* — The effect of chain unsaturation on bilayer response to pressure has been investigated via wideline deuterium NMR observations of 16:0-18:1 PC-d_{31} (POPC-d_{31}) and 16:0-18:2 PC-d_{31} (PLPC-d_{31}). For bilayers of each lipid, saturated chain orientational order was measured as a function of pressure for selected temperatures and as a function of temperature for selected pressures up to 193 MPa. For POPC-d_{31}, the main transition temperature increased by ~0.18 K/MPa, a rate that is similar to that found for bilayers of disaturated PCs. For PLPC-d_{31}, the increase in transition temperature with pressure was slightly smaller at ~0.13 K/MPa. To investigate the isothermal response of chain orientational order parameters to pressure, spectra for each lipid were obtained for three pressures (ambient, 55 MPa, and 110 MPa) at 25°C and for three pressures (ambient, 110 MPa, and 193 MPa) at 40°C. Application of a given pressure was found to increase orientational order for each methylene group on the saturated chain of a particular lipid by roughly similar amounts. This corresponds to an approximately uniform shift of the saturated chain orientational order parameter profile with pressure. Within the liquid crystalline phase, the response to pressure decreased with increasing temperature. Comparision of the responses of POPC and PLPC to pressure at corresponding temperatures relative to their respective ambient pressure transition temperatures showed that PLPC saturated-chain orientational order was less sensitive to pressure than that of POPC.

These observations suggest that increasing levels of chain unsaturation may reduce the sensitivity of bilayer order to variations in pressure.

* Supported by NSERC (MRM) and CIHR (KMWK).

MO-POS-82

Characterization Of Anisotropy In Foams: An Ultrasonic Approach*, **Hussein Elmehdi**, J.H. Page AND M.G. Scanlon, *University of Maitoba* — We use low frequency ultrasonic waves (50 kHz) to investigate the mechanical properties of anisotropic freeze-dried bread foams that were prepared by applying uniaxial stress to fresh breadcrumb. Longitudinal ultrasonic velocity and amplitude measurements were taken in directions parallel and perpendicular to the compression direction. The velocity was found to decrease as the amount of compression is increased, with the decrease being greater in the parallel direction. The velocity data were interpreted using two theoretical models, one based on the static compression of a simplified strut model of foams and the other including the effects of tortuosity on wave propagation through anisotropic media. Both models allowed the velocity anisotropy to be directly related to the anisotropy of the foam structure, and give predictions in good overall agreement with the data. The results also allowed us to conclude that there must be a weakening of the cell walls caused by the uniaxial compression in addition to the effects resulting from the anisotropy alone.

* This work is being supported by NSERC.

MO-POS-83

Structure of a Homologue Series of Banana Mesogens Studied By C13 NMR Spectrum*, **J. Xu** and R.Y. Dong, *University of Manitoba* — C13 NMR spectroscopy was used to obtain the geometrical information in three members of a homologue series of banana molecules, 9ClPBBC, 8DClPBBC and 9DClPBBC. The orientational order parameter S, bending angles and tilt angles between the biphenyl rings were determined from the temperature dependent chemical shifts in the nematic phases. Although the temperature dependence of S was found to be different for these molecules, the S values at Tc were almost identical. It was also found that tilt angles depend linearly on temperature, and the bending angle in the mono-substituted molecule is about 14 degree smaller than the di-substituted molecular. A SUPER (Separation of Undistored Chemical-Shift Anisotropy Powder Patterns) technique was used to determine the chemical shift tensors of carbons of model compounds (*e.g.* 4-Chlororesorcinol). These tensorial components are required for fitting the temperature dependent chemical shifts in aligned samples.

* Research is supported by NSERC and Brandon University

MO-POS-84

On the Physical Mechanism of Vortex Stirring in MHD-Driven Two-Fluid Molten Metal Flows, **David Munger** and A. Vincent, *Université de Montréal* — Magnetohydrodynamic (MHD) instabilities such as those observed in aluminum reduction cells have been thoroughly studied, for instance by means of linear analysis by Sneyd (1992) and numerical simulation by Potocnik (1989) using industrial codes, as well as by Gerbeau (2001) using finite elements. Though its understanding is critical for efficient aluminium production, the physical mechanism is still unknown. We focus on the stability of vortex stirring that naturally occurs in MHD-driven systems of two fluids with a large electrical conductivity ratio, traversed by an intense vertical electric current and under a strong background magnetic field. We perform three-dimensional nonstationnary numerical simulations of the conservative equations, using a levelset technique to track the position of the interface between the two fluids. Periodic transport of large eddies occurs, in which we observe an oscillation of vortex energy arising from a balance between the dissipation forces and the supply from the imposed electric current. The corresponding frequencies are orders of magnitude smaller than those observed in typical metal pad roll, so that long-lasting simulations are necessary to track slowly growing instabilities. We are able to find a stability threshold in terms of the electrical conductivity of the fluids, and we are currently trying to correlate it with the cell's dimensions. We conjecture that an increase of the latter will compensate a decrease of conductivity in the triggering of instabilities. Simulations are underway and results will be presented at the conference.

MO-POS-85

Spin Wave Dispersion of the 2D Hubbard Model at Intermediate Coupling*, **Walter Stephan**, *Bishop's University* — The spin wave dispersion relation for the 2D square lattice Hubbard model at half-filling is calculated using an "exact" linked cluster expansion method. The approach used is most reliable at strong coupling, but still converges reasonably well when the Coulomb repulsion is of the same order of magnitude as the band width. Results are compared to those of other approximate calculations as well as neutron scattering measurements of undoped cuprates.

* This work is being supported by NSERC.

MO-POS-86

The Giant Magnetocaloric Effect (GMCE) in Ni-Mn-Ga, **Wei Li**, Xuezhi Zhou, H P Kunkel and Gwyn Williams, *Univeristy of* Manitoba — Several previous investigations have demonstrated that a giant magnetocaloric effect (GMCE) – a large isothermal entropy / adiabatic temperature change associated with the application of an external magnetic field to a system – is most often linked to the substantial entropy change accompanying a first-order phase change. However, it appeared plausible that in systems exhibiting sequential magnetic transitions – specifically a continuous paramagnetic to ferromagnetic transition followed by a first-order / discontinuous (order-order) transition - this effect might be enhanced if these two transitions could be brought into close proximity, or better still, merged. The veracity of this suggestion has been demonstrated in the Ni-Mn-Ga system where such a coincidence can be achieved through careful compositional tuning, thus for $Ni_{55.2}Mn_{18.6}Ga_{26.2}$ an entropy change of $\Delta S_M = -20.4\, J\, kg^{-1}\, K^{-1}$ is observed at 317K in a field of 5T, one of the larger values measured at or above room temperature.

MO-POS-87

Comparison of Electron Mobility in Zincblende and wurtzite GaInN, **A. Somaee** [2], M. Sadeghi [2], H. Arabshahi [1], M. Ghazi [2], [1] Tarbiat Moallem University and [2] *Shahrod University*, Shahrod, Iran — GaN has received much attention in recent years because of its potential for a wide range of applications in high power and optoelectronic devices. The demands of device designs have encouraged numerical studies of electron transport in the material. In this research a numerical iteration method has been developed and used to model electron transport in zincblende and wurtzite GaInN at low electric fields. Our results show that the electron drift mobility of wurtzite GaInN is lower than that for the zincblende structure at all temperatures. This is largely due to the higher G valley effective mass and a higher electron scattering rate in the wurtzite phase.

MO-POS-88

Low-Field Electron Transport Calculations in Bulk Wurtzite GaN Using Iterative Technique, **Hadi Arabshahi**, *Tarbiat Moallem University* — Temperature and electric field-dependent electron transport in bulk wurtzite GaN structure have been calculated using an iterative technique. The following scattering mechanisims, *i.e*, impurity, polar optical phonon, acoustic phonon, piezoelectric and electron plasmon are inculded in the calculation. Ionized imurity scattering has been treated beyound the Born approximation using the phase-shift analysis. The low electron drift mobility is calculated for temperatures in the range of 300-600K and for ionized impurity concentrations between 10^{16} and 10^{18} Cm^{-3}. The low temperature value of electron mobilty increases significantly with increasing doping concentration. The iterative results are in fair agreement with other recent calculations obtained using the relaxation-time approximation and experimental methods. Compensation effects on the mobility are also examined. Due to the freezout of deep donor levels the role of ionized impurity scattering in bulk wurtzite GaN is suppressed and the role of phonon scattering is enhanced, compared to zincblende structure. Electron transport properties have been modelled with an electric field applied both parallel and perpendicular to the (0001)c-axis. The extracted model parameters can be used for electron transport simulations in GaN-based transistors.

MO-POS-89

Design and Modelling of Inductively Heated Substrate Holders for Advanced Plasma Materials Processing Applications*, Ajay K. Singh and **Michael P. Bradley**, *University of Saskatchewan* — Plasma processing of materials will be one of the key enablers for advances in electronics and photonics technology in the 21st century. Effective plasma materials processing requires careful control of process parameters, including the temperature of the target material. For example, a minimum target temperature ~ 800 Celsius is required for plasma deposition of diamond films. Unfortunately, in high pressure (~ 10 Torr) microwave plasma systems (such as the diamond film growth system at the University of Saskatchewan) the ultimate target temperature may be limited to ~ 500 Celsius because ion-neutral collisions limit the amount of heat delivered to the target, and because of relatively high convective cooling rates. Thus it is necessary to directly heat the target to achieve the high temperatures required. Direct heating via heating wire may be difficult to implement because in most cases the substrate must be biased with respect to the grounded chamber walls to achieve good film growth. Inductive eddy current heating provides a solution. Heating energy is efficiently coupled into the substrate via induced eddy currents, providing rapid and potentially highly uniform heating. The purely inductive coupling means that the substrate can be biased to arbitrary voltages as required. This presentation will discuss our design efforts on heated substrate holders. We will present results of thermal modelling calculations (*i.e*. heating curves, mean temperature, temperature uniformity) and will discuss their implications for advanced target holder design.

* This work is being supported by NSERC.

MO-POS-90

Elastic Fields from Reconstructed Terraces of a Semi-Infinite Solid*, **R. Arief Budiman**, *University of Calgary* — Two-dimensional problem of a semi-infinite solid with surface reconstruction boundary condition is considered. Surface reconstruction produces sinusoidal displacement fields on a terrace and attractive interaction due to the reconstruction is

found. Stress fields and surface forces due to the surface reconstruction are presented. With the addition of the step-step interaction model by Marchenko and Parshin, the equilibrium surface configuration under the presence of step array and reconstructed terraces is presented.

* This work is being supported by NSERC.

