

[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 Wang², Ivan Deutsch³ and Barry Sanders^{1, 2}, *University of Calgary*, ²Macquarie University and ³University 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 Sakhr², ¹*Northern Digital Inc.*, and ²McMaster 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 ²Mount 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

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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 $E_p = m(\lt c^2)$, 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 atypical collision mechanics of quanta structures more efficient than typical 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 atypical 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.