C^2AM SCHEDULE

All times are in Eastern Daytime Timezone (EDT).

AUGUST 3, 2022, WEDNESDAY

Contents

9:00 – 10:00 Keynote Speaker: Dr. Darío Núñez Zúñiga

Title: *Sharing Physics with the national communities - Challenges and lessons*

Abstract: Sharing the knowledge in Physics, among the scientific community and the rest of the society, is one of the main lines of action of the Mexican Physical Society. In Mexico, we are fortunate to still have 8% of the population belonging to the native, aka national, communities. Several millions, children included, do not have Spanish as their first language, and many of them do not speak it at all. Nevertheless, the elementary education is given with books in Spanish and often by only Spanish speakers teachers. In this talk we will describe the experience and lessons obtained in our efforts to share news and concepts of modern physics in several native languages of our Country.

10:00 – 11:30 Session 1A: Condensed Matter, Solid State, and Materials Physics

- Andrew Hardy (University of Toronto - Canada)

  Title: *Nematic phases and elastoresistivity from a multiorbital non-Fermi Liquid*

Abstract: We propose and study a two-orbital lattice extension of the Sachdev-Ye-Kitaev model in the large-N limit. The phase diagram of this model features a high temperature isotropic non-Fermi liquid which undergoes a first-order thermal transition into a nematic insulator or a continuous thermal transition into nematic metal phase, separated by a tunable tricritical point. These phases arise from spontaneous partial orbital polarization of the multiorbital non-Fermi liquid. We explore the spectral and transport properties of this model,including the d.c. elastoresistivity, which exhibits a peak near the nematic transition, as well as the nonzero frequency elastoconductivity. Our work offers a useful perspective on nematic phases and transport in correlated multiorbital systems.

- Kyle Bryenton (Dalhousie University - Canada)

Title: *Capturing Many-Body Dispersion with Exchange-Hole Dipoles*

Abstract: London dispersion is a weak, attractive, intermolecular force that occurs in most quantum systems due to instantaneous dipole moments. While individual dispersion contributions are small, they are the dominating force between non-polar species and determine many properties of interest. Standard methods in density-functional theory (DFT) do not account for dispersion contributions, so a correction such as the exchange-hole dipole moment (XDM) or many-body dispersion (MBD) models must be added. Recent literature has discussed the importance of many-body effects on dispersion, and attention has turned to which methods accurately capture them. By studying systems of interacting quantum harmonic oscillators from first principles, we have shown that these many-body effects are captured by the XDM model. Results will be presented and compared to the MBD model, which is also known to capture these effects.

- Alejandro Carlos Iglesias Jaime (University of Havana - Cuba)

Title: *Figures of merit of PLZT ferroelectric ceramics for practical applications*

Abstract: Structural, microstructural and pyroelectric properties were investigated in PZT-based ferroelectric ceramics for a composition close to the morphotropic phase boundary (Zr/Ti=53/47), as a function of the lanthanum content. The samples were prepared via the conventional solid-state reaction sintering method. Three compositions were synthetized and studied following the $PbZr_{0.53}Ti_{0.47}O_3$ + x mole% La nominal formula, where x = 0.0, 2.5 and 5.0. The structural characterization confirmed the presence of both tetragonal and rhombohedral phases for all the studied compositions, showing a decrease in the tetragonality factor (c/a) with the increase of the lanthanum concentration. The observed decrease in the stability of the ferroelectric phase (in favor of the paraelectric one) have been discussed in light of the solubility of the doping cation into the studied PZT perovskite structure. Microstructural properties revealed low pores concentration micrographs, showing homogeneous microstructures and uniform grain-sizes. The pyroelectric response of the as-prepared PLZT samples was also investigated in a wide temperature interval. The lower lanthanum content composition exhibited the best properties, characterized by a high pyroelectric coefficient and enhanced figures of merit. These characteristics make such a composition a promising material for practical applications.

- Yosvany Silva Solis (InSTEC/UH , AMU - Cuba)

  Title: *Model for the solubility and diffusion of hydrogen at the tungsten/copper interface in ITER cooling monoblocks*