MO-POS-91

High Resolution Oxide Single - Crystalline X-Ray Screens, **S. Nedilko**, *Kyiv National Taras Schevchenko University*, *Ukraine* — There are well known applications of scintillating materials in imaging devices: X-ray imaging, X-ray computed tomography (X-ray CT), single photon emission computed tomography (SPECT) and positron emission tomography (PET). Here we will talk only concerning X-ray imaging with micrometer resolution. Decreasing of exposure dose during diagnostics, medical, biological *in vivo* etc., when ionizing irradiation is used, can be achieved by increasing of spatial resolution of the screens used for visualization of X-rays image. At present X-rays screens are made, as a rule, on the polycrystalline powder luminophors base with the 5 – 200 μ grain dimensions which determine spatial resolution of the screens. Essential increasing of spatial resolution became possible by using of screens those are the single crystalline thin film (SCF) scintillator with a high coefficient of X-ray absorption applied on the surface of non-luminescent single crystalline substrate by means of liquid phase epitaxy method. At first, the X-ray image detector with resolution near 1.3 – 1.5 μ with the screen on the doped with Ce ions yttrium aluminum garnet SCF with thickness h = 5 μ was described by A. Koch *et al.* in 1998. The further increase of resolution can be achieved by thickness decreasing that requires higher SCF X-ray absorption (the last is proportional to effective atomic number of SCF) and by increasing of SCF light output. In this paper the results of investigation the set of doped oxide materials with the garnet and perovscite structure which allow significant improving of the X – ray screens parameters are presented and the perspectives of their using are discussed as well.

MO-POS-92

Thermostimulated Self-Assembled Formation of Semiconductors Micro – Inclusions in Matrices of Oxide Dielectric Sulphate Crystals, **V. Sheludko** [1] and S. Nedilko [2], [1] *Glukhiv Pedagogical University, Ukraine* and [2] *Kyiv National Taras Shevchenko University, Ukraine* — Paper reports about formation of the CdS semiconductor micro-inclusions in the dielectric matrix of $CdSO_4$. The formation of the CdS is a result of the $CdSO_4$ annealing. Temperature diapasons and atmosphere effects on results of the thermal treatment were established. The excess of the sulfur is necessary condition of the CdS formation. Control of the micro-inclusions formation and determination of their spatial and energy parameters was carried out by observation of the optical (luminescent) properties of the samples. Spectral distribution and decay parameters reveal a recombination character of this emission - luminescence of the donor-acceptor pairs in semiconductors of the A(II)B(VI) group. Obtained results are analyzed from the point of view of formation of other compound micro-inclusions in a volume of the initial crystal matrix. A close similarity of observed characteristics to characteristics of the so called “green” edge emission of very well known material as the cadmium sulfide CdS don’t allow any doubts concerning the fact that thermal treatment results the inclusions just of cadmium sulfide semiconductor phase into volume of the $CdSO_4$. The same luminescence properties had been observed for the K_2SO_4 and Rb_2SO_4 crystals. K_2S and Rb_2S are formed there after thermal treatment. Energy characteristics and the sizes of the clusters (25 - 50 nm) of the inclusions were estimated.

MO-POS-93

Modelling the Magnetic Response of Fe Nanoparticles in Alumina: A Preisach Approach, **Candice A.H. Viddal** and R.M. Roshko, *University of Manitoba* — Measurements of the field cooled moment, the zero field cooled moment, the isothermal remanent moment, the thermo remanent moment, and hysteresis isotherms, were performed on a thin film of nanodimensional Fe particles embedded in Al_2O_3 over a temperature range $10K \le T \le 300K$ and a field range $|H_a| \le 2kOe$. The data were analyzed within the framework of a Preisach model, which assumes that the free energy landscape can be decomposed into an ensemble of bistable Barkhausen elements, each with two moment configurations $\pm\mu$, a dissipation barrier $W_d = \mu H_d$, which measures energy dissipated as heat, and a level splitting $W_s = 2\mu H_s$,which measures energy stored reversibly. Numerical simulations based on the Preisach model, assuming a lognormal distribution of dissipation fields H_d and a Lorentzian distribution of bias fields H_s, were able to replicate all of the principal structural features of the experimental data, and their systematic variation with field and temperature. In particular, fits to the experimental data yield the temperature dependence of the mean dissipation field $\bar{H}_d(T)$, and the dispersions of dissipation fields $\sigma_d(T)$ and bias fields $\sigma_s(T)$, and show that the magnetic response below T≅150K is dominated by field activated transitions over free energy excitation barriers which collapse rapidly with increasing temperature, and which are most likely related to disordered spin configurations on the surfaces of the Fe nanoparticles. By contrast, at temperatures above 150K, the response is dominated by thermal relaxation of Barkhausen elements with an average moment $\mu \cong 10^{-10}$ emu, which probably originates from the ferromagnetic cores of the Fe nanoparticles.

MO-POS-94

Thermally Activated Diffusion of Indium into 2H-$TaSe_2$, **Onkar Rajora,** *University College of the Cariboo* — We have studied the thermal diffusion of indium into the layered compound 2H-$TaSe_2$ single crystals parallel to the layers. Measurements [1] were done *in situ* in a scanning electron microscope equipped with an x-ray energy dispersive system. The distance of the diffusing indium front into the crystal was determined as a function of time from secondary electron image as well as from x-ray line scans for indium taken at different time intervals. The diffusion coefficients D were found by fitting the data to $\langle r^2 \rangle = 2\,D\,t$, where $\langle r^2 \rangle$ is the mean square displacement in time t. The diffusion coefficients thus obtained were 1.5 x 10^{-12}, 3.8 x 10^{-12}, 7.7 x 10^{-12} and 17.5 x 10^{-12} m^2/s with an uncertainty of about 10 percent at 351, 375, 411, and 458 K respectively. The activation energy E_0 of indium diffusion into $TaSe_2$ using $D = D_0 e^{-E_0/k_B T}$, was calculated to be 0.32 ± 0.04 eV. The results show that diffusing indium atoms put severe stress on the layers as they intercalate between them. This stress is relieved by buckling of the layers and these buckling features are clearly visible in secondary electron images.

1. O. Singh and A.E. Curzon, J. Appl. Phys., 17, 1415, 1984.

MO-POS-95

Magnetic Properties of $ErFe_2$/$DyFe_2$ Superlattices Studies by Neutron Diffraction*, **Z. Yamani** [1], H. Fritzsche [1], W.J.L. Buyers [1], Z. Tun [1], R.A. Cowley [2] and R.C.C. Ward [2], [1] *Neutron Program for Materials Research* and [2] Oxford Physics, Clarendon Laboratory, UK — Magnetic structure of two superlattices of the form [60Å $ErFe_2$ / 60Å $DyFe_2$]$_{40}$ and [80 Å $ErFe_2$ / 40 Å $DyFe_2$]$_{40}$, prepared by molecular beam epitaxy on a sapphire $(11\bar{2}0)$ substrate, is determined by neutron diffraction technique using the triple—axis spectrometer C5 at the NRU reactor in Chalk River. The experiments were performed at zero field, in a horizontal field of 2.63 T applied along [001] (the easy axis for bulk $DyFe_2$), along [111] (the easy axis of bulk $ErFe_2$), and along the surface normal [110]. The temperature dependence of several Bragg reflections both at zero field and non—zero field was determined in the range of 4 K to 250 K. The data analysis shows that the easy magnetization direction is determined by a competition between the Zeeman energy favoring the field direction, the crystalline anisotropy favoring either the [001] or [111] directions, the exchange interaction at the interface favoring a parallel orientation of the magnetizations of both layers, and finally the magnetoelastic energy.

* This work is being supported by NRC.

[MO-POS] NUCLEAR PHYSICS / PHYSIQUE NUCLÉAIRE — Monday / Lundi

MO-POS-96

Preliminary Results of the FINUDA Experiment at DAFNE*, **George Beer for the FINUDA Collaboration**, *University of Victoria* — The FINUDA experiment studies the formation and decay of hypernuclei produced by stopping kaons through the reaction $K^-_{stop} + {}^A_Z \to {}^A_\Lambda Z + \pi^-$ FINUDA is a large acceptance spectrometer with resolution below 1 MeV which measures energy levels of the hypernuclei and the particles produced by hypernuclear weak decay. Approximately 250 pb^{-1} integrated luminosity has been collected in 2003-2004. We present preliminary results concerning detector calibration, spectrometer performance, and hypernuclear formation and decay spectra.

* This work is being supported by Art Olin.

MO-POS-97

Measurement of the Parity Violating Asymmetry in Radiative Neutron-Proton Capture*, **Chad Gillis**, *University of Manitoba* — The NPDGamma experiment [1] will measure the parity-violating gamma-ray asymmetry A_γ in the reaction $\vec{n} + p \to d + \gamma$ in order to provide a theoretically clean measurement of the pion-nucleon weak coupling constant f_π to high precision. The Los Alamos Neutron Science Centre provides a pulsed cold neutron beam which is then polarized by transmission through polarized ^{3}He and captured in a liquid para-hydrogen target. The 2.2 MeV gamma rays from the capture reaction are detected in an array of CsI(Tl) scintillators which are read out in current mode by vacuum photodiodes. The pulsed nature of the beam provides a crucial capability to distinguish systematic error contributions through their unique time-of-flight dependences. The appa-

ratus is being commissioned during the spring of 2004; initial results from the commissioning data will be discussed.

* Supported by the US DOE, NSF, TRIUMF, and NSERC Canada.

MO-POS-98

Design Optimization of TIGRESS using a GEANT4 Simulation, **Michael Schumaker,** *University of Guelph* — The TRIUMF-ISAC Gamma-Ray Escape-Suppressed Spectrometer (TIGRESS) will be an important experimental facility for the ISAC-II post-accelerator at TRIUMF. It will consist of twelve Compton-suppressed High-Purity Germanium (HPGe) detectors. A number of design optimization studies were conducted using a GEANT4 simulation of the TIGRESS array. These studies were carried out using a Monte-Carlo simulation created using the GEANT4 toolkit. The goal of these studies was the improvement of the expected absolute gamma ray efficiency and peak-to-total ratio, and the reduction of experimental error due to Doppler-broadening. In this presentation, I will discuss the results of these simulations, and show how these results have been incorporated into the TIGRESS detector design.

MO-POS-99

Effects of the Symmetry Energy in the Mid-Rapidity Zone*, **René Roy** and the Heavy-Ion Collision Dynamics Research Team, *Université Laval* — The density dependence of the symmetry term of the equation of state (EOS) is a major point of interest in the heavy-ion dynamics. Using a soft Skyrme-like parametrisation, different symmetry terms are tested in the BUU calculations framework. These terms are constant, linear and quadratic with different compressibility moduli. Their effects are observed in the mid-rapidity zone. The chosen observable is the global N/Z ratio of this zone.

* This work is being supported by CRSNG.

