beyond the standard model (BSM). While previous BSM searches have been performed with cold beams of diatomic molecules, which were able to probe TeV energy scales, laser-cooled molecules offer orders of magnitude improvement in measurement time, with the potential to increase sensitivity to PeV scales. Unfortunately, laser-coolable diatomic species lack easily polarizable parity doublets. Such so-called internal co-magnetometer states are a prerequisite for significantly enhanced systematic error rejection. Conversely, certain polyatomic molecules, such as linear tri-atomics or symmetric tops, exhibit both internal co-magnetometers and electronic structures favorable to laser-cooling, making them ideal candidates to extend the frontier of precision measurement searches. We propose combining laser-cooling and cryogenic buffer gas cooling of YbOH to search for new hadronic and leptonic physics at the PeV scale. Laser-cooled, easily polarized molecules also have applications in fields beyond precision measurement, such as quantum information, many-body quantum dynamics, and ultracold chemistry.

T01 82 Apparatus for Laser-Cooling and Trapping Potassium KELLAN KREMER, MATT BUTSCHEK, JONATHAN WRUBEL, *Creighton Univ* We present our apparatus for laser cooling and trapping potassium atoms. The apparatus utilizes a compact permanent-magnet 2D magneto-optical trap (MOT) as a low-velocity intense source for the 3D MOT. The science chamber is an octagonal glass cell chosen to allow for precise control over the magnetic field at the atoms. The goal of the apparatus is to study the hyperfine (radio-frequency) Feshbach resonance, which requires excellent magnetic field stability.

T01 83 Photoassociation spectroscopy and Atom-Molecule Coherence in Ultracold Li-Yb Mixtures* JUN HUI SEE TOH, ALAINA GREEN, KHANG TON, SUBHADEEP GUPTA, *University of Washington* The non-bialkali LiYb molecule possesses both electric and magnetic dipole moments, and the unpaired electron degree of freedom could be utilized towards magnetic trapping of ultracold molecules as well as tuning of molecular collisions and reactions. We present photoassociation (PA) spectroscopy of ground and excited state potentials of the ^{6}Li^{174}Yb molecule. We have observed several vibrational states in an excited state potential using 1-photon PA spectroscopy, detected as atom loss in an ultracold mixture of Li and Yb atoms confined in an optical dipole trap. Using 2-photon PA to couple the excited state to the ground state, we have observed several vibrational states in the ground state potential. The binding energies, linewidths, and the line strengths will be reported. We have also observed narrow atom-molecule dark state resonances in coherent two-photon spectroscopy. We intend to utilize these dark states to perform Stimulated Raman Adiabatic Passage (StiRAP) to create ultracold samples of LiYb in the electronic ground state.

*This work is funded by NSF Grant No. PHY-1306647, AFOSR Grant No. FA 9550-15-1-0220, and ARO MURI Grant No. W911NF-12-1-0476.

T01 84 Undergraduate Research Laboratory for Controlling Atoms with Frequency Modulated Light MATTHEW WRIGHT, *Adelphi Univ* TANNER GROGAN, JAMES ST. JOHN, TARA PENA, *Adelphi University* We have developed an undergraduate research lab for controlling atoms with pulsed frequency chirped laser light. We can tune the chirp rate to 1 GHz in 4 ns and pulse the laser as short as 3 ns. We will discuss recent results of undergraduate research probing interference in spontaneous emission in dilute Rb gases with pulsed lasers. We will also discuss how we plan to use this apparatus to explore standard atomic physics experiments such as STIRAP, ARP, etc and use it to conduct future research on coherently controlling photon-assisted ultracold collisions.

T01 85 An efficient 2D array of blue-detuned optical traps* TRENT GRAHAM, XIAOYU JIANG, CODY POOLE, *Physics, University of Wisconsin-Madison* YUAN SUN, *Interdisciplinary Center for Quantum Information, National University of Defense Technology, Changsha 410073, P.R.China* MARTIN LICHTMAN, *Joint Quantum Institute, University of Maryland* MARK SAFFMAN, *Physics, University of Wisconsin-Madison* We demonstrate a 2D lattice of blue-detuned optical traps which uses laser power efficiently, is tolerant to perturbations in beam alignment, and is insensitive to interferometric phases. Blue traps have several advantages over red traps despite requiring a more complicated beam geometry. Since atoms in a blue trap sit at an intensity minimum, Stark shift noise and site-to-site calibrations are minimized. However, constructing a blue lattice which efficiently converts laser power into trap depth, is challenging. For example, a lattice of bottle beams is inefficient because neighboring sites are separated by two walls, limiting the number of traps that can be formed. An array of tightly spaced Gaussian beams is a more efficient blue trap, but the trap potentials are susceptible to alignment perturbations. We demonstrate an array which uses diffractive optical elements to create a cross-hatched pattern of lines in the focal region where the atoms are trapped in up to 121 sites. This "line array" is almost twice as efficient as the Gaussian beam array and is more resilient to perturbations in beam alignment.