  Abstract: The International Thermonuclear Experimental Reactor (ITER) is currently built in Cadarache, France, with the aim to demonstrate the feasibility of producing energy from the fusion of hydrogen's (H) isotopes nuclei. ITER hosts a divertor at the bottom of the vacuum vessel, which main goal is to extract heat and impurities from the plasma. The divertor is built using tungsten (W) monoblocks cooled by water in copper (Cu) tubes. Consequently, H isotopes might be lost by diffusing in W, through the W/Cu interface, in Cu and finally up to the water coolant. It means that tritium would be released in nature and that its amount should be determined. If the solubility and diffusivity of H are already known in pure W and Cu, everything is to be established at the interface, which is the aim of this work. To accomplish our objective, we built a model based on Density Functional Theory (DFT). First, we did a convergence study to determine the number of Cu and W layers that converge the model. Also, we determined the cell parameters for W and Cu at the interface. Finally, we determined the solution energy of H in W and Cu with the cell-parameter in perfect bulks, and with the cell parameters at the interface. Two high symmetry positions were considered: the octahedral and tetrahedral sites. Our convergence studies led us to use a 2×2×8 interface unit cell as a model, which convergences the energy of the interface to less than 1 meV/Å2. We determined a small contraction of the W cell-parameters in the X and Y direction, while those for Cu are largely expanded. In the Z direction, the cell parameter for W is expanded from 3.18 Å to 3.21 Å, while the one for Cu is dramatically compressed from 2.88 Å to 2.53 Å. The impact of these geometric variations on the solution energy of H was finally determined. The change is moderate for the solubility of H in W, while it is huge for Cu with respect to perfect Cu bulk. Finally, this study allows us to conclude that the solubility of H drastically increases on the Cu side of the interface which should behave as a sink for H.

- Miguel Lindero Hernández (Instituto Politécnico Nacional - Mexico)

  Title: *Superconductive wireless charging system*

  Abstract: Power Wireless Transmission using High Temperature Superconductors is gaining attention today mainly because superconductors are capable to create high currents and high magnetic fields, thus allowing a high energy density. Wireless chargers for electrical vehicles are systems in which superconductors have been implemented to rise the energy transmited rate. The challenge to achieve high wireless power lies in the reduction of ac losses in superconductive coils. An optimal design coil configuration, a high quality factor Q and a high coupling constant k are

among the most important variables necessary to accomplish high efficiencies. Therefore the aforementioned parameters need to be analyzed at various frequencies (up to 300 kHz) and powers up to 10 kW in order to establish the criteria where the Power Wireless Transmission System can work with the highest efficiency.

- Musiliyu Kazeem Adeleke (Afe Babalola University - Nigeria)

  Title: Effect of concentration on the properties of nitrogen-doped zinc oxide thin films grown by electrodeposition

  Abstract: Zinc Oxide is one of the most researched semiconductors owning to its outstandingproperties that make it useful in various industrial applications, such as solar cells and other optoelectronics. In this work, ZnO thin films were prepared in five different concentrations and doped with four nitrogen atomsfrom ethylene-tetramine(ETA) with the aim to fabricate aZnO for optoelectronic applications using electrodeposition technique. The doped ZnO thin films were synthesized and deposited on ITO glass substrates. The deposited thin films were annealed at 400°C for 60 minsin a furnace under the same conditions. The optical, electrical and surface morphological properties of the thin films were characterized using UV-Vis Spectrophotometer, Four Point Probe (FPP) and Scanning Electron Microscope (SEM) respectively. The optical properties confirmed the films suitability for various transparent device applications with high optical transmittance of about 90% at the wavelength between 250nm – 950nm. The optical bandgaps of 3.25 eV to 3.50eV were obtained at ZnO concentrations from 0.2 M to 1.0 M. The SEM images depicted a polycrystalline nature of the films with irregular nano-particle shapes across the substrates. Electrical results established the high conductivity of nitrogen doped ZnO thin films, thereby making the thin films suitable as transparent conducting oxides for devices such as solar cells and optoelectronics.

10:00 – 11:30 Session 1B: Quantum Information and Computing

- David Amaro Alcala (Institute for Quantum Science and Technology, University of Calgary - Canada)

  Title: *Benchmarking of universal qutrit gates*

  Abstract: We present a method to estimate the average gate fidelity for universal ternary quantum gates. Using representation theory and the Fourier transformation on the space of irreducible representations, we obtain expressions for the survival probability, allowing experimental access to the parameters necessary to the computation of the average gate fidelity. Following the state-of-the-art, our method is shown to be invariant under similarity transformations of the noisy gates. Finally, we present numerical evidence that our method provides, for fidelities reported in the literature, an estimate close to the empirical average gate fidelity.

- Sarmed A Rahman (York University - Canada)

  Title: *Error Mitigation for Lattice Gauge Theory on a Quantum Computer*

  Abstract: Lattice Gauge Theory is what is used to perform non-perturbative Quantum Field Theory calculations. We perform real-time evolution on IBM's quantum computer. To achieve meaningful results, we introduce a new method of error mitigation in which the physics circuit is run forward in time and then backwards.

- Shawn Skelton (University of Waterloo - Canada)

  Title: *Getting to Low Ground: A Quantum Imaginary Time Evolution focused Study of Ground State Approximation*

  Abstract: Identifying the ground state of a local Hamiltonian on a quantum device is in general a computationally hard problem, with relevance to many sub-disciplines of physics and chemistry. Algorithms to identify ground states often rely on subroutines with quantum Fourier transformations on ancillary qubits. A recent proposal, Quantum imaginary time evolution (QITE), instead approximates imaginary time evolution to the ground state. QITE requires a bound on the correlations between subsets of the system, and an initial state with at least an exponentially small overlap with the ground state. We present an overview the circuit model, ground state problem, and QITE algorithm, highlighting restrictions on when the method can be appropriate, and the expected costs of the algorithm.