MO-POS-100

Detection Prototype with Position Sensitive Photomultiplier / Prototype de détection avec photomultiplicateur à position*, **R. Roy**, *Groupe de recherche en physique des ions lourds, Université Laval* — In the case of heavy-ion collisions physics, the reaction studies must be supported by a good detection matrix with good mass, charge, energy and position resolutions. For this we need a good set of photomultipliers. Then I have choosen to study a position sensitive photomultiplier, which gives great gain and compactness, to improve position resolution. It is giving good results in position, up to 1mm of position resolution. Also, it can be coupled with a large set of different form scintillators, giving unlike resolutions. *Dans le cadre de la physique des collisions d'ions lourds, l'étude des reactions doit être soutenue par une bonne matrice de detection, possédant de bonnes résolutions en masse, charge, énergie et position. Pour cela, nous avons besoin d'un montage adéquat de photomultiplicateurs. Le choix d'utiliser un photomultiplicateur à position, ici, viendra améliorer la résolution en position. Il possède un grand gain et il est intéressant pour son aspect très compact. Les résultats obtenus parlent par eux-mêmes ; j'ai obtenu des résolutions en position allant jusqu'à 1 mm. Il peut aussi être couplé avec des scintillateurs de différentes tailles et formes, donnant évidemment des résolutions propres à chacun des couplages.*

* This work is being supported by CRSNG.

MO-POS-101

Agreement in Supernova Simulations with Boltzmann Neutrino Transport and its Connection to Nuclear Input Physics, **Matthias Liebendoerfer**, *CITA, University of Toronto* — Three independent supernova groups have built detailed Boltzmann neutrino transport into spherically symmetric supernova simulations [1,2,3]. In large scale computations, the energy- and angle-dependent distribution functions for the three neutrino flavors are determined during stellar core collapse and post-bounce evolution. The results of the general relativistic Boltzmann solver, Agile-Boltztran, are compared [4,5] with those of alternative codes that either use approximations for the general relativistic effects or rely on the multi-group flux-limited diffusion approximation for the neutrino transport. The finding that spherically symmetric supernova models with standard input physics do not lead to explosions has settled in qualitative and quantitative agreement. Not so in the dynamically more comprehensive multi-dimensional simulations: they still produce controversial results, as many of them have to rely on severe simplifications in the neutrino treatment. The accurate knowledge of the energy-resolved neutrino abundances throughout the star is a prerequisit to accurately evaluate and improve the underlying nuclear input physics. I point to the dominant reactions and where current supernova models would be most sensitive to changes in the input physics. Some reactions (*e.g.* electron capture rates on nuclei) are crucial for core collapse while others (*e.g.* neutrino opacities in hot dissociated matter) may determine the delay and success for the neutrino-driven ejection of the surface layers. The collapse of the inner core and the ejection of the surface layers should be regarded as distinctive physical events.

1. Rampp & Janka, *ApJ*, **539**, L33 (2000)
2. Liebendoerfer, Mezzacappa, Thielemann, Messer, Hix & Bruenn, *Phys. Rev. D*, **63**, 103004 (2001)
3. Thompson, Burrows & Pinto, *ApJ*, **592**, 434 (2003)
4. Liebendoerfer, Rampp, Janka & Mezzacappa, astro-ph/0310662
5. Liebendoerfer, Messer, Mezzacappa, Bruenn, Cardall & Thielemann, *ApJS*, **150**, 263 (2004)

[MO-POS] OPTICS AND PHOTONICS / *OPTIQUES ET PHOTONIQUES* — Monday / *Lundi*

MO-POS-102

Dynamic ^{129}Xe NMR Spectroscopy in an Experimental Model of Pneumonitis in Rat Lung Induced by Exposure to *Stachybotrys Chartarum* Spores*, **Nishard Abdeen** [1], Albert Cross [2], Tom Rand [3] and Giles Santyr [1], [1] *Carleton University*, [2] University of Lethbridge and [3] St. Mary's University — Hyperpolarized Xenon(H-Xe) NMR spectroscopy demonstrates the dynamics of gas exchange in rat lung *in vivo*, aided by the large chemical shift between gas phase and xenon dissolved in red blood cells and lung parenchyma. By repeating a pulse sequence consisting of selective saturation of the dissolved phase peaks followed by a readout pulse at variable time delay intervals, the time dependence of the exchange between gas phase xenon and xenon dissolved in the lung and red blood cells can be determined within a single lung inflation. This dependence is characterized by a gas transfer time constant which depends on diffusion across the alveoli, lung parenchyma, and blood and is therefore sensitive to changes in gas exchange and compartment effects. In this study, the time constant is measured in a rat model of chronic alveolar inflammation induced by intra tracheal instillation of fungal (*Stachybotrys chartarum*) spores. A significant difference is demonstrated between experimental animals (recovery time 25.1+/- 4.7 ms) and control animals (17.2+/-1.6 ms). These results show promise for detection of subtle alterations in gas exchange in lung disease. The applicability of this technique to other models of lung disease in animal and humans is discussed.

* This work is being supported by NSERC.

[MO-POS] PHYSICS EDUCATION / *ENSEIGNEMENT DE LA PHYSIQUE* — Monday / *Lundi*

MO-POS-103

Ongoing Professional Development Projects – BC Association of Physics Teachers, **Donald Mathewson**, *Kwantlen University College* — The BC Association of Physics Teachers is a chapter of the American Association of Physics Teachers. Our membership is comprised of a wide cross-section of high school, college and university physics teachers. On behalf of the membership, the BCAPT executive has recently embarked on an ambitious series of professional development projects for teachers. These initiatives have been enthusiastically embraced by the physics teaching community and have positively impacted the BC physics teaching community. For those within CAP and its member institutions interested in outreach, some information about the BCAPT and its professional development programs will be presented.

[MO-POS] THEORETICAL PHYSICS / PHYSIQUE THÉORIQUE — Monday / Lundi

MO-POS-104

Geometric Phase of a System Coupled to a Reservoir*, **Karl-Peter Marzlin**, S. Ghose and B.C. Sanders, *University of Calgary* - We present a new approach to Berry's phase for mixed states in non-unitary, non-cyclic evolution. Starting from a general system coupled to a reservoir we define Berry's phase using Kraus operators. The mixed-state evolution of Berry's phase is compared to the evolution for a pure state when no coupling to a reservoir is present.

* This work is being supported by iCore Alberta.

MO-POS-105

Axisymmetric Charged Matter Accretion on Kerr Black Holes*, **Roman J.W. Petryk** and M.W. Choptuik, *University of British Columbia*, CIAR — Accretion and jet formation of charged matter about black holes is not well understood. It is thought that twisting of magnetic field lines within the ergosphere of rotating black holes plays a role in collimating matter and radiation as bipolar jets. We numerically investigate these processes in axial symmetry for scalar fields on Kerr spacetime.

* This work is being supported by CIAR; CFI; NSERC.

MO-POS-106

Cycle Expansion of a Driven Pendulum / L'Expansion Périodique d'Orbite d'un Pendule Conduit, **Andrew Penner**, Randy Kobes and Slaven Peles, *University of Manitoba* — Chaos is fundamental to nature. Perhaps the most illustrative examples are atmospheric processes, but even further than that, some systems that had been commonly thought to be periodic, such as planetary motion, were recently proven to be chaotic. Chaos refers to a deterministic behavior characterized by a high sensitivity to a change of initial conditions. Due to these qualities any long term predictions are impossible, and consequently any solution of a given initial condition problem is not a physical observable. Calculating expectation values of observables for chaotic systems is usually done numerically and often marred by numerical artifacts. In this presentation we investigate a more subtle approach for evaluating expectation values for a chaotic system. We demonstrate our results in the example of a driven pendulum. Chaotic behavior may be thought of as motion over an infinite number of periodic orbits. A feasible mathematical solution to determine the expectation values is through cycle expansion, where an expectation value is calculated as a statistical average over periodic orbits in phase space. Statistical weight of each orbit is determined by its stability. Ultimately our goal was two fold. First we were to find the periodic orbits that contributed the most to the averages. Second, through use of these relatively few periodic orbits, we were to estimate expectation values for the rotation number and Lyapunov exponent of the driven pendulum to a high level of accuracy, and compare them to the brute force numerical calculations.

MO-POS-107

Dynamical Entanglement in Chaotic Systems, **Shohini Ghose** [1], Xiaoguang Wang [2], Ivan Deutsch [3] and Barry Sanders [1], [1] *University of Calgary*, [2] Macquarie University and [3] University of New Mexico — We analyze the entanglement dynamics of systems that are chaotic in the classical limit using cold atoms trapped in a magneto-optical lattice as a test system. Coupling between the atomic center-of mass motion and spin leads to entangled spinor wave packets. The ability to reconstruct the reduced density matrix of spin subsystem via quantum state tomography makes it possible for entanglement dynamics to be studied in actual experiments. For states initially localized in a regular region of the phase space, the entanglement shows quasi-periodic behavior, whereas for states localized in a chaotic region, the growth of entanglement is faster and no quasi-periodic behavior is present. These features are similar to those seen in other chaotic systems such as the quantum kicked top. We explain the main features by examining the support of the initial state on 'regular' and 'chaotic' eigenstates of the Hamiltonian. Our analysis is general and applicable to other quantum chaotic systems.

MO-POS-108

Surprising Symmetries in Relativistic Charge Dynamics*, **William E. Baylis**, *University of Windsor* — The eigenspinor approach uses the classical amplitude of the algebraic Lorentz rotation connecting the lab and rest frames to study the relativistic motion of particles. When applied to the dynamics of a point charge in an external electromagnetic field, it reveals surprising symmetries, particularly the invariance of a couple of field properties in the rest frame of the accelerating charge. The symmetries facilitate the discovery of analytic solutions of the charge motion and are simply explained in terms of the geometry of spacetime. The eigenspinor approach also suggests a simple covariant extension of the common definition of the electric field: the electromagnetic field can be defined as the proper spacetime rotation rate it induces in the particle times its mass-to-charge ratio.

* This work is being supported by NSERC.

MO-POS-109

Poissonian Random Process on a Regular Fractal, **John M. Nieminen** [1] and Jamal Sakhr [2], [1] *Northern Digital Inc.*, and [2] McMaster University — A new measure of fractal dimension, based on the nearest-neighbour spacings of a Poissonian random process, is proposed. The validity of this measure is demonstrated by calculating the dimensions of several well-known regular fractals. For all fractals studied, the calculated dimension is within two percent of the accepted fractal dimension. A formal connection between this new measure of dimension and the familiar Brody parameter of Random Matrix Theory is also discussed.

MO-POS-110

Bohmian Trajectories and Numerical Solution of the Schrödinger Equation, **Louis Marchildon** and Emilie Guay, *Université du Québec à Trois-Rivières* — In Bohmian quantum mechanics, particles follow definite trajectories governed by deterministic laws. The initial conditions of the particles, however, are known only probabilistically. The statistical predictions of quantum mechanics are recovered because the equations of motion of the particles involve the system's total wave function in an essential way. In situations where the wave function is known analytically, the numerical computation of trajectories is rather straightforward and reduces to the integration of first or second-order coupled ordinary differential equations. Where the wave function is not known, however, it must first be obtained by appropriate numerical methods. We investigate the case of two-slit interference involving one particle or two identical particles. Two kinds of methods are considered. The first one, based on the hydrodynamic formulation of the Schrödinger equation, uses either a fixed or a comoving grid. The second one is based on simple splitting of the Schrödinger equation into real and imaginary parts. Although the former (especially with a comoving grid) is computationally effective in many-dimensional problems, we find that the latter is more accurate around near-zeros of the total wave function. Trajectories obtained through the numerical integration of the Schrödinger equation are compared with similar ones computed from exact wave functions.

