Graduate Student Poster Session

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GSP1: Estimating the Cosmic Ray Exposure of the Super Cryogenic Dark Matter Search Detectors

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The Super Cryogenic Dark Matter Search (SuperCDMS) experiment at SNOLAB will use detectors instrumented with phonon and ionization sensors to attempt to measure the recoil energy imparted to Germanium (Ge) and Silicon (Si) nuclei due to collisions of dark matter particles. During fabrication and shipment, the detectors are exposed to cosmic-ray secondaries that collide with the Ge and Si nuclei and through spallation create radioisotopes within the detector crystals. A particular isotope of concern is tritium which has a 12-year half-life and creates a background that diminishes the detectors' sensitivity to dark matter interactions. To estimate the cosmic-ray exposure of the crystals along shipment routes and to select future routes with minimum cosmic-ray exposure, a MATLAB program was created taking into account geographical location, duration of route, driver rest period (sleeping, refueling, etc.), and elevation.

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GSP2: Measuring the CO/CO_2 Mixing Ratio in Comets

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CO and CO_2 are abundant molecules in comets that may play important roles in driving distant activity, and their relative abundances may provide important observational constraints to models of solar system formation and evolution. Recent discussions often assume that Q(CO_2) >> Q(CO) for most comets within 5 au, but we show that the documented record is not well-enough established to support this. This is highly relevant for studies that rely on NEOWISE and Spitzer photometric data obtained at ~4.5 μm which contains combined emission from CO+CO_2 and emission is typically attributed to only one of the volatiles. We compiled a comprehensive list of individually determined CO and CO_2 production rates from the literature which shows that there is a non-negligible

percentage of comets in each group of CO-rich, CO_2-rich, and those with equal amounts of both. We present a preferred way to establish the relative abundances of CO and CO_2 using NEOWISE or Spitzer 4.5 μm data when simultaneous CO spectra are available. We also discuss plans to incorporate the heliocentric distance of comets to include differential thermal effects, and to use modeling of spatial profiles of CO and CO_2 in photometric images to establish the mixing ratio when CO spectra is not available.

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GSP3: VSe2: A Ferromagnetic 2d Material

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Reduced dimensionality and interlayer coupling in van der Waals materials gives rise to fundamentally different electronic, optical, and many body quantum properties in monolayers compared to bulk. This layer-dependence permits the discovery of novel material properties in the monolayer regime. Ferromagnetic order in two-dimensional materials is a coveted property that would allow fundamental studies of spin behavior in low dimensions and enable new spintronics applications. Recent studies have shown that for the bulk-ferromagnetic layered materials CrI3 and Cr2Ge2Te6 ferromagnetic order is maintained down to the ultrathin limit at low temperatures. Contrary to these observations, we report the emergence of strong ferromagnetic ordering for the monolayer of VSe2, a material that is paramagnetic in the bulk. Importantly, the ferromagnetic ordering with a large magnetic moment persists to above room temperature, making VSe2 an attractive material for van der Waals spintronics applications.

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GSP4: Using a String Derived cMSSM to analyze regions of the Parameter Space to Find Dark Matter Candidates

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The research our group is focused on is using computational models to analyze dark matter candidates from the Xenon experiment. By finding a particle that maintains the correct Higgs mass, cross section and dark matter relic density, we would find evidence of dark matter existing. We are using a string theory derived cMSSM(Constrained Minimal Supersymmetric Standard Model) to deal with the issue of naturalness and fine tuning.

With acknowledgment to University Of Houston - Clear Lake for providing funding.

GSP5: Tracking the motion of Majorana Bound States attached to Josephson Vortices in S/TI/S Junctions

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The detection and imaging of superconducting vortices is a desirable tool for studying exotic emergent behavior such as the presence of Majorana bound states in a proximitized topological insulator. This requires a very sensitive magnetometer with sub-micron spatial resolution which may be achieved by a Superconducting Quantum Interference Device (SQUID) coupled to a scanning probe. We propose a design for a Scanning SQUID Microscope (SSM) which involves inductively coupling a commercial SQUID to a superconducting pickup loop we have fabricated. Said loop acts as our scanning probe and is patterned with a multi-step fabrication procedure utilizing a combination of electron beam lithography and focused ion beam etching. The spatial resolution of our SSM - limited by the size of our pickup loop - may be able to reach sub-micron dimensions. We present preliminary results of cryogenic probe approach tests and topographic imaging of Niobium wires with a large pickup loop.