- Christian Louis Hanotel Pinzón (Instituto de Ciencias Nucleares, UNAM - Mexico)

  Title: *Holonomic Quantum Computation using anticoherent planes*

  Abstract: We present a proposal to generate quantum gates for holonomic quantum computation, i.e., quantum computation where gates are non-abelian geometric factors of suitable chosen quantum evolutions. In particular, we show that for particular hamiltonians and particular states forming an anticoherent plane, these gates are topologically protected against different kinds of noise. After a quick review of anticoherent states, i.e., spin states that have vanishing polarization vector, we present a generalization of them to the case of planes that will be useful to present our results and a collection of examples. We finally state some remarks about the geometric nature of our results.

- César Enrique Terán Cisneros (Instituto de Ciencias Físicas, Universidad Nacional Autónoma de México - Mexico)

  Title: *Ionization processes in collisions of an antiproton with a hydrogen atom*

  Abstract: In this work, the dynamics of the collision between an antiproton and a hydrogen atom is studied by solving the time-dependent Schrödinger equation with the finite difference method implementing the Crank-Nicolson approximation. Due to the charges of the projectile antiproton and the electron, the interaction between these particles will be described through a repulsive Coulomb potential, giving rise to the possible ionization process where the electron is ejected into the continuum. The electron of the target atom is described quantumly, while the nucleus of the target (the proton) and the projectile antiproton are treated as classical point particles. The total cross section for ionization in the collision is reported by implementing absorbing boundaries through masking functions. The results obtained agree quite well with other theoretical models in the range of collision energy from 0.1 keV to 1000 keV, as well as with experimental measurements.

- Sachin Satish Bharadwaj (New York University - United States of America)

  Title: *Exploring the practicability of quantum linear solvers for QCFD simulations*

  Abstract: Quantum computing (QC) as we know today, has begun to proliferate its presence in many scientific disciplines. With every advancement in quantum algorithms and error correction, QC challenges its classical counterpart. However, for QC to emerge as an indispensable tool for practical applications, the exigency is not just for novel protocols that process quantum information but also for extracting it wisely in classical formats that cater to the solution of practical problems. Here we draw attention to potential methods of conducting fluid mechanics research using QC, which we call Quantum Computation of Fluid Dynamics (QCFD). In this light, we evaluate an end-to-end performance demonstration of modified Harrow-Hassidim-Lloyd (HHL) type algorithms to study problems such as the Poiseuille and Couette flows. For this, we also introduce here a new, high performance QC simulator, specific to fluid-dynamics, which we call "QuOn", designed to simulate most standard quantum algorithms. We shall present results using both QuOn and the IBMQ - Qiskit tools.

12:00 – 13:30 Session 2A: Condensed Matter, Solid State, and Materials Physics

- Raidel Martin Barrios (University of Havana - Cuba)

  Title*: Translational Inelasticity of Hydrogen Atoms Scattering off Hydrogen-Covered W(110) Surfaces*

  Abstract: Quasi-classical trajectory simulations are performed to investigate the energy transfer upon scattering of hydrogen atoms off hydrogen-covered (110) tungsten surfaces. For hydrogen atoms impinging clean metal surfaces at energies of the order of few electronvolts, translation energy loss has been recently demonstrated to be mainly mediated via electron-hole pair excitations. The present theoretical approach scrutinizes the effect of coverage by hydrogen pre-adsorbed atoms. Scattering can be rationalized in terms of three distinct dynamical mechanisms, the contribution of which changes with coverage. These allow in particular to understand why the shape of the energy loss spectra critically depends on whether scattering is analyzed in the whole space or at specular angle.

- David Machado Pérez (University of Havana - Cuba)

  Title: *Spin-glass dynamics of the p-spin ferromagnet: terminal states and zero temperature limit near stationary points.*

  Abstract: The cavity master equation (CME) is a closure to the usual master equation for the dynamics of discrete variables on random graphs. It provides a general procedure for the study of diverse out-of-equilibrium processes. So far, this technique has been used to understand some properties of disordered systems, which can have a rich phenomenology related to the emergence of spin-glass phases. As a continuation of previous developments, this work concentrates on the low-temperature regime of the p-spin model on random hypergraphs. A modification of the original equations is introduced and used to predict the final states of Monte Carlo simulations of the dynamics. The latter is possible when the equations are combined with a novel extension of a method that allows to locate dynamic spin-glass transitions. A generalized point-to-set correlation length is computed in both equilibrium and non-equilibrium settings, and its divergence is inspected to detect the spin-glass. The new CME is also useful to recover the system's behavior near stationary points.