MO-POS-111

Vector Fields and Topological Counting Numbers, **J.G. Williams** [1] and Tina A. Harriott [2], [1] *Brandon University* and [2] Mount Saint Vincent University — Monopoles, instantons and skyrmions are all topological structures that can be counted by integrating a suitable Jacobian, thereby computing the degree of the mapping represented by the relevant (vector) field. In this paper, the usual Euclidean integral formula is modified to produce a covariant formula that can be applied to general relativistic kinks. The kink number is calculated for some simple-to-visualize examples in 2+1 dimensions.

MO-POS-112

Observable 3-D Boundary in 4-D Space-Time Defined by the Diachronic Now*,.**Michel A. Duguay** and C. Grenon, *Centre d'Optique, Photonique et Laser, Université Laval* — In diachronic time first considered by Einstein [1] one assigns Greenwich time to astronomical events. In a diachronic representation of 4-D space-time events on our past light cone form a Lorentz invariant 3-D boundary of 4-D space-time characterizing an extended diachronic now [2]. In the diachronic perspective the conventional speed of light is identified with the flow of time. In this perspective recent speculation about a varying speed of light as a function of cosmological look-distance is equivalent to a varying rate in the flow of remote time relative to us. The observed red-shift of distant galaxies is usually attributed to a Doppler effect, but an alternative explanation is a slower flow of time relative to us, immediately perceived thanks to the infinite diachronic speed of incoming light. In a cosmology built with a single boundary for space-time the need for a second boundary, as

might be defined by the Big Bang theory, would disappear. A straightforward prediction of such a cosmology is that there will be no limit to the look-distance at which distant supernovae or quasars will be discovered in the future.

1. A. Einstein, Annalen der Physik, 17, 891-921 (1905).
2. M.A. Duguay, ''Diachronic representation of space-time applied to problems in special relativity and in quantum optics'', submitted to The Can. J. Physics, 27 Feb. 2003.
* This work is being supported by NSERC.

MO-POS-113

Unstable Nuclei / Dialectic Equilibrates: A Violent Collision, **William Simmons**, David Mu and Reinhardt Bsumek, *Energy Metals Corporation* — Albert Einstein postulated only for maximum mass energy with $E = mc^2$. We present dialectic antithesis for Einstein's Equation with $Ep = m (<c^2)$, mass energy at less speed of light is ground state energy potential. For energy of unstable nuclei released in a heterogeneous non-fertile field becomes field energy. We will show further that when a field is a ground state, all radioactive prodigies of the unstable nuclei surcease because primal heritage desists and benign stability results since the energy normally conceived to daughters by natural radioactive decay becomes embryonic energy for the field instead. Profound *a*typical collision mechanics of quanta structures more efficient than *t*ypical collider physics [1] facilitate heterogeneous nucleation to pattern minority unstable energy to majority stable field energy when unified field force subsides and capture is complete. Energy in entropy fosters field energy equilibrium. Einstein's Equation for, mass/energy (having normal binding energy) increases with velocity. By dialectic equilibrates we will show that mass/energy decreases when velocity is reduced by negating binding energy potential. Hence, unstable mass/energy transforms to rest and precipitates in the capture field stable. Such that matter and energy are interchangeable and different only in form, we simply replicate a phenomenon of unstable energy in extreme *a*typical violent collisions by antithesis synthesizes to its ground state in one forward non-sustaining reaction and further radioactive decay is eliminated.

1. I.e. Collider/accelerator physics such as that practiced at Fermi Lab, Jlab, ANL, etc.

MO-POS-114

Global Optimization Algorithms and the Sodium Chloride Cluster Problem, **Richard Hodgson**, *University of Ottawa* — In this work we evaluate and compare the performance of three different global optimization algorithms when applied to the challenging problem of determining the structure of sodium chloride clusters of a given size. In general the task of finding a cluster's global minimum structure is a difficult one. For a simple pair potential which only takes into account the two major interaction effects, the number of local minima on the potential energy hyper-surface grows exponentially with increasing cluster size. The algorithms which are investigated include a) an improved genetic algorithm which makes use of a self-guiding search strategy, using a combination of "traditional" and geometric genetic operators; b) a fast annealing evolutionary algorithm which combines the aspect of population in genetic algorithm and a simulated annealing algorithm; and c) a modification of the standard Lipschitzian approach that removes the need to specify a Lipschitz constant. Instead simultaneous searches are conducted using all possible constants.

[MO-POS] INDUSTRIAL AND APPLIED PHYSICS / PHYSIQUE INDUSTRIELLE ET APPLIQUÉE — Monday / *Lundi*

MO-POS-115

Characterizing Multiple Bubbles In An Agar Gel With Ultrasonic Spectroscopy And Optical Imaging, **K.A. Ross** [1,2], L.J. Pyrak-Nolte [3], and O.H. Campanella [4],[1] *Department of Food Science, University of Manitoba*, [2] *Department of Physics and Astronomy, University of Manitoba*, [3] Department of Physics and Astronomy, Purdue University and [4] Department of Agricultural and Biological Engineering, Purdue University — The presence of inhomogeneities, such as bubbles or pores, affects the physical properties of any solid material. This is especially important for food products, whose textural attributes are strongly influenced by bubble/pore size distribution, bubble/pore size orientation, and air volume fraction/porosity. The main focus of this work was to use ultrasonic spectroscopy, based on the frequency dependence of the ultrasonic attenuation, to determine the pore size distribution of air bubbles in an agar gel, which may be considered a model biological system with laboratory, pharmaceutical and food applications. Different bubble size distributions were introduced into the gels by varying the mixing conditions. A fundamental spectroscopic analysis of the ultrasonic attenuation was performed to demonstrate that both the bubble size distribution and the spacing between the bubbles could be successfully determined. Since the gels are transparent, digital imaging of the bubbles could also be performed, allowing the two-point spatial correlation function to be determined and giving a direct measurement of the bubble/pore sizes and porosity. Good agreement was found between the results of ultrasonic spectroscopy and the two-point correlation function, thereby validating the ultrasound bubble sizing data. Overall, this work indicates that these techniques may be applied to a biological system containing polydisperse bubbles/pores in order to determine the structure of the system through effective characterization of bubble/pore size and porosity. This is significant as bubble/pore size and porosity affect mechanical properties and the utility of such materials, which is of technological importance.

[MO-POS] INSTRUMENTATION AND MEASUREMENT PHYSICS / PHYSIQUE DES INSTRUMENTS ET MESURES — Monday / *Lundi*

MO-POS-116

Submicron Gold Wires Fabricated Via Dielectrophoresis Of A Colloidal Suspension*, **C.T. Harrower** and D.R. Oliver, *Electrical & Computer Engineering, University of Manitoba* — Sub-micron metallic wires may be fabricated via dielectrophoresis of a colloidal suspension [1,2]. The goal of this project is to study the conduction character of these wires as the early stages of formation involve very small contact areas. Colloidal gold was prepared by the reduction of tetrachloroauric [III] acid with sodium citrate [3,4] and the particle sizes obtained depend upon the concentrations. The particle size distribution for the suspensions obtained has been estimated using Mie Theory and extinction measurements obtained with a spectrophotometer. In order to form wires the colloidal solution must be further concentrated by a factor of about 20 before wires could be grown at a reasonable rate. Submicron wires were grown between two gold electrodes (0.25 mm diameter wire) and placed in the colloidal solution. The wires were grown over a sub-millimeter electrode spacing using both electrophoresis (DC) and dielectrophoresis (AC). Control of the growth was obtained by varying the electric field strength and, in the case of dielectrophoresis, frequency. The conductivity through the system was studied during and after wire formation.

1. K. Hermanson, et al., *Science* **294** p1082 (2001)
2. R. M. Penner, *J. Phys. Chem. B* **106** p3339 (2002)
3. G. Frens, *Nature* **41** p20 (1973)
4. J.W. Slot & H.J. Geuze, *J. Cell Biol.* **90** p533 (1981)
* This work is being supported by NSERC.

MO-POS-117

Experimental Characterization of an Aerogel Cherenkov Prototype for the G0 Experiment, **Marcus J. Steeds** [1], J. Birchall [1], B. Clement [1], W. Falk [1], L. Lee [1], S.A. Page [1], W.D. Ramsay [1], W.T.H. van Oers [1], E. Korkmaz [2], T.A. Porcelli [2] and C.A. Davis [3], [1] *University of Manitoba*, [2] University of Northern British Columbia and [3] TRIUMF — The G0 experiment in Hall C at Jefferson Lab will determine the strange quark contributions to the vector form factors of the proton. The upcoming back-angle mode will use aerogel Cherenkov detectors for threshold discrimination of an electron signal against a pionic background. The results of electron beam tests of the North American prototype detector conducted at TRIUMF's M11 experimental beamline will be presented.

[MO-POS] MEDICAL AND BIOLOGICAL PHYSICS / PHYSIQUE MÉDICALE ET BIOLOGIQUE — Monday / *Lundi*

MO-POS-118

Investigation of SNR and SAR for Low-Frequency Polarized Noble Gas MRI of the Lung*, **Erin Chapple**, C.P. Bidinosti, J. Cha, N.A. David, M.E. Hayden, *Simon Fraser University* — Low-field magnetic resonance imaging (MRI) of human lungs using hyperpolarized noble gases has only recently been demonstrated for the first time. As a result there are still a number of surrounding issues that are poorly characterized at low frequencies, such as fundamental signal-to-noise ratio (SNR) limitations and specific-absorption rates (SARs). Here we present the results of an ongoing study that probes SNR and SAR from 100 kHz – 1 MHz, the range of frequencies relevant to this new MRI technique. Resonant coil structures suitable for the study of each property were constructed, and a determination of the effective coil resistance was made with and without a human subject inside each coil type. For the SNR study, rectangular Helmholtz coils (34 x 40 cm) were placed at the front and back of the chest of the subject. At all frequencies the coil resistance is at least an order of magnitude larger than the effective resistance of the subject, implying that optimal SNR might only be achieved with cryogenically cooled coils.

For the SAR study, a birdcage-like transmit (B_1) coil which had a homogeneous field map over the volume of the chest was used. An SAR value of $1.5 \times 10^{-5} \int^{2} \cdot B_1^{2}$ W/kg (MKS units) was determined. This result is suitable for any body coil of comparable homogeneity, and is useful for determining limits on RF pulse rates.

* This work is being supported by NSERC.