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GSP6: Thickness Dependence of the Topological Hall Effect in SrRuO3/SrIrO3/SrTiO3 Superlattices

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Topological magnetic structures have attracted interest recently due to the possible application in memory storage. Electrical detection through the topological Hall effect (THE) has been a primary method of detection of these structures. Multilayers of perovskites (metal oxides with the form ABO3) are valuable for investigating this phenomenon due to the wide range of electrical and magnetic properties and very low lattice mismatch allowing for high quality crystalline growths. SrRuO3/SrIrO3 bilayers films were found to exhibit topological Hall (TH) signals when the layers are only a few unit cells thick due to interfacial Dzyaloshinskii-Moriya interactions between the ferromagnetic/heavy metal interface. Here we investigated the effect of interlayer coupling on the topological Hall effect in superlattices of SrRuO3, SrIrO3, and SrTiO3. Superlattice structures comprised of 8 repetitions of SrRuO3/SrIrO3/SrTiO3 trilayers were grown with UHV magnetron sputtering on (001)-oriented SrTiO3 substrates (STO(001)/[SrRuO3(10uc)/SrIrO3(4uc)/SrTiO3(2, 6, 10uc)]x8). As the separation between adjacent SrRuO3/SrIrO3 layers is increased the magnitude of the TH resistivity decreases and a sign change in the TH resistivity is suppressed. A temperature

dependent study shows that the topological Hall signal transitions from appearing before to after the coercivity as the temperature is increased. These trends do not appear in SrRuO3/SrIrO3 bilayer structures and are unique to the superlattice structures.

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GSP7: Host Environments of Fast-Ejecta Core-Collapse Explosions

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Only one type of supernova has been observed at the locations of gamma-ray bursts and those are SN Ic, in particular SN Ic-BL, where BL denotes the presence of broad line features in the supernova's spectra. This in turn indicates relativistic ejecta velocities of the order ~ 0.1c. Recent work has shown evidence that on rare occasions and given the right conditions, a massive star ends its life in a supernova explosion accompanied by relativistic jets of gamma-rays. Because gamma-ray bursts are observable at much greater distances than supernovae, establishing a solid connection between SN Ic-BL and GRBs will introduce a new tool for probing the earliest stellar populations and chemical evolution of the universe.

GSP8: Shadow Show: Transverse Kinematic Variables Reveal New Qe Neutrino Sample Features

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The MINERVA experiment, located at the Fermi National Accelerator Laboratory (Illinois), is a detector designed to study neutrino-nuclear interactions. MINERVA has been instrumental in understanding how neutrinos interact with detectors and its research has been used to better analyze data from oscillation experiments like DUNE(Deep Underground Neutrino Experiment) and NOVA(NuMi Off Axis eAppearance). Though MINERvA has ended data collection this year, more analysis on the models of nuclear interaction happening in the nucleus is required. GENIE, a neutrino event generator, is one used to model such interactions. Upon reviewing special features in transverse kinematic distributions the task to remodel some of these interactions ensued. On this poster, a new GENIE simulation of a class of quasielastic neutrino events will be presented, along with results for the new transverse distributions along with MINERvA's big plans for these results. (https://arxiv.org/abs/1910.08658, https://arxiv.org/abs/1906.10576)

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GSP9: Correlated Insulating And Superconducting States In Twisted Bilayer Graphene Below The Magic Angle

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The emergence of flat bands and correlated behaviors in “magic angle” twisted bilayer graphene (tBLG) has sparked tremendous interest, though its many aspects are under intense debate. Here we report observation of both superconductivity and the Mott-like insulating state in a tBLG device with a twist angle of ~0.93°, which is smaller than the magic angle by 15%. At an electron concentration of ±5 electrons/moiré unit cell, we observe a narrow resistance peak with an activation energy gap ~0.1 meV. This indicates additional correlated insulating state, and is consistent with theory predicting a high-energy flat band. At doping of ±12 electrons/moiré unit cell we observe resistance peaks arising from the Dirac points in the spectrum. Our results reveal that the “magic” range of tBLG is in fact larger than what is previously expected, and provide a wealth of new information to help decipher the strongly correlated phenomena observed in tBLG.

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GSP10: Frequency-Resolved Third-Order Correlations in Quantum Dot Resonance Fluorescence

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We investigated the three-photon spectrum of quantum dot resonance fluorescence, revealing significantly more pronounced photon anti-bunching at the Mollow triplet sidebands and more strongly correlated emission through virtual states than at second-order.

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