- Jesús Antonio Alba Cabañas (University of Havana - Cuba)

  Title: *Semiconductor nanostructured oxides by low-cost techniques for photovoltaics application*

  Abstract: Photovoltaic devices based on nanostructures have high expectations of increasing the conversion efficiency of solar energy to electricity. Achieving this using abundant, non-toxic materials and low-cost techniques is one of the fundamental challenges of this family of cells. In this sense, our laboratory has developed various low-cost growth techniques; like nanoparticle laser induced growth, electric field assisted chemical bath deposition and SILAR automated homemade equipment. A pulsed laser as a thermal source allowed us to achieve a homogeneous growth of ZnO nanorods as well as to achieve a CdS-nanoparticles/ZnO-nanorods heterostructure. As a results of using a constant electric field in the step previous to the growth process, changes in the vertical alignment and compactness of the ZnO nanorods were achieved. In addition, the use of a variable electric field during the nanorod growth was experimented, resulted in a remarkable control of the morphology of the nanostructures.

- José Luis Fajardo Montenegro (University of Lehtbridge and Universidad del Valle – Canada and Colombia)

  Title: *Looking for the FFLO phase through bosonization*

Abstract: A magnetic field destroys superconductivity by coupling to both orbital an spin degrees of freedom. In the latter case, the Zeeman effect in the strong regime gives rise to an unconventional superconducting phase, the Fulde-Ferrell-Larkinv-Ovchinnikov (FFLO) phase, characterized by finite pairing momentum and the breakdown of time-reversal symmetry. In the present work, we employ the bosonization technique to investigate the appearance of the FFLO phase in an ultracold Fermi gas loaded in a one-dimensional lattice, in the presence of a magnetic field. On our way to that goal, we bosonize the Hamiltonian of the Asymmetric Hubbard Model (AHM) which is a limit case of the Hamiltonian of the system and allows us to discuss carefully the treatment of the Klein factors within the bosonization program. Finally, we adressed the next steps towards a bosonized version of the Hamiltonian of the system.

- Juan Carlos Obeso Jureidini (Universidad Nacional Autónoma de México - Mexico)

  Title: *Large-distance behavior of the pair wave function and the density correlation functions throughout the BEC-BCS crossover in two and three dimensions*

  Abstract: When modulating the strength of the interaction between fermions in a homogeneous two-component Fermi gas at zero temperature we can obtain a crossover from a Bardeen-Cooper-Schrieffer (BCS) state to a molecular Bose-Einstein condensate (BEC). In the mean-field approach a complete image of the formation of molecules and Cooper pairs can be obtained by analyzing the density-density correlation functions and the variational pair wave function. In this talk we present a study of the large-distance behavior of the two-body distributions in two dimensions (2D) and in three dimensions (3D). It is found that in both dimensions they exhibit an exponential decay characterized by the length associated to the threshold energy required to break a pair. Also we found that they exhibit a large-distance oscillatory behavior that is different between the 2D case and the 3D case.

- Elena Esther Torres Miyares (University of Havana - Cuba)

  Title: *Surface diffusion within the Caldeira-Leggett Formalism*

  Abstract: Surface diffusion is described in terms of the intermediate scattering function in the time domain and reciprocal space. Two extreme time regimes are analyzed, ballistic (very short times) and Brownian or diffusive (very long times). This open dynamics is studied from the master equation for the reduced density matrix within the Caldeira-Leggett formalism. Several characteristic magnitudes in this decoherence process such as the coherence length, ensemble width and purity of the density matrix are analyzed. Furthermore, for flat surfaces, the surface diffusion is considered for the Schrödinger cat states and identical adsorbates or adparticles, bosons and fermions. The analytical results are compared with those issued from solving the Lindblad master equation through the stochastic wave function method. This numerical analysis is extended to be applied to corrugated surfaces.

12:00 – 13:30 Session 2B: Machine Learning and Numerical Methods - Physics Education

- Andrea Arlette España (Universidad Autónoma de San Luis Potosí - Mexico)

  Title: *Complexity of the paths towards synchronization*

  Abstract: In this work, a way to quantify the synchronization of a system is introduced, from a coding of the paths towards synchronization to synchronize flows defined on a network. Specifically, I focus on the Laplacian system and the Kuramoto model. The collection of paths towards synchronization defines a combinatorial structure, which is called: transition diagram, and is completelly described when the system acts on the completely connected graph. The cardinality of these collections defines a complexity function that has a factorial rate of growth.

