2012 Midwestern Cold Atom Workshop

All talks will be held in Loomis 141, and will be 20 minutes plus 5 minutes for questions. Breakfast, coffee breaks, lunch, and the poster session will be held in the "walnut hallway" (around the corner from 141 on the 1st floor of Loomis) and adjacent rooms.

	Activity/Chair	Speaker	Title	Abstract
8:00-9:00	Registration & Breakfast			
9:00-9:25	Yong Chen	Brian DeMarco (University of Illinois)	*Introduction to MCAW 2012 and DeMarco Group Experiments*	I will give an overview of recent results from the DeMarco group, including the observation of a metal to insulator transition in the disordered Fermi-Hubbard model, measurements of band decay in a spin-dependent lattice, and dynamic Anderson localization measurements.
9:25-9:50		Wei Jiang (Argonne National Lab)	TBA	TBA
9:50-10:15		Yen-Wei Lin (Northwestern University)	*State readout by coherent motion with few-photon seeding*	I will discuss the motion of a single trapped Ba+ ion, resonantly driven by a pulsed light pressure force. We recently demonstrated that the driven ion quickly builds up coherent oscillations above the thermal motion, after scattering of order one hundred photons. The motion is analyzed by Doppler velocimetry with subsequent motional amplification. Since the light pressure force is state-dependent, this motional seeding technique provides a simple method to readout the spectroscopy result from a single non-fluorescing molecular ion with partially closed cycling transitions such as SiO+ in our application.
10:15-10:30	Coffee break			
10:30-10:55	Jon Simon	Marty Lichtman (University of	*Development and characterization of a*	We have developed a 2D array of atom traps, currently with 6 single atom sites, and to be scaled

	Wisconsin)	*6-site blue-detuned Cesium trap array*	up in the near future. Cesium atoms are loaded into the traps using a ballistic 2D MOT to 3D MOT transfer to achieve high loading rates with low background pressure. The traps are blue detuned (780 nm) and the walls are generated an array of Gaussian beams generated using diffractive elements and calcite beam displacers. The trap spacing of 4 um will allow entanglement between atoms using the Rydberg blockade interaction. The traps currently have a lifetime of ~1 second, although experiments using red traps have demonstrated the vacuum limited lifetime of the apparatus is at least 25 seconds. Single atoms are loaded at an efficiency as high as 60% per site, with 6 atoms loading in 2.3% of shots. Plans for implementation of the quantum search algorithm will be discussed.
10:55-11:20	Skyler Degenkolb (University of Michigan, Leanhardt group)	*Precision Magnetometry and the Neutron Electric Dipole Moment at FRM-II*	A permanent electric dipole moment of the neutron (nEDM) is a CP- and T-violating projection of the charge separation along the spin axis. Experiments have searched for the nEDM over the past 55 years with steadily improving sensitivity, and the most recent measurement, $\|d\|<2.9E-26$ e-cm, is consistent with zero. The Standard Model of particle interactions provides two sources of the nEDM: a phase in the mixing of quark generations by the weak interaction and a strong-interaction parameter, theta_QCD. The contribution of the quark-mixing phase is constrained by other laboratory measurements to be far below the current experimental sensitivity, but measurements of the nEDM and similar observables can be interpreted as constraining theta_QCD. Extensions of the Standard Model that explain, for example,