MO-POS-119

A Structural Study of a Myristoylated Membrane Binding Peptide, **T.A. Harroun** [1], K. Balali-Mood [2], J.P. Bradshaw [2] and J. Katsaras [1], [1] *National Research Council* and [2] University of Edinburgh, - Myristoylation is a common post-transcriptional modification to proteins that confers additional membrane binding affinity. The process involves the attachment of the fourteen carbon saturated acyl-chain of myristic acid to the N-terminus of the protein. Such modified proteins include the adenosine ribosylation factor (ARF) family. Using specific deuterium labeling and neutron diffraction, we previously determined that the 15 amino acid peptide from the N-terminal sequence of ARF1 (pARF1) lies parallel to the membrane interface, in the region of the headgroup. We have repeated this experiment with the myrisoylated form of the peptide, and found that the effect of myristoylation is to tighten the helical structure of the membrane-binding domain, forming a new hydrophobic face for the protein, increasing its membrane binding capabilities. These results confirm the theoretical prediction that the effect of myristoylation can extend many residues along the amino acid sequence from the terminus.

MO-POS-120

A Method for Concentrating Nucleic Acids by Synchronous Perturbation of Electrophoretic Mobility, A. Marziali [1], J. Pel [1], E. Holtham [1], **D. Broemeling** [1], R. Coope [1], D. Bizzotto [2] and L. Whitehead [1], [1] *Dept. of Physics and Astronomy* and [2] Dept. of Chemistry, *University of British Columbia* — Electrophoretic current fields are divergence free, which prevents spatial concentration of DNA by standard electrophoresis in uniform, non-binding media. In this presentation, we demonstrate a general method for achieving electrophoretic concentration of DNA using alternating electric fields and synchronized coefficient of drag alteration. We demonstrate DNA concentration in low (<1%) agarose gel by focussing a uniform DNA solution to a single region in the center of the gel. This is done by applying a mix of dipole and quadropole electric fields to four electrodes contacting the side of the gel, such that the DNA undergoes oscillatory motion, but its mobility is always higher when moving toward the centre of the gel. Recent results and theory behind this effect will be presented, as well as initial work toward DNA purification applications.

MO-POS-121

Analysis of Nucleic Acid Dissociation Rates using a Trans-membrane Single Molecule Sensor*, **Jonathan Nakane**, M. Wiggin and A. Marziali, *University of British Columbia* — A self-assembling nanosensor for sequence-specific detection of nucleotides across a membrane has been constructed from a single alpha-hemolysin nanopore self-assembled into a lipid bilayer, and a DNA probe tethered to avidin at one end and complementary to the analyte nucleotide at the other end. By monitoring the dissociation rate of single DNA molecules on the trans side of the membrane after binding to the trapped probe strand, we can uncover the energy landscape of these events, allowing us to detect and identify short (14-mer) perfectly complementary strands and localize regions of single base mutations in strands specifically targeted based on the sensor probe sequence. Further analysis of the energy landscapes reveals that several characteristics of the binding interaction, including the length and number of contiguous regions of complementary nucleotides, and the overall free energy of binding between may be used to distinguish populations of different oligonucleotides.

* This work is being supported by NSERC.

MO-POS-122

A 3D Ultrasound Scanner for Evaluation of Musculoskeletal Disorders, Andrea Lai [2], **Daniel W. Rickey** [1,3,5] and Martin H. Reed [2,4,5], [1] *Medical Physics, CancerCare Manitoba*, [2] Faculty of Medicine, University of Manitoba, [3] *Dept of Physics, University of Manitoba*, [4] Department of Radiology, Children's Hospital, Winnipeg and [5] *Department of Radiology, Health Sciences Centre* — Ultrasound is a primary imaging technique for diagnosis and assessment of musculoskeletal disorders because it gives excellent visualization of soft tissues and cartilaginous components. The common ultrasound method used is conventional 2-dimensional technology. There is much interest in newer 3-dimensional (3D) ultrasound technology. Although, there are many advantages to 3D methods, it has been weak in scanning over the curved surfaces of the body. The goal of this project is to develop and evaluate a novel 3D ultrasound technique that allows scanning over curved surfaces. In this poster we will show ultrasound images of various musculoskeletal anatomy acquired with a diagnostic ultrasound machine coupled to a system that obtains 3D images over curved surfaces. The usefulness of this 3D technique was evaluated by scanning a number of pediatric patients. The technology was found to easily move over the curved surfaces of the subjects. In addition, the 3D images were tested for geometric fidelity. The scanner reproduced image geometry with a high degree of fidelity, *i.e.*, within 0.3 mm. Motion artefacts could be corrected to a certain degree, however some distortion remained in images acquired from neonates and infants who had been in constant motion during the scan.

MO-POS-123

The Effect of Bone Shape and Orientation in X-Ray Fluorescence Bone Lead Measurement, **A.F. McDonald**, N. Ahmed and D.E.B. Fleming, *Mount Allison University* - Lead is a nonessential trace metal in the human body and has been associated with a variety of adverse health effects. Since the half-life of lead in bone tissue is 10-20 years, measurement of lead concentration in bone allows one to ascertain long-term exposure. Our group uses X-ray fluorescence (XRF) to analyze bone lead levels. This method is performed *in vivo* and is capable of measuring bone lead levels above 5 ppm. The focus of the research project was to investigate some of the factors that may affect precision and accuracy of the technique. The XRF instrument is calibrated using cylindrical bone phantoms doped with known quantities of lead. We constructed additional phantoms of other shapes in order to investigate what effect, if any, bone shape and orientation might have on the technique. Preliminary results are presented and their implications assessed.

MO-POS-124

Localized Ion Depletion And Read Length Degradation In Capillary Electrophoresis For DNA Sequencing*, **Robin Coope** and Andre Marziali, *University of British Columbia* — We have investigated the performance degradation in capillary sequencing of DNA samples that contain slow-moving contaminant fragments such as genomic DNA. Analysis of current and fluorescence data from a 96 capillary electrophoresis instrument has shown that poor reads are primarily due to low capillary current, resulting in a large increase in run length for some capillaries. While the peak shape of different length DNA bands is maintained, simply not enough bands in the affected capillaries reach the detector during the run. While this effect has been observed for years in production DNA sequencing, no satisfactory explanation has been advanced. The mechanism of current reduction has been identified as the catastrophic development of an ionic depletion region downstream of low mobility DNA fragments remaining from the e-coli based DNA preparation protocol. The depletion region, with ~5% the conductivity of the background region, grows over time and as a result, the current declines and read length is reduced. We present experimental results showing the growth and propagation of this depletion region, and present analytic and numerical models of this effect.

* This work is being supported by National Institues of Health.

[MO-POS] COMP/OCPM — Monday / *Lundi*

MO-POS-125

A Note on Interpolation and Extrapolation Methods in Brachytherapy Dose Calculations*, **Jason Sun**, *Nucletron Canada Inc.,* — In brachytherapy treatment planning, dose-rate distribution data for a given source, obtained from phantom measurements or Monte Carlo calculations, are usually reported on a polar or Cartesian grid. Interpolation and extrapolation are always required for determining the dose rate on off-grid points. Since the dose rate changes rapidly around a source, there has been a general belief that one would have more accurate results if the inverse-square factor were extracted from the dose-rate distribution before interpolation or extrapolation is performed. This is found to be true for point sources. For line sources, the AAPM TG-43 recommends that a geometric factor, which is different from the inverse-square factor, be separated from other slow-varying factors or functions, *e.g.*, radial dose function and anisotropy function. According to TG-43 and its revised protocol (drafted by the AAPM LIBD subcommittee), for each off-grid point, one should calculate the geometric factor specifically, using the well-defined equation. Interpolation or extrapolation should be made only on other factors. Recently, within the brachytherapy community, there is an open debate on the necessity of making such a separation. This paper clearly shows that, without a proper handling of the geometric factor, *i.e.*, not separating this factor from dose-rate distribution, or simply applying the inverse-square factor for a line-source, the interpolation or extrapolation may certainly result in errors well beyond the acceptable range. The published dosimetric data of Iodine-125 6711 source, commonly used for treating prostate cancer, are used in this study.

* This work is supported by Nucletron Canada Inc.

MO-POS-126

Simulation of a Radioactive Eluting Stent Using Geant4*, **Jean-Francois Carrier** [1,2], L. Beaulieu [1,2], R. Roy [2] and O. Bertrand [3], [1] *Hôtel-Dieu de Québec,* [2] *Université Laval* and [3] Hôpital Laval — Radiation therapy has been identified as a promising means of treating coronary restenosis. However, precise dosimetry simulations have to be done in order to make sure the dose deposited in the artery wall is uniformly distributed. The project currently under study is a radioactive eluting stent with a polymer coating. Following stent implantation in the vessel, radioactive 45 isotopes are delivered to the artery wall from the polymer matrix. Numerical simulations were done in order to study the diffusion of the isotopes through the wall. Afterwards, the irradiation of the target volume is studied with Monte Carlo simulations. The Monte Carlo toolkit used for the dosimetry simulations is Geant4, an object-oriented toolkit developed at CERN. Simulations were done for a 2D artery static model for specific parameter values. The parameters are inter-strut spacing, polymer coating thickness and diffusivity coefficients in wall, blood and coating. Dose deposited distributions were also calculated for a dynamic model. The total dose distribution in the artery wall after two weeks of diffusion and radiation will be presented. The dose delivery success is measured using two quantities: the dose homogeneity in the therapeutic region and the percentage of activity remaining in the therapeutic region after a defined duration. A 3D artery model has also been developed and preliminary results will also be presented.

* This work is being supported by FQRNT.

MO-POS-127

Performance Evaluation of a CT/PET Imaging System for Radiation Oncology Treatment Simulation. **P.S. Basran** [1], C. Caldwell [2] and K. Mah [1], [1] *Department of Medical Physics, Toronto-Sunnybrook Regional Cancer Centre & Department of Radiation Oncology and* [2] *Sunnybrook and Womens College Health Science Centre & Department of Medical Imaging, University of Toronto* — Acceptance testing of a new combined Positron Emission Tomography (PET) multi-slice CT scanner (Philips Gemini PET-CT System) dedicated for radiation oncology simulation was undertaken at our institute. Testing was divided into the evaluation of the i) CT-simulator and imaging system; ii) PET-imaging system; and iii) the registration of the PET and CT data. Performance of the CT-simulator system was evaluated with tests described by the American Association of Medical Physicists Task Group Reports 2 and 66, plus some additional tests that examine the multi-slice capabilities of the system. In this poster, we present details on the electromechanical and image quality characteristics of the multi-slice CT scanner. To summarize our results, the performance characteristics of the imaging systems were favourable; however, there were some mechanical challenges when using the system as a radiotherapy simulator due to greater demands in geometrical accuracy when simulating radiation therapy. Some key findings include: a systematic couch tilt with and without the flat-bed top; an (expected) increase in radiation profile thickness for the multiple CT images due to beam divergence; signature image artifacts from multi-slice helical scanning; and, a systematic in-plane rotation in reconstructed images. While many of these findings do not impact radiation therapy simulation significantly, some findings required in-house modifications or other ameliorations. Since November 2003, the CT simulator component of the imaging system has been commissioned for clinical use. In this poster, we describe the major results of these tests along with modifications to the radiation therapy CT simulator.