- Iván Margarito Álvarez Rios (Universidad Michoacana de San Nicolás de Hidalgo - Mexico)

  Title: *A code that solves the Schrodinger-Poisson-Euler system with periodic boundary conditions*

  Abstract: We present a code that simultaneously solves the Schrödinger-Poisson (SP) system together with the Euler equations. We have developed a tool that allows the study the interaction between the scalar dark matter described by the SP system weakly coupled to the luminous matter modeled by the Euler equations through the Poisson equation using periodic boundary conditions in each of the system components. We describe the numerical methods used together with convergence tests in some simple scenarios. The boundary conditions in these simulations play a very important role since depending on the type of condition used, it can lead to different density profiles outside a galactic core. Our code uses periodic boundary conditions which allow the formation of core-halo structures.

- Joeluis Cerutti Torres (Universidad Politécnica de Madrid - Spain)

  Title: *Into an accurate and low computational cost prediction of bandgaps in cupper based delafossite oxides: a DFT and ML study*

  Abstract: Copper based delafossite oxides of the form $CuMO_2$ have been reported as promising candidates for transparent conducting oxides (TCOs) materials in the construction of solar cell devices, among other applications based on their optical and electronical properties. In the present work we report density functional theory simmulations on the compunds of the form $CuMO_2$ with $M=Al, Ga, Fe, Cr, Ni, Co$. For the calculations GGA, GGA+U and HSE schemes were tested and their results compared. The use of hybrid functionals in HSE approximation improves considerably the bandgaps when compared with the experimental results, but takes considerable time to converge. Therefore, using the projected DOS for the different elements in HSE simmulations, different GGA+U were performed to obtaing the parameter U that more accuratly placed the \textit{d} orbitals of the transition metals in the valence band. Having the bands accurately described in a GGA+U scheme, other optical calculations with a reasonable computational cost and an acceptable accuracy can be performed. Lastly, maching learning is used to estimate the bandgaps of mixed delafossite compounds of the form $CuM_xN_{1-x}O_2$ being M, N the same metals previously mentioned.

- Camille A. Coffie (University of Central Florida - United States of America)

  Title: *Identifying Academic Ableism: Case Study of a UDL-Learning Community Participant*

  Abstract: To improve accessibility and inclusion in postsecondary STEM education, we propose implementing Universal Design for Learning (UDL) based practices to meet the needs of a variety of learners. The UDL is a design framework aimed at improving and optimizing teaching and learning for all people, regardless of their disability status. As part of a larger professional development project, interviews were conducted with members of a faculty learning community to discuss their instructional practices and to offer feedback regarding opportunities to remove barriers to access and participation. In this study, we focus on an interview with a physics instructor and examine their beliefs about students with disabilities as evidenced by the disability-specific language used in the interview. This prompted a new perspective on professional development regarding accommodating students with disabilities that focuses on confronting ablest beliefs as a crucial component in promoting inclusion in STEM education.

14:00 – 15:00 Keynote Speaker: Dr. Ivan Booth

Title: *Things I didn't know when I was a grad student*

Abstract: Life and work as a graduate student is quite different from undergrad. As a grad student, courses are just a small part of the "job": now you also have to worry about your TA responsibilities and, most importantly, research. This includes not only doing the science but also writing papers, interacting with professors and presenting at conferences. Much of this is new and can be quite stressful. In this talk I will discuss what I learned about all of this while I was a grad student and, just as importantly, the "secrets" I have learned in the 20 years since.

15:00 – 16:30 Session 3A: Atmospheric and Space Physics

- Ángel Martín Ramírez Rabelo (Universidad Autónoma Metropolitana - Mexico)

  Title: *Mass-Cossistent Velocity Fields Estimation with the Variational Formulation*

  Abstract: Atmospheric dynamics is a complex system composed of a great diversity of factors and variables that interact with each other. The high sensitivity in its initial conditions also makes this a chaotic system. That is why it is essential to guarantee the physical consistency of our models and to have methods that determine the variables at stake as precisely as possible. The importance of the mass balance in atmospheric transport models generated approaches that propose ignoring the divergent term of the transport equation; ignoring this term causes substantial changes in the structure of the velocity field. The solution is to use velocity fields that are non-divergent so that the divergent term naturally vanishes. The simplest case of a conservative velocity field is the field that results from the sum of an interpolated initial field obtained from horizontal wind data and the imposition of conservation of mass. This field is useless in trajectory calculations because it reproduces vertical terrain variations indefinitely. There are two equivalent alternatives to solve this problem; the Helmholtz decomposition and the variational formulation. We focus on the variational formulation since it results in a well-defined problem with unique solutions, however, we differentiate between the standard formulation and a proposal whose difference lies in the type of boundary conditions used. This proposal greatly improves the mass balance and therefore the physical consistency of the wind field.