*This research was supported by the ARL-CDQI under cooperative agreement W911NF-15-2-0061 and NSF award PHY-1720220.

T01 86 Critical vortex shedding in a strongly interacting fermionic superfluid JEE WOO PARK, BUMSUK KO, YONG-IL SHIN, *Seoul National University* Quantized vortices in superfluids are fundamental topological excitations whose creation and dynamics reveal the underlying thermodynamic and transport properties of the medium. Here, we report on the experimental study of the critical velocity for vortex shedding in a strongly interacting fermionic superfluid. The sample consists of a balanced mixture of two lowest hyperfine states of ^{6}Li atoms prepared in a highly oblate trap near a broad s-wave Feshbach resonance. By moving a repulsive optical obstacle through the condensate and directly imaging the vortices after time of flight, we measure the critical velocity for vortex shedding as a function of the interaction parameter $1/k_F a$ and the obstacle travel distance L. The critical velocity displays markedly different behaviors in the two limits of L. For short L, it shows a pronounced peak near unitarity, whereas for long L the peak is strongly suppressed, implying that the onset of drag force occurs at a lower velocity and that the increase of the drag force with velocity is slow near unitarity. Further comparison of the measured critical velocity to the speed of sound and the pair breaking velocity, and the application of the periodic shedding model to determine the onset of the drag force will be discussed.

T01 87 Spin-orbit coupling and superfluidity in ultracold quantum gases BENJAMIN SMITH, LOGAN COOKE, ANINDYA RASTOGI, TARAS HRUSHEVSKYI, ERHAN SAGLAMYUREK, LINDSAY LEBLANC, *University of Alberta* Considering BECs of ^{87}Rb and ^{39}K, we explore the effects of spin-orbit coupling on the superfluidity of this ultracold quantum gas. In particular, we are interested in the analogue of a spin-Hall effect in this system, where, effectively, two different spin states experience

different magnetic fields. We study this system numerically using the Gross-Piteavskii equation, and find that various "structures" emerge depending on the spin-orbit, trap, and interaction parameters, such as the formation of oppositely rotating vortices in the two different spin components, or stripes, or spin-domain formation. We discuss progress towards realizing this system with our BEC experiments in the laboratory.

T01 88 Toward Magneto-Optical Trapping of Polyatomic Molecules LOUIS BAUM, IVAN KOZYRYEV, ZOE ZHU, PHELAN YU, JOHN M. DOYLE, *Harvard University* Three dimensional confinement of atoms inside a magneto-optical trap (MOT) revolutionized atomic physics and along with evaporative cooling led to the development of ultracold atomic gases in the quantum degenerate regime. Recently, groundbreaking experimental and theoretical work in molecular physics culminated with the creation of MOTs for diatomic molecules trapped below 1 mK [1-3]. Building on these achievements and our previous work on laser cooling of polyatomic molecules [4], we will present our progress towards creating a RF MOT of a triatomic radical, CaOH. Our experimental and theoretical results indicate that laser cooling can also be extended to hexatomic symmetric top molecules, e.g. $CaOCH_3$. Non-zero vibrational angular momentum of linear triatomics and finite projection of rotational angular momentum onto the body frame of symmetric top molecules result in linear Stark shifts, enabling novel quantum science applications.

[1]Norrgard *et al.*, PRL **116**, 063004 (2016).
[2]Truppe *et al.*, Nat. Phys. **13**, 1173 (2017).
[3]Anderegg *et al.*, PRL **119**, 103201 (2017).
[4]Kozyryev *et al.*, PRL **118**, 173201 (2017).

