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Society of Physics Students (SPS)
Poster Session

October 4, 2017 (2:30-4pm)
SR Atrium
Welcome to the Zone 7 SPS Meeting at CSU!

Some key info about CSU’s Physics Program:

**Undergraduate Program**
- **No. 2** among all Physics Departments in Ohio where MS is the highest degree (in number of undergrad Physics degrees).
- CSU Physics is **one of only 3** Physics Departments in Ohio to host NSF’s sponsored REU program
- **10%** of CSU Physics graduates (BS and BS Honors) in the last 12 years have been accepted into physics/ engineering PhD programs
- **38%** more undergrad degrees granted by CSU Physics department than an average of undergrad degrees from all Physics Depts in US (with MS- highest degree)
- CSU’s SPS chapter has been recognized as Outstanding SPS chapter for 7 consecutive years ([www.spscsu.org](http://www.spscsu.org))

**Graduate Program**
- **No. 3** among all MS granting Physics Depts in Ohio (total count 11) in number of MS Physics degrees
- **No. 7** among all Physics Departments in US where MS is the highest degree (total count of 63) in Fraction of Female MS Physics degrees
- **40%** - Fraction of Female MS Physics degrees
- Our MS program in Medical Physics is **the only CAMPEP-accredited graduate program** in Northeast Ohio.
- It is one of only three CAMPEP-accredited Medical Physics MS programs in Ohio (along with the University of Toledo and the University of Cincinnati).
- Our Medical Physics Certificate program is **the only CAMPEP-accredited Certificate program** in Ohio.

**Poster 17: Synthesis Optimization and Characterization of Polymeric Microgels**

Student Researchers: **Samantha Tietjen** (CSU), **Samantha Hudson** (Hiram College)

Faculty Advisor: Kiril A Streletzky, PhD (Physics)

Microgels are spherical particles suspended in solution, comprised of crosslinked polymer chains. Due to the amphiphilic property of the parent polymer, microgels display a temperature dependent de-swelling property, and therefore have the potential to be used for drug delivery. In this case, microgels were synthesized using hydroxypropyl cellulose (HPC) polymer and divinyl sulfone (DVS) cross-linker, as well as dodecyltrimethylammonium bromide (DTAB) surfactant to decrease particle size and promote microgel monodispersity. Synthesized particles were then characterized using dynamic light scattering (DLS) for both temperature and angle dependence to determine hydrodynamic radius, $R_h$, at a range of temperatures showing a transition from the swollen to deswollen states. Previous studies suggest that increasing the concentrations of either the chemical cross-linker [1] or the surfactant [2] reduce $R_h$. Primary experiments focused on the variation of DVS and DTAB concentrations. Increasing the DVS:HPC ratio from 1 to 30 results in microgels that decrease in swollen size from 190 to 150nm and deswollen size from 95 to 65nm. However, at higher DVS:HPC ratio synthesized particles grow rather than shrink with increasing temperature. Surprisingly, increasing the surfactant concentration resulted in an increase in $R_h$; this might be related to DTAB effect on polymer transition temperature. Additionally, DLS experiments revealed a dependence of $R_h$ on microgel concentration in samples. $R_h$ at infinite dilution was extrapolated from the concentration dependence. Continued work with the synthesis procedure also revealed the importance of a meticulous synthesis procedure; most notably in regards to polymer stock preparation, pH and temperature control, and consistent stirring.

Poster 16: Reconciling Linear Measurements of Fractal Cloud Structures

Student Researchers: Nicholas Barron (CSU)

Faculty Advisors: Shawn Ryan, PhD (Math); Thijs Heus, PhD (Physics)

Clouds are a large unknown in meteorological predictions. Most of the issue can be derived from the odd shape of clouds. So, in order to correct the measurements of clouds, a thorough investigation of fractal cloud structures must be performed. Using the results from this study, a reconciliation method can then be constructed and applied to linear measurements of clouds.
Current climate models and weather forecasts suffer due to an uncertainty associated with the behavior of clouds, which directly impact the energy exchange between the earth and the Sun. This impact is determined in part by the shape of the clouds, thereby making the study of what affects cloud shape an area of interest. To characterize the shape of cumulus clouds we study the behavior of the cloud overlap ratio, or the ratio between the average cloud fraction and projected cloud cover. In this study, we used a high resolution computer model to 1) determine how the cloud overlap ratio is related to the height and layer depth of clouds where it is defined, 2) to study how the overlap behaves under different physical circumstances, and 3) to study how the fractal nature and wind shear impact cloud shape. We found that the shape is sensitive to cloud layer depth, the fractal nature and wind shear; but not to cloud height, time of day or location of the cloud field.
Due to their unique properties, anisotropic nanoparticles are desirable components for future applications yet there are few processes capable of fabricating nanoparticle impregnated coatings for the manufacturing environment. Our work seeks to develop new masking techniques for the production of the templated substrates that will induce ordered nanoparticle films. Specifically, we are fabricating non-close packed colloidal monolayers onto silicon substrates, which then serve as the template for ion irradiation. The first steps to creating this monolayer are obtaining a spin-coated poly(vinyl alcohol) (PVA) thin film of \( \sim 200 \text{ nm} \) and a close-packed colloidal monolayer using a peltier heater. We achieved a thin film of PVA with the desired thickness by examining the effects of the RPM and viscosity, measured by a rheometer, on film thickness which was evaluated with atomic force microscopy. Results showed that as the RPM increases and the viscosity decreases, the thickness decreases. To form the colloidal monolayer, a drop of silica spheres suspended in ethanol was placed on a silicon wafer and mounted onto a peltier element inside a closed box with fixed tilt, temperature, and humidity. We show that we can reduce the number of defects in the monolayer by cleaning with a piranha etch.
**Posters about us**

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**Research Posters**