- Oliver-Isac Ruiz-Hernandez (Benemérita Universidad Autónoma de Puebla - Mexico)

  Title: *The orbital telescope TUS: Reconstruction of events with track*

  Abstract: The TUS (Tracking Ultraviolet Set-up) detector is the first fluorescence telescope aimed to measuring Extensive Air Showers (EAS) from space. Its main operation mode has a 0.8 μs temporal resolution and was devoted for EAS detection, also it was able to measure different slower luminescent phenomena in the near ultraviolet range as Transient Luminous Events (TLEs) micro-meteors and thunderstorm activity. In this talk we present the kinematics reconstruction of events recorded on the fast and slowest mode which possess a linear track. We discuss the possible source of them and their luminosity. The experience of these orbital observations will be useful for future more sensitive space missions.

- Nurlan Rzayev (University of Alberta - Canada)

  Title: *Lagrangian Coherent Structures and Transport in Magnetized Plasma Temperature Filaments*

  Abstract: Our study is motivated by magnetized temperature filament experiments performed in the Large Plasma Device (LaPD). We study energy and particle transport analytically as well as numerically based on experimental results. It has been previously shown that the experimental results are in agreement with the classical heat transport theory in an early stage with quiescent conditions. This stage is followed by an anomalous transport with the emergence of drift-Alfven waves that are driven by temperature gradients and lead to enhanced cross-field transport. The results have been shown to diverge from the predictions of the classical theory [1]. A model electric potential, introduced by M. Shi. et. al. [2], capturing the main experimentally observed features in magnetized filament experiments, such as temperature-gradient driven drift waves, is considered. We use analytical and diagnostic methods previously formulated to detect Lagrangian Coherent Structures (LCSs) for this model flow field advected by [E cross B] drift velocity to locate underlying transport barriers such as repelling and attracting material lines and vortices. Four detection methods for LCS (out of 12 methods which are described and compared in [3]) are considered and compared. Next, we plan to apply these methods to the flow fields in three filament experiments and gyro-kinetic simulations to explore the underlying non-linear structures that are not present in the analytical model field. [1] A. T. Burke, J. E. Maggs, and G. J. Morales, Phys. Plasmas 7, 544 (2000). [2] M. Shi, D. C. Pace, G. J. Morales, J. E. Maggs, and T. A. Carter, Phys. Plasmas 16, 062306 (2009). [3] A. Hadjighasem, M. M. Farazmand, D. Blazevski, G. Froyland, and G. Haller, Chaos 27, 053104 (2017).

- Itzayana del Carmen Izquierdo Guzmán (Universidad Michoacana de San Nicolás de Hidalgo - Mexico)

  Title: *A study of conversion of energy during the magnetic reconnection in a solar flare process*

  Abstract: A mechanism of the solar flare formation is the so-called magnetic reconnection, during which the conversion of magnetic energy into kinetic and thermal energy occurs. In order to quantify this phenomenon we make simulations of plasma evolution during a flare. The simulation is made by resolving the resistive MHD equations with thermal conductivity. We employ a 2.5D configuration on a rectangular domain that is perpendicular to the solar surface and contains the chromosphere-corona interface. To begin the flare we consider an initial force free magnetic field which contains a change of polarity along a vertical line, and a Gaussian resistivity profile is used to define the diffusion zone where the magnetic reconnection takes place. The analysis determines the influence of the strength of the magnetic field in the process, that ranges from 22G to 50G in the maximum of the configurations with β from 0.19 to 0.059 for case with and without thermal conductivity. In each case, the magnetic reconnection rate is measured as well as the conversion of magnetic energy into kinetic and thermal energy inside the diffusion zone. From our analysis we quantify the influence of magnetic field strength and of thermal conductivity in the plasma evolution.

- Lismary de la Caridad Suárez González (Institute of Cybernetics, Mathematics and Physics (ICIMAF) - Cuba)

  Title: *Finite temperature effects on relativistic Bose-Einstein Condensate stars with magnetic field*

  Abstract: We study the role of temperature on the macroscopic properties of magnetized Bose-Einstein condensate stars. These compact objects are composed of a gas of interacting neutral vector bosons coupled to a uniform and constant magnetic field. We assume that the boson-boson interactions are independent of the temperature and the magnetic field, and modeled them as tow-body contact interactions, while the thermal part was described through the exact thermodynamic potential of a hot gas of free vector bosons under the action of an uniform and constant magnetic field, including antiparticles. To obtain the macroscopic properties we used the γ-structure equations since they properly describe the axial deformation of magnetized stars. The main consequence of a finite temperature in the magnetized equations of state is to increase the inner pressure of the star. As a consequence, magnetized hot Bose-Einstein condensate stars are, in general, larger and heavier than their zero-temperature counterparts. However, the maximum masses given by the model remain almost unchanged, and the magnetic deformation of the star increases with the temperature. Besides, augmenting the temperature reduces the number of stable stars, an effect that the magnetic field enhances. The implications of our results for other stars´ observables and evolution are analyzed.