MO-POS-128

A Bench-top Megavoltage CT Scanner with Cadmium Tungstate-Photodiode Detectors*, **D. Tu** [1], T.T. Monajemi [1], D. Rickey [2], B.G. Fallone [1], S. Rathee [1], [1] *Medical Physics, Cross Cancer Institute, University of Alberta* and [2] Medical Physics, CancerCare Manitoba — Imaging patients in treatment position for accurate patient set up and dose delivery verification in radiotherapy is possible with megavoltage computed tomography (MVCT). However, in order to overcome the poor contrast and higher dose resulting from megavoltage photons, the MVCT detector must be designed to provide the optimal detective quantum efficiency (DQE). The aim of the present study is to fabricate a prototype (80-element, 25 cm) fan-beam CT detector using $CdWO_4$ scintillator and photodiodes. In a previous study, we determined that the zero frequency DQE of an 8-element $CdWO_4$ array was 26% and 19% in 1.25 MeV and 6 MV photons, respectively. We have designed, fabricated and tested the data acquisition timing control, precision rotary stage control and an analog data multiplexer unit for the prototype 80-element detector array. The data acquisition is synchronized with radiation producing pulses from the linear accelerator. We have tested the linearity of the prototype detector array with respect to the dose rate, and its ability to accurately measure the attenuation of 6 MV photon beam by solid water. The pre-sampled line spread function, modulation transfer function (MTF), the noise power spectrum, and the spatial frequency dependent DQE of the detector have been measured in 6 MV photon beam. In future, this detector, along with the precision rotary stage, will be used for collecting the fan beam projection data for a standard CT phantom (CATPHAN500) in order to assess the basic MVCT image quality. The system block diagram and the preliminary results will be presented.

* This work is being supported by CIHR(MOP 43254), ACB (RE-78).

MO-POS-129

Development of Megavoltage Cone-beam CT for Image-guided Radiotherapy Treatment*, **Geordi Pang**, J.A. Rowlands, P.F. O'Brien, X. Mei, C. Yeboah, M. Tambasco, *Toronto-Sunnybrook Regional Cancer Centre* — Soft tissue imaging in the treatment room is one of the main challenges faced today in radiation therapy. Our overall goal is to develop a megavoltage cone beam CT (MVCT) which can be used to image soft tissue targets, such as the prostate, with a low dose (<5% of the treatment dose) so that daily imaging would become feasible and image-guided radiotherapy using MVCT could be realised. The precise knowledge of patient anatomy at the time of treatment obtained with MVCT will permit higher radiation doses to be delivered to the target volume with potentially greater cancer control but without an increase of side effects. Compared to kVCT (*i.e.*, cone beam CT with a kilovoltage x-ray source mounted on the linear accelerator), MVCT has the advantages of simplicity and potentially higher accuracy. A MVCT system has been built which consists of a flat panel detector and a linear accelerator fitted with a low-z target and a removable flattening filter. Effects of various factors on phantom image quality such as the x-ray focal spot, x-ray spectrum, phantom scatter, imaging geometry and detector quality have been investigated. A method aimed to improve the MVCT image quality and reduce the imaging dose has been proposed. This includes the optimization of the beamline components, the reduction of x-ray scatter as well as a significant increase in the quantum efficiency of the flat panel detector for MV x-rays.

* This work was supported by Siemens Medical Solutions USA, Inc.

MO-POS-130

An Empirical Model to Estimate the Mean Square Scattering Angle of Electron Beams for Use in Treatment Planning Systems, **Deborah Hodefi**, *Hôpital Maisonneuve-Rosemont* — Electron pencil beam algorithms, such as that employed by CadPlan (Varian), generally rely on the mean square scattering angle (msa) to characterize the beam spread. Usually, one virtual machine is created per electron energy. This practice implies that one value for the msa is sufficient to model dose distributions of any field size. The field size is delimited by the jaw positions, applicator and cut-out. As electrons are easily scattered, variation of these parameters will influence the angular spread. The msa used as input for a treatment planning system may differ considerably from the msa associated with a given set of conditions. Subsequently, error may be introduced into the calculated dose distribution The objective of this work was to develop an empirical formula, suitable for use in a treatment planning system, which is capable of determining the msa particu-

lar to each case. Measurements were carried out using an Elekta SL25 accelerator. A p-type silicon diode was utilized to measure profiles at the surface of a water phantom for various combinations of energy, applicator, cut-out size and jaw position. The corresponding msa was derived from the penumbra of each profile. For a given energy, the msa has been shown to vary dramatically over the range of applicators used in the clinic. An expression was formulated which predicts the msa, accounting for applicator, cut-out size, energy and jaw effects. By providing a significantly more accurate msa for a given set of conditions, more realistic dose distributions may be generated.

MO-POS-131

Proposed Definitions for Isodose Flatness and Symmetry in Clinical Radiotherapy Beams, **Eduardo Galiano** [1], T. Joly [1] and F. Wiebe [2], [1] *Laurentian University* and [2] Universidad Nacional de Asuncion — In radiotherapy it is important that beam intensity be as homogeneous as possible to reduce the probability of treatment failure. As extensions of the concepts of beam flatness and symmetry, the concepts of isodose flatness (IF) and symmetry (IS) are introduced. An isodose curve is a planar curve across a radiation beam, such that every point on the curve receives the same dose. Using a 10 x 10 cm field, an 80 cm SSD, and a phantom measurement depth of 10 cm, we propose defining isodose flatness for an isodose curve as the maximum absolute spatial deviation from the mean expressed as a percentage of the measurement depth of 10 cm. With identical geometry we propose defining isodose symmetry (IS) as the maximum spatial deviation between any pair of symmetric points about the beam midline expressed as a percentage of the same measurement depth. Mathematically:

$$IF = (\tfrac{1}{2}x_i - m\tfrac{1}{2}_{max} \times 100\%) / 10 \text{ cm}$$

and

$$IS = (\tfrac{1}{2}x_i - x_i'\tfrac{1}{2}_{max} \times 100\%) / 10 \text{ cm}$$

where x_i is any point on the isodose curve, x_i' is its symmetric point with respect to the beam midline, and m is the mean of all x_i's. These definitions were tested with actual data obtained from a Co-60 unit and a linear accelerator, with film. The calculated IF and IS for the Co-60 unit were 3.20 ± 69 % and 3.02 ± 69 % respectively. The calculated IF and IS for the accelerator were 6.11 ± 2.19 % and 11.01 ± 2.19 % respectively.

MO-POS-132

Analytic Expressions for Depth-Dose Curve in a Homogeneous Cylindrical Phantom for Photon Beam Irradiation, **Jose M. Martinez-Ortega**, *Ottawa-Carleton Medical Physics Institute,.Carleton University* — Analytic expression for dose calculation is quite rare in radiotherapy context. The main reason of that is due to the high complexity of the catastrophic electron-transport mechanism as the electron slowing down in media. Currently condensed histories of MC algorithms have been postulated as the best candidate for dose calculation purposes. The present work is one of the first attempts toward to find analytic solutions for the depth-dose curve in a homogeneous cylindrical phantom irradiated by photon beam. In order to illustrate how this theory works the scatter fluence inside of homogeneous cylinder irradiated by monenergetic Cobalt-60 beam was determined. The beam was considered a set of parallel photons rays hitting perpendicular to the top of cylinder's surface and the probability of photon scattering was assumed via Thomson. As result a set of fast convergent analytic series were obtained allowing compute the depth-dose curve along the main axis of the cylinder. Due to the simplicity of the photon-electron transport mechanism considered here, this first model has been considered for academic purposes only. However, further development of this theory is an outgoing investigation.

MO-POS-133

Virtual Compensation Compared with Physical Compensation in Head and Neck Radiotherapy, **Darcy Mason**, C. Araujo, J. Wilson and A. Baillie, *BC Cancer Agency - Southern Interior* — A common head and neck technique uses parallel opposed lateral fields matched to a supraclavicular field. The lateral fields need tissue compensation in two dimensions; this was formerly achieved at our centre using wedges placed thick end anterior for most fractions, and thick end inferior for the last few fractions. We now use "virtual compensation" provided by beam segments shaped by multi-leaf collimators (MLC). The segments are designed by inspection of a dose distribution on a mid-sagittal slice. Uniform doses can be achieved with three segments per field, and often with only two segments by staggering the shapes from the opposing fields. We compared the virtual compensator (v-comp) technique with physical compensators (p-comps) made of brass. Dose distributions were measured for v-comps and p-comps for an anthropomorphic head phantom and a flat phantom. The two compensator types produced clinically equivalent dose distributions, and the measurements confirmed the dose predictions of the treatment planning system within a few percent. Initially the v-comp technique required a lot of planning time, but we have streamlined the process. Patient treatment times are not significantly different from the previous technique. Unlike inverse-planned intensity modulated radiation therapy (IMRT), our field sizes and shapes fall within the normal parameters of conventional treatment. The only extra work needed was to confirm our linear accelerator stability for the low monitor units used in some segments. Thus the v-comp technique provides a simple but effective IMRT without the complications of special planning software or per-patient measurements.

MO-POS-134

A Dosimetric Comparison of Four External Beam Techniques for Accelerated Partial Breast Irradiation: Set-up of Study and Preliminary Results, **Mike Oliver**, Jeff Chen, Eugene Wong, Tomas Kron, Jake Van Dyk and Francisco Perera, *Department of Medical Biophysics, University of Western Ontario and Department of Physics and Engineering, London Regional Cancer Center* — Conventional early breast cancer treatment consists of a lumpectomy followed by whole breast radiation therapy (WBRT). Accelerated partial breast irradiation (APBI) is a method to reduce the irradiation volume to the lumpectomy site only. APBI may deliver more uniform dose to the target, while sparing healthy tissues better than WBRT. In addition, APBI reduces the overall treatment time from 5-6 weeks to 1 week. A treatment planning study was undertaken to compare four external beam techniques for APBI: small-field tangents, conformal radiotherapy (2 and 4-field), intensity-modulated radiation therapy (2 and 4-field) and helical tomotherapy. Critical structures (heart, contra-lateral breast, uninvolved breast, lungs and skin) were contoured on the CT simulator. The gross tumour volume (GTV) was defined as the union of seroma volume and the volume bounding the surgical clips. Clinical target volume (CTV) was defined with a 1.5 cm margin around GTV, constrained to within 5 mm to the skin surface. A further 1 cm uniform expansion was used to create the planning target volume (PTV). Treatment plans were generated using conventional and tomotherapy planning systems with plans normalized to D_{95}=37.2 Gy to the PTV. The ratio of CTV to whole breast volume was determined for 13 cases and varied greatly from case to case with an average of 30.1 ± 13.4 % (min: 12.7%, max: 60.1%). Initial dose volume histogram analysis showed that the four APBI techniques produce superior dose distributions compared to WBRT. Results for the superior APBI technique will be presented.