T01 89 Optical Dipole Trapping of Holmium* CHRISTOPHER YIP, DONALD BOOTH, HUAXIA ZHOU, *University of Wisconsin-Madison* JEFFREY COLLETT,† *Lawrence University* JAMES HOSTETTER,‡ *Honeywell* MARK SAFFMAN,§ *University of Wisconsin-Madison* Neutral Holmium's 128 ground hyperfine states, the most of any non-radioactive element, is a testbed for quantum control of a very high dimensional Hilbert space, and offers a promising platform for quantum computing. Previously we have cooled Holmium atoms in a MOT on a 410.5 nm transition and characterized its Rydberg spectra. We report here on the first optical dipole trapping of Holmium with a 532 nm wavelength trap laser. The trap lifetime is close to 1 sec., limited by photon scattering from nearby transitions. The trapped atoms are used to measure the dynamic scalar and tensor polarizabilities which are compared with calculations based on measured oscillator strengths. We also report progress towards narrow line cooling and magnetic trapping of single atoms.

*This research was supported by NSF award PHY-1707854.
†Permanent address: Department of Physics, Lawrence University, Appleton, Wisconsin 54911.
‡Present address: Honeywell, Golden Valley, Minnesota 55422.
§Department of Physics, University of Wisconsin-Madison, Madison, Wisconsin 53706.

T01 90 Atomic properties of actinide ions with particle-hole configurations MARIANNA SAFRONOVA, *University of Delaware* ULYANA SAFRONOVA, *University of Nevada, Reno* MIKHAIL KOZLOV, *Petersburg Nuclear Physics Institute of NRC, Russia* We study the effects of higher-order electronic correlations in the systems with particle-hole excited states using a relativistic hybrid method that combines configuration interaction and linearized coupled-cluster approaches. We find the configuration interaction part of the calculation sufficiently complete for eight electrons while maintaining good quality of the effective coupled-cluster potential for the core. Excellent agreement with experiment was demonstrated for a test case of La^{3+}. We apply our method for homologue actinide ions Th^{4+} and U^{6+} which are of experimental interest due to a puzzle associated with the resonant excitation Stark ionization spectroscopy (RESIS) method. These ions are also of interest to actinide chemistry and this is the first precision calculation of their atomic properties.

T01 91 Demonstration of metrologically relevant spin-squeezing in free space with an ensemble of ^{87}Rb atoms YUNFAN WU, ONUR HOSTEN, *Stanford Univ* RAJIV KRISHNAKUMAR, *Caltech/INQNET* JULIAN MARTINEZ, BENJAMIN PICHLER, MARK KASEVICH, *Stanford Univ* CQED TEAM Entangled atomic states such as spin-squeezed states can overcome the atomic projection noise that limits the precision of atomic sensors. Various experiments have successfully demonstrated such states. For precision sensing applications requiring the atoms to be freely moving, such as fountain clocks and atom interferometers, the homogeneity of the prepared squeezed states is crucial for their successful retrieval. In this work, we initially generated 12dB spin-squeezed states using an optical-cavity that uniformly interacts with 500,000 ^{87}Rb atoms trapped in an optical lattice. Then we released these atoms into free space and recaptured them back into the lattice after a variable duration. The final state of the atoms was then measured with the help of the cavity. We characterized the degradation in squeezing as a function of release time, and modeled it including the effects of atom loss and loss in atom-cavity coupling homogeneity. We demonstrated the retrieval of spin-squeezing in free space for up to 2ms limited by our ability to recapture the atoms. This result is a crucial step towards implementing metrologically relevant spin-squeezed atomic sensors in free space.

T01 92 Quadratic optomechanical interaction in the reversed dissipation regime HYOJUN SEOK, *Department of Physics Education, Kongju National University* JAE HOON LEE, *Center for Time and Frequency, Division of Physical Metrology, Korea Research Institute of Standards and Science* Cavity optomechanics is an important platform for which the interaction between light and the motional degrees of freedom of a mechanical oscillator can be engineered for specific objectives such as cooling the mechanical state or amplifying the electromagnetic field. Here we theoretically examine an optomechanical resonator coupled to both mechanical and optical reservoirs in the reversed dissipation regime. We show that in the case of quadratic coupling between the electromagnetic field and mechanical oscillator, the linewidth of the noise spectra of the cavity field is dependent on the mean phonon number of the mechanical oscillator. Using advanced fabrication methods for optomechanical devices, we propose to develop reservoir engineered optomechanical devices for temperature measurement in the quantum regime.

T01 93 Hydrodynamics in a uniform Fermi Gas* XIN WANG, LORIN BAIRD, STETSON ROOF, JOHN THOMAS, *North Carolina State University* We are working towards trapping a strongly interacting ultracold Fermi gas of ^{6}Li atoms in a uniform box potential. The potential is created by applying repulsive blue-detuned beams shaped by Digital Micromirror Devices (DMD). The DMDs are more flexible compared to diffractive optics as they are capable

THURSDAY AFTERNOON \ T01