- Ricardo Ochoa-Armenta (Universidad Michoacana de San Nicolás de Hidalgo - Mexico)

  Title: *Adaptive Mesh Refinement for the solution of MHD equations*

  Abstract: Magnetohydrodynamics equations (MHD) are useful to describe a great variety of plasma physics phenomena, from laboratory to space weather. Several analytical and numerical advances have been made regarding their use and solution. In this context, Adaptive Mesh Refinement (AMR) is a technique that solves the aforementioned equation by managing computational resources more efficiently, and also adequately evolves plasma behavior when great disparities in the spatial and temporal scales occur simultaneously, i. e. , when the flow dynamics have very localized features. In this talk we present a new tool we have developed from the scratch, namely a code that solves the plasma physics MHD equations, with the orientation toward solar physics. The code is equipped to solve the MHD equations in various contexts, from ideal to resistive and thermal conduction regimes. It uses high resolution shock capturing methods with flux formulae of the HLLC class, linear and high order variable reconstructors. Evolution is integrated using the method of lines with explicit solvers. The code is mounted on top of our home made Adaptive Mesh Refinement driver, based on self similar block data structures ordered in hierarchical trees, and parallelized with the MPI library. We describe physics and computing tests that illustrate the capabilities of the code within space science.

- Suman Kumar Kundu (Syracuse University - United States of America)

  Title: *Mild Compression of Radiative Stars by Supermassive Black Holes*

  Abstract: Tidal disruption events (TDEs) are events in which the tidal influence of supermassive black holes either partially or completely destroys stars. The outcomes of such events are largely controlled by the parameter $\beta \equiv r_{\rm t}/r_{\rm p}$, where $r_{\rm t}$ is the tidal radius and $r_{\rm p}$ is the distance of the closest approach. In events where the star enters deep within the SMBH tidal radius (i.e. $\beta \gg 1$), often referred to as deep TDEs, the star experiences high adiabatic compression, and the density and temperature of the stellar core increases. The

maximum central density (maximum temperature) thus achieved was shown to scale as $\propto \beta^3(\propto \beta^2)$, strong enough to trigger nuclear detonation of the stellar core in TDEs with $\beta \gtrsim 5$; but this prediction has been debated thoroughly to date. We perform high-resolution smoothed particle hydrodynamics (SPH) simulations to mimic the tidal engagements of a Sun-like star, modeled with the Eddington standard model, with a $10^6 M_\odot$ black hole for β values in the range $2-10$. We find the maximum density does not follow the predicted $\propto \beta^3$ or any power-law scaling. Additionally, we confirm that the time the star spends at high density and temperature is small compared to the dynamical timescale of the star. Therefore, even for highly penetrating $(\beta \gtrsim 25)$ TDEs, the nuclear burning rate in a Sun-like star triggered by tidal compression is expected to be very small.

15:00 – 16:30 Session 3B: Optics - Applied Physics

- Sara Medhet (Quaid-i-azam University - Pakistan)

  Title: *Signatures of inter-band transitions on dynamical localization*

  Abstract: We explain the dynamics of ultracold atoms in amplitude modulated optical lattice with harmonic confinement. We show the existence of dynamical localization that manifests itself as the cold atoms exhibit quantum suppression of classical chaos in the dynamical system. The exponential localization takes place both in momentum as well as in coordinate space within certain windows on modulation amplitude. We show that inter-band transitions, taking place due to the amplitude modulation in optical lattice, play an important role in controlling the dynamical localization of matter waves. Our obtained results can be generalized to other dynamical systems and are experimentally realizable as we consider the values of parameters from the present-day available experiments.

- Aaron T. Bondy (University of Windsor - Canada)

  Title: *Finite-mass and relativistic corrections to helium two-photon decay rates*

  Abstract: Two-photon transition rates are important in determining astrophysical quantities such as population balance in planetary nebulae. We recently calculated two-photon decay rates in heliumlike ions including the finite-nuclear-mass effects [1]. We established useful algebraic relations by treating mass polarization effects as a power series expansion in μ/M. I will also report of progress on our effort to perturbatively add relativistic corrections of order $(\alpha Z)^2$ to these results, which together with the finite-mass corrections will give the most precise and accurate calculations to date. A continuous gauge parameter is used in our calcualtions, and the operators are compared with the long-wavelength QED operators derived previously for few-electron atoms [2]. [1] A. T. Bondy, D. C. Morton,

and G. W. F. Drake. 102, 052807 (2020). [2] K. Pachucki, Phys. Rev. A 69, 052502 (2004).