MO-POS-135

Distributed Monte Carlo Calculations in a Multi-Platform Environment, **Patrice Munger**, *Hôpital Maisonneuve-Rosemont* — Clinically realistic, Monte Carlo calculations with BEAMnrc and DOSXYZnrc may require large amounts of computing power. In a typical configuration, several computers are used in parallel. In our department, only one Linux workstation is completely dedicated to Monte Carlo calculations. The majority of the other computers in the department run various flavours of Windows operating systems. We also have a few IRIX and HP-UX workstations. In an attempt to make maximum use of this heterogeneous computer park, we have created a distributed job submission system which allows any of the computers present in our department, regardless if the OS it runs, to act as a Monte Carlo computation engine. All components of our system were written in Python, a high-level, object-oriented, multi-purpose language. In addition to allowing compact programs to be written, its multi-platform character is an obvious advantage in an heterogeneous environment like ours. The system was designed to satisfy some important requirements. First, due to the low priority assigned to Monte Carlo processes running on the computation engines, these processes do not disturb users that may be using these computers locally. Also, limits on the number of Monte Carlo processes simultaneously running, and on the maximum memory that they can consume, can be adjusted for every computation engine, preventing Monte Carlo processes to use all the resources of a given computer. Our system has been proven to be efficient at employing the existing computer resources of our department that otherwise would not be fully exploited.

MO-POS-136

Web-based Electronic Physics Database in the Grand River Regional Cancer Center, **Rob B. Barnett**, James C.L. Chow, David Shenton and Steve Kennedy, *Medical Physics Department, Grand River Regional Cancer Center* — An "In-house" web-based Physics database was developed and implemented in the Medical Physics Department of the Grand River Regional Cancer Center (GRRCC). The database has a window front-end and web application domain developed by VB.NET and ASP.NET respectively. The database architecture is designed to be easily maintainable and extensible. It also provides an arbitrary file/data format, report generation and graphical analysis tools for analyzing the QA data. The database contains both "static" and "dynamic" records. The "static" records include the treatment unit commissioning data, a physics handbook, the radiation survey/protection data, physics equipment inventory, electronic instrument manuals and manufacturers' contact information. For the "dynamic" records (data varying over time) such as the linac maintenance/repair history, and routine QA test data, the user can submit the information on a computer (desktop or laptop with wireless Internet) through a web interface linked to the Cancer Center network. For example, for routine machine QA, the testing user can input measured results through the web. Physicist can access, investigate and approve the results once data has been entered electronically. Comparison can easily be made between current and previous data, which can be graphically analyzed and printed. Physicist approval is password controlled and can be assigned to specific tasks. Such a web-based database is needed for a "paperless center" which was a principal objective for GRRCC.

MO-POS-137

Characterization of the Energy Spectra of a Cobalt-60 Tomotherapy Beam, **Johnson Darko**, C.P. Joshi , L.J. Schreiner and A.T. Kerr, *Kingston Regional Cancer Centre and Queen's University* — Tomotherapy is a technique for delivering Intensity Modulated Radiation Therapy based on a rotating fan-beam geometry, analogous to a CT-like delivery. The geometry is ideally suited for CT image acquisition for patient position verification. We have been investigating the feasibility of using a Co-60 source for CT imaging (Co-60CT) in the context of tomotherapy. We have observed that Co-60CT images lack beam-hardening characteristics and thus offer a potential advantage in dose reconstruction analysis. As part of our effort to more carefully quantify this behavior, and to design an optimal detector for Co-60CT imaging, the goal of this work is to model the fluence spectra for our Co-60CT benchtop pencil-beam ($1x1cm^2$) and fan-beam ($1x30cm^2$). The BEAMnrc Monte Carlo code was used to model a realistic Co-60 source and associated collimation and patient geometries. The fluence spectra were scored at the imaging detector plane with and without a typical patient in the beam. In-air simulations (no patient in the beam) yielded spectra with fairly evenly distributed low energy components, forming 30 % of the total fluence. The pencil beam collimator had no significant effect on the in-air spectrum compared to a broad beam. When the beam passes through a typical patient the total low energy component of fluence changes, as does the relative contribution of scatter, depending on the shape and size of the beam. Details of these simulations will be presented. The results obtained from this work form a strong basis for future work designing an optimal detector for Co-60CT imaging.

MO-POS-138

Gantry Angle Optimization for Conventional Radiotherapy*, **Peter Potrebko** and B. McCurdy, *CancerCare Manitoba/The University of Manitoba* — In conventional radiotherapy, the incident beam orientations are often determined using a manual trial and error search and may not be truly optimal. A fast, 3D-geometric-based optimization algorithm for gantry angle selection is proposed. The algorithm is interfaced with the Pinnacle^3 treatment planning system to extract patient contour data. The voxels contained in a particular patient structure are uniquely identified with a tagging index allowing the determination of which structure each voxel is attributed to. The radiation portal is defined by the Beams-Eye-View perspective of the planning target volume (PTV). Each beam portal is divided into a grid of beamlets. A score function is used to measure the 'goodness' of each beamlet at a given gantry angle. The overall score of the beam angle is given by a sum of the scores of all beamlets. The score function contains geometric factors that are taken into account in radiation therapy treatment planning. Such factors include: maximizing irradiation of the PTV, minimizing irradiation of the Organs-At-Risk (OARS), the depth of the OARS with respect to the PTV (avoiding irradiation of OARS upstream of the PTV), minimizing irradiation of other normal tissue both upstream and downstream of the PTV, the incidence angle of the beam (perpendicular incidence is favourable because it creates less skin reaction), and the separation angle of the beams. Once the algorithm populates the solution space, the optimal orientations are input into the Pinnacle^3 treatment planning system. Optimal solutions are presented for phantom and patient examples.

* This work is being supported by NSERC

MO-POS-139

Measurement of Beam-Spot Size for Siemens Linear Accelerators, **Collins Yeboah**, P. O'Brien and G. Pang, *Toronto-Sunnybrook Regional Cancer Centre* — The goal of intensity-modulated radiotherapy is to minimize the volume of normal tissues irradiated to high doses so that the tumour dose may be escalated without increasing normal tissue complications. This necessitates precise localization of tumour and adjacent sensitive structures just prior to delivery of each treatment fraction. To accomplish this, megavoltage cone-beam CT (MV-CBCT) has been proposed for repeatedly imaging and guiding patient positioning throughout the entire course of treatment. For this to be clinically feasible low doses (≤5% of treatment dose) must be used for each imaging session. Consequently, stability of the beam-spot size and position during the first few seconds after beam start-up becomes crucial. Therefore, measurement of beam-spot size and motion, assessment of their effects on low-dose MV-CBCT, and methods for minimizing them are of interest. In this work, measurements of the beam-spot size in the two principal planes were performed on a number of Siemens linacs using 20-cm long laminated beam-spot camera and verification films. The measured beam-spot diameters (FWHM) range from 2.0-3.4 mm. In all cases, the in-plane spot size was equal to or larger than the corresponding cross-plane spot size. For machines of the same design, the spot sizes were, in general, not identical but differences of up to 0.7 mm were observed. Comparison of measurements on the old and newer models of the linacs showed that the spot sizes for the latter are not necessarily sharper. For a given dual-energy linac, the spot sizes for the two energies were found to be similar.

MO-POS-140

An Intuitive Algorithm for Converting Electron Beam Ionization Measurements to Absorbed Dose*, **Myron Rogers** and L.J. Schreiner, *Kingston Regional Cancer Centre* — In medical physics, electron dosimetry with ionization chambers tends to be complicated since the energy spectrum changes so rapidly as electrons travel through a medium. Of particular concern in dosimetry is the depth dependence of the mean restricted stopping power ratios (SPR) between air and water $(L/\rho)^{w}_{air}$ that results from this energy loss. Early protocols for electron dosimetry attempted to account for this by correlating the SPR with beam energy for depths in water, although the average beam energies were either crudely estimated using the Harder equation, or lost within look-up tables. Furthermore, the approximations provided by these approaches weren't sufficiently accurate, therefore, current dosimetry protocols (the AAPM TG-51 and the IAEA TRS-398) now use a universal fit to Monte Carlo data to determine the SPR. In this work, we revisit the energy dependence of an electron beam in water using historical work and current modelling within the BEAM/egsnrc Monte Carlo program. We determine the full energy spectra at depth for various monoenergetic beams from 4 MeV to 40 MeV impinging on a water phantom. We show that the complications in some of the earlier approaches arise from the differences in the spectra for beams that have similar average energies. However, with a small correction determined from the initial beam energy, one can approximate the SPR at any depth from the average electron beam energy at that depth.

* This work is being supported by ORDCF (OCITS).

MO-POS-141

Unsettling Behaviour: Pre-irradiation Effects and Long-term Stability of Ionization Chambers, **John McCaffrey** [1], M. McEwen [1], D. Niven [2], B. Downton [1] and H. Shen [1], [1] *National Research Council (NRC)* and [2] Carleton University — Dosimetry protocols recommend that ionization chambers be pre-irradiated until a stable reading is obtained. Previous studies have shown that a lack of any pre-irradiation could result in errors up to several percent. Recently, data collected for a large number of commonly used ion chambers at the Institute for National Measurement Standards, NRC, Canada and the National Physical Laboratory, UK, have been collated and analysed. With such a data set it is now possible to relate patterns of ion chamber behaviour to design parameters. While several mechanisms seem to contribute, the most obvious correlation relates the extent of collector electrode shielding to settling time. Ion chambers with guarded electrodes up to the active air volume settle quickly (~6 minutes) and the change in response is less (up to 0.2%). For ion chambers where the guard connection around the central collector electrode does not extend up to the active air volume, settling times of 20 minutes (with an associated change in response of up to 1%) are typical. This settling time is not dependent on beam quality. This settling data was combined with a study of long-term stability and it was found that there was no correlation between settling behaviour and stability of response, and a change in settling behaviour was no predictor of chamber failure. The air-kerma to absorbed dose ratio, Ck, is shown to be a very sensitive parameter for monitoring ion chamber response.

MO-POS-142

Fractal Quantification of the Architectural Complexity of Computer Simulated Vasculature, **Brian Lim** [1] and Ivan Yeung [1,2], [1] *Department of Radiation Physics, Princess Margaret Hospital* and [2] Department of Radiation Oncology, University of Toronto — It is well known that tumour vascular architecture differs greatly from that of normal tissue, tending to be quite tortuous with seemingly irregular spatial distribution. While the measurement of microvascular density (MVD) has been widely applied to many kinds of tumours, and is generally accepted as having prognostic value for long-term survival, it has been recently suggested that the fractal dimension (FD) is more useful for quantifying the complexity of tumor and normal vascular architecture. In contrast to MVD, which may only be a rough indicator of the complexity of vascular architecture in a 2D cross-sectional slice, the FD is a measure of the vascular network's topology when calculated on a 3D volume. However, the FD is usually measured on 2D sectioned slices. The correlation between the FD of 2D slices and the 3D vascular structure remains unclear, although it is hypothesized that higher 3D complexity should be reflected in the slice FD. The purpose of this computer simulation study was to investigate this hypothesis. Three-dimensional networks representing tumor and normal vasculature were simulated, and the architectural complexity of the resulting networks was then analyzed by calculating the FD. The FD was calculated for the 3D volumes and for orthogonal and oblique slices. The results showed that simulated tumour networks displayed consistently higher slice and volume FDs than for normal vasculature, demonstrating the robustness of the FD as a measure of vascular architecture complexity. The FD promises to be useful for validating functional imaging techniques being developed for vascular characterization.