			the cosmological excess of matter over antimatter also predict EDMs at the level of current experimental sensitivity. Seven experiments on three continents are currently preparing improved apparatus for next-generation measurements, which rely heavily on precision techniques from atomic physics. In particular, magnetometry with ground-state atoms is crucial for quantifying systematic errors associated with applied and ambient fields. Co-habiting magnetometers of He-3, Hg-199, or Xe-129 monitor field inhomogeneities and fluctuations by approximating the spatial and velocity distributions of trapped neutrons. External alkali-based magnetometers and SQUIDs can provide additional information, or couple to the co-magnetometer for readout. Both optical and inductive readout mechanisms exploit powerful new methods, including deep-UV laser locking, nonlinear optics in gaseous media, and highly efficient optical pumping. A new technique using two-photon scattering and dispersion in Xe-129 and Yb-171 is highlighted.
11:20-11:45	Chen Zhang (Purdue University, Greene group)	*Ultracold scattering and molecule formation in a Bose-Fermi mixture*	Few-body ultracold scattering in a Bose-Fermi mixture is studied theoretically. The energy spectrum for the few-body Bose-Fermi system in a harmonic trap is calculated using a correlated Gaussian basis. The dynamical evolution of this system when ramped across a Fano-Feshbach resonance is also explored, and we connect our few-body prediction of the molecule formation efficiency to observations in many-body experiments.

11:45-12:10		Rebecca Holmes (University of Illinois, Kwiat group)	*Determining the Lower Limit of Human Vision Using a Single-Photon Source*	I will discuss the use of a source of heralded single photons to investigate possible single-photon vision in humans. Physiological research has shown that photoreceptor cells in the retina are sensitive to single photons, and studies with human observers have also suggested that the threshold for vision may be as low as one photon. Previous studies have used classical light sources. Spontaneous parametric down-conversion, a well-known source of heralded single photons for quantum information research, can be used to test the vision threshold directly with single photons. Our source, experimental design, and recent progress toward human trials will be discussed.
12:10-2:00	Lunch & lab tours			
12:45-1:15	Lab tour I			
1:15-1:45	Lab tour II			
1:45-2:00	Clean up, reconvene			
2:00-2:25		Abraham Olson (Purdue University, Chen group)	*Purdue Updates --- Gauge fields, spin-orbit coupling, and photo-association*	We will give an update on the Purdue experiments on BEC and cold molecules. We have improved production of BEC via all optical evaporative cooling with optimized efficiency. We have realized both synthetic gauge fields and spin-orbit coupling in our Rb-87 BEC subject to optical Raman transitions, and made a preliminary observation of a spin-Hall like effect of cold atoms in synthetic spin-orbit coupling. We have also photoassociated ultracold Rb-87 dimers and rebuilt our dual species LiRb MOT to create LiRb molecules.
2:25-2:50	Brian Odom	Shih-Kuang Tung (University of Chicago, Chin Group)	*Identification of collisional resonances and three-body universality based on an ultracold mixture of*	One unique feature about ultracold atom experiments is that we are able to control how atoms interact. When two atoms move towards each other, their scattering wavefunction can couple to a bound state near the scattering

			Li-6 and Cs-133 atoms	continuum, and the scattering amplitude can develop a resonant enhancement, which we called a Feshbach resonance. Here we report our observations on the Feshbach resonances in an ultracold mixture of fermionic Li-6 and bosonic Cs-133 atoms. Those resonances provides us essential information to control the interactions between the two atomic species, which opens up many exciting research fronts, especially to explore the universality of three-body Efimov states.
2:50-3:15		Eric Paradis (University of Michigan, Raithel group)	*High-magnetic field atom trapping and Rydberg spectroscopy*	
3:15-3:40		Jon Simon (University of Chicago, Simon group)	*Engineering Quantum Materials from Cold Atoms: Mott Insulators to Emergent Crystals*	The tools of atomic physics provide a unique and powerful toolbox for studies of quantum many-body physics. Using such systems it has recently become possible to engineer strongly-correlated materials from the ground up and probe them with single-atom resolution. I will describe experiments in which we have synthesized the first magnetic material composed of ultracold atoms, and watched it undergo a quantum phase transition from a paramagnet to an antiferromagnet. I will then introduce a new algorithmic cooling scheme that we have demonstrated, pointing the way to yet more exotic quantum phases that exist at lower temperatures. Finally, I will describe ongoing efforts to develop materials composed of strongly correlated photons whose long-range anisotropic interactions will open new horizons, permitting studies of quantum soft-matter.
3:40-5:00	Poster session &			

	snacks