- Kárel García Medina (University of Havana - Cuba)

  Title: *On the puzzle of collective behavior in locally-interacting systems*

  Abstract: Synchronization, and collective phenomena, on large populations of individual units have been a research subject in many branches of knowledge. The appearance of correlations and emergent behaviors in such systems continues to attract the attention of researchers, since it can be observed in a wide range of different contexts. A common approach has been to model the individual component units as phase oscillators. Under this approach, the analysis of the dynamics of the system is reduced to the study of the laws that govern the evolution of the units that form it. One of the most representative models in this context is the Kuramoto model, where almost identical weakly coupled oscillators are considered. The general problem is, nevertheless, highly sensitive to the topology of the particular system. Great steps have been taken since then, but mostly in globally-interacting systems where a mean- field treatment is possible. In this contribution we propose a model consisting on a ring of identical oscillatory units with Kuramoto-like local coupling. The dynamics and phenomenology of this model are discussed in detail. The model is analyzed both analytically and numerically. Significant points of the phase space are located and sufficient conditions are found for the appearance of emergent phenomena. The system exhibits a rich set of behaviors depending on the balance between different parameters. Mechanisms behind spontaneous synchronization are discussed. The appearance of complex patterns and the computational complexity of the model are also analyzed by means of entropic markers.

- Paul M Ryan (University of Arizona - United States of America)

  Title: *Understanding Spiroplasma Swimming Modalities through Experimental and Computational Methods*

  Abstract: Nearly all swimming bacteria have evolved to utilize external, helical, rotating appendages called flagella to achieve motility. These flagella are anchored into a cell wall which provides a structural rigidity and elasticity during the swimming process. Contrary to this, a unique bacterium called spiroplasma has neither a cell wall nor flagella, yet still swims in water. Instead, this bacterium utilizes a set of actively deformable cytoskeletal filaments, internal to the cell, which allows for swimming motility. These filaments deform the entire cell body, however, the interaction between the cell body and these filaments is unclear. Using this information, we have created a finite volume algorithm using resistive force theory which accurately describes spiroplasma's motion. In this presentation, we'll explore the current understanding of how spiroplasma swims, how our novel algorithm's simulations give insight into that mechanism, and how this information influenced experimental methods to shed more light on this motility mystery.

- Alfredo Reyes González (University of Havana - Cuba)

  Title: *Transmission of danger information past physical barriers by ants*

  Abstract: Can insects transmit information through a physical barrier they cannot cross? Here we investigate the transmission of danger information from a group of ants located in two arenas separated by a barrier: ants in the danger arena are exposed to a threat while individuals located in a safe arena are not. Experimental details are shown followed by a statistical analysis of the center of mass of ant members. A model that has its origin in an Ornstein-Uhlenbeck process to describe ant's interactions is introduced. We show that before panic is induced ants' movement can be described following a superstatistics approach and how the model should be modified to explain panic response is finally presented.

- Daniel López Díaz (Institute of Cybernetics, Mathematics and Physics (ICIMAF) - Cuba)

  Title: *A new channel for excitonic transport in the Fenna-Matthews-Olson complex*

  Abstract: The light-harvesting complexes within most photosynthetic organisms reach 80-90% quantum efficiency (QE) in the energy transfer chain. Hence, two interests around these naturally optimized nanosystems are: (1) to understand the transport channels behind such high QE, (2) to elucidate design principles that can increase QE in devised applications. In this sense, the Fenna-Matthews-Olson (FMO) complex of green sulfur bacteria is a typical system for research. Also, its study has recently received a new boost due to the presumptive role that quantum coherence seems to play in its energy transfer chain. FMO is a trimer that hosts 7 embedded pigments per monomer (namely, intramonomeric), whereas other 3 are localized at the space in and between monomers (namely, intermonomeric). The intuitive transport channel for FMO, labeled as FMO8′, consists that intramonomeric pigments (1-7 indexes) partner with their closest intermonomeric counterpart (8′ index). Here, we considered a counterintuitive transport channel, labeled as FMO8, consisting of the 1-7 pigments and their second nearest intermonomeric pigment (8 index). FMO pigments and their environment are modeled as a site network described by an excitonic Hamiltonian. We analysed usual mechanisms for FMO8′ and FMO8 channels: a fully coherent Schrödinger dynamic and a totally incoherent Förster Resonant Energy Transfer (FRET). Additionally, a new hybrid mechanism is considered for FMO8 channel: a FRET out of pigment 8 combined with a collective excitonic state of the 1-7 pigments due to quantum coherence. Results using the experimental Hamiltonian show that, during the quantum coherence time window, FMO8 channel efficiency with hybrid mechanism outperforms all other considered possibilities. From structural data for FMO, we found that this performance relies on a dipolar resonance related to the fourth excitonic state. Interestingly, the tuning of pigment couplings suggests this 'bright' state is an effect of quantum coherence. Finally, simulations applying a genetic algorithm highlight the differentiated fitness and peculiarity of FMO8 channel with hybrid mechanism, as is expected for natural selection. In conclusion, a new excitation channel (FMO8) in the energy transport chain is proposed for FMO. Regarding aspect (1), its superior performance seems to rely on the interplay between incoherent transfer and quantum coherence. Also, the obtained bright dipolar resonance may shed new light on (2).

17:00 – 18:30 AWARDS CEREMONY