MO-POS-143

Estimation of X-Ray Dual-Basis-Material Thicknesses from Multiple Energy-Bin Measurements, **Yang Cai** [1] and Paul C. Johns [1,2], [1] *Dept. of Physics, Carleton University* and [2] Dept. of Radiology, University of Ottawa — Detectors now under development, capable of counting xray photons and scoring the energy detected at clinical fluence rates, will

facilitate single-exposure dual-energy radiography and CT. The natural logarithm of the patient transmission at energy E is given quite accurately by $T(E) = A_\alpha \mu_\alpha(E) + A_\beta \mu_\beta(E)$, where A_α and A_β are the thicknesses of the equivalent basis materials a , b (e.g., poly methyl methacrylate, aluminum), and μ_α , μ_β are their linear attenuation coefficients. The crux of dual-energy radiography is to determine A_α , A_β for each pixel. Classically, measurements are made with two spectra and an empirical nonlinear transformation is made from the two log transmissions T_1 , T_2 to A_α , A_b . Suppose an energy-scoring detector measures a single spectrum and bins the events into energy intervals i=1,2,...,n. $\text{Log}_2 n$ is the number of bits to which the detector must digitize the energies in real time. At the bin centres, $T_i = A_\alpha \mu_\alpha(E_i) + A_\beta \mu_\beta(E_i)$, i=1,2...,n. Algebraically, write **T**=**UA**, where **T** is a vector of length n, **A** is a vector of length 2 containing A_α , A_β , and **U** is an n x 2 matrix. In the limit of infinitesimal bin widths, the basis thicknesses are $\mathbf{A}=(\mathbf{U}^T\mathbf{U})^{-1}\mathbf{U}^T\mathbf{T}$. In reality the bins are of finite width and the transmission $\exp[-(A_\alpha \mu_\alpha(E)+A_\beta \mu_\beta(E))]$, weighted by the incident spectrum, must be integrated over the bin. We use Taylor expansions of the transmissions about their values at the bin centres E_i . The linear terms in the expansion are sufficient for accurate determination of the basis material thicknesses. For an imaging task in which the patient is 18 cm soft tissue plus 2 cm bone and the final image is to have bone-tissue contrast suppressed, by sorting the transmission of a 140 kV spectrum into 8 bins one can obtain accuracy of 2.3 % in the pixel value. If 16 bins are used, 0.50 % is achieved.

MO-POS-144

Projection Imaging of Plastic Materials using Coherently-Scattered X Rays, **Mohammad Nisar** [1] and Paul C. Johns [1,2], [1] *Dept. of Physics, Carleton University* and [2] Dept. of Radiology, University of Ottawa - The conventional x-ray imaging technique based on the transmission of primary photons works well to distinguish between hard and soft tissues. To distinguish between different kinds of soft tissues the scatter x-ray imaging technique can be used. Low-angle scattered photons can only be distinguished from primary on the basis of direction and consequently a well-collimated x-ray system is required. A hexagonal array of seven pinholes, each with a diameter of 1.5 mm, has been designed and tested to record the diffraction patterns of homogeneous plastic phantoms and of phantoms comprised of slabs of different plastics in a water tank. The phantom materials are amorphous solids and result in rotationally-symmetric diffraction patterns which are characteristic of the materials. The intensities of the diffraction patterns are numerically integrated over concentric rings and the scatter images are made by assigning the ring sums as the pixel values. A finite size (5 x 5 x 5 cm^3) water tank containing plastics is scanned to make the scatter images. For these measurements the tube is operated at 100 kV and 800 mAs. A storage phosphor image plate is used to record the scatter patterns. The ultimate goal is to make scatter images of different kinds of tissues for better diagnostic information.

MO-POS-145

Energy-DispersiveTechnique to Measure X-Ray Scattering Form Factors over a Wide Momentum Transfer Range, **Ziaul Hasan** [1] and Paul C. Johns [1,2], [1] *Dept. of Physics, Carleton University* and [2] Dept. of Radiology, University of Ottawa — In some particular diagnostic xray exams such as neuroradiology and breast imaging, scattered radiation can give more information than conventional transmission imaging. To optimize a scatter imaging system, it is required to know the coherent scattering form factors of biological materials. An energy-dispersive form factor measurement technique has been developed. It uses a geometry that consists of an x-ray tube, target, and high purity germanium detector. The tube and detector are kept fixed and the target is moved transversely to get the desired scatter angles. Geometry was optimized by analyzing the variation of scatter angle with the dimensions of the extended target and with other geometric parameters. To develop the technique, coherent form factors in the range 0.15 nm^{-1} to 11.87 nm^{-1} of the momentum transfer parameter $x = \lambda^{-1}\sin(\theta/2)$ were measured for lexan, poly methyl methacrylate, polystyrene, polyethylene, nylon, and water. The scatter angles as obtained by geometry optimization and the respective x-ray spectra used were 1.32º, 86 kV; 3.13º, 106 kV; and 15.41º, 121 kV. Weighted averaging was done at the two overlapping regions of the three form factor datasets to get one continuous dataset. Comparison of our data with published data obtained by the angle-dispersive technique using a powder diffractometer shows that the energy-dispersive technique can be used as a substitute for the angle-dispersive technique.

MO-POS-146

An Improved Volumetric (3d) Look-Locker Imaging Method for Longitudinal Relaxation Time (T1) Estimation, **Ken Nkongchu**, G. Santyr, *Carleton University* — A three-dimensional (3D) Look-Locker imaging pulse sequence employing a segmented acquisition of k-space with an improved accuracy in the estimation of the longitudinal relaxation time, T_1, was achieved in this study. To achieve adequate signal-to-noise ratio (SNR), the conventional 3D Look-Locker imaging sequence presented uses a large number (> 150) of small angles of only about 5º and a constant inter-pulse timing through out the image acquisition. In this study, a novel modification of the 3D Look-Locker imaging sequence is described where the inter-pulse timings are not constant. This variable inter-pulse timing allows for the inclusion of an intermediate recovery timing variable, and permits use of tip angles as large as 15º in the k-space acquisition, thereby improving the SNR. The T_1 accuracy of the method was tested for a phantom containing Gd-DTPA doped water with T_1 values varying between approximately 300 ms and 1700ms. For a 10º tip angle, T_1 accuracy was found to be within 3 % compared to conventional inversion recovery estimates. This compares favourably with an accuracy of only 11 % for the conventional 3D Look-Locker imaging sequence using an optimal 5º tip angle pulse.

MO-POS-147

Assessment of Phototimer Operation, **Harry Johnson** [1], L. Kurjewicz [1] and C. Neduzak [2], [1] *University of Winnipeg* and [2] CancerCare Manitoba — Phototimer systems provide automatic exposure control (AEC) to terminate the imaging exposure of a diagnostic x-ray beam. Proper functioning of the AEC system is essential to control x-ray image exposure, both for diagnostic image quality and patient dose. Quantitiative assessment of the calibration and operability of the photo cells is needed but is time consuming and requires repeated films. Radiation Protection Services, a department of the Medical Physics Division of CancerCare Manitoba regulates x-ray safety and compliance in Manitoba. RPS has undertaken tests of a new quantitative digital tool to measure exposure to the x-ray imaging plane. The device consists of a casette and a digital readout unit. The cassette contains the sensory components and is placed in the film plane – image plate plane, It measures the exposure (calibrated re mR) required to produce the image and hence also the imaging speed, independent of the processor (either film or computed radiographic plate). In a 400 speed system, the skin entrance dose for a chest x-ray is 0.11 mGy, effective patient dose is 0.03 mSv. This is the average for film systems in Manitoba. CR imaging is at lower speed, higher dose. Our findings indicate: (1) Calibrations of the left-centre-right photo cells vary; (2) Photo cells have been found inoperative, unknown to the technologists; (3) Speed of most film systems is at “400” plus; (4) Speed of CR systems is approximately “200”. Data will be provided of the results of surveys and the review will include service- related discussions.

MO-POS-148

Standards for Quality Control for Canadian Radiation Treatment Centres, Peter Dunscombe [1], Clément Arsenault [2], **Jean-Pierre Bissonnette** [3], Harry Johnson [4], George Mawko [5], and Jan Seuntjens [6], [1] Tom Baker Cancer Centre, [2] Hôpital Dr Georges-L Dumont, [3] *Princess Margaret Hospital*, [4] CancerCare Manitoba, [5] QEII Health Sciences Centre and [6] Montreal General Hospital — The Canadian Association of Provincial Cancer Agencies (CAPCA) has begun a standardisation process for the establishment and maintenance of quality radiation treatment across Canada. A final draft of the “Standards for Quality Assurance at Canadian Radiation Treatment Centers” has been submitted, and the Canadian Organisation of Medical Physicists has been mandated to develop a series of appendices to this final draft to document national quality control standards for the equipment used in Canadian radiation therapy clinics. All documents use a standard format, thereby providing a unique consistency across the entire proposed quality assurance standard. Each document details quality control frequencies, tolerances, and action levels for the given equipment or modality. All quality control procedures echo, where applicable, accepted international standards, such as those endorsed by the AAPM or IPEM, or with other current publications. We have submitted the content of each quality control protocol for review by a recognized Canadian expert. Documents have been drafted so far for simulators, cobalt units, linear accelerator, dosimetry instruments, orthovoltage units, multi-leaf collimators, portal imaging systems, brachytherapy, and intensity-modulated radiotherapy, and will be made available through the COMP/CCPM web site. Other standards are planned for CT simulation, record-and-verify systems, radiosurgery, and prostate implants. These documents reflect the spirit of continuous quality improvement: clinics can use them as templates and revise test frequencies and tolerances based on accumulated evidence. We expect that, upon approval from CAPCA, federal and provincial regulations and accreditations bodies shall require compliance to these quality control standard.

MO-POS-149

The BioMedical Imaging and Therapy Beamline at the Canadian Light Source Inc. **Colleen Christensen**, *Canadian Light Source Inc* — The BioMedical Imaging and Therapy (BMIT) Beamline is a multidisciplinary, multiuse facility that is being proposed for the Canadian Light Source, Canada’s National Synchrotron Facility. The BMIT Beamline will have two specific research uses, non destructive imaging of tissues and radiation therapy in living organisms. The total cost of this project will be approximately $17M. Funding for this project will be obtained from the Canadian Foundation for Innovation, the provincial governments and charitable foundations. The BMIT Beamline is projected to be ready for operations in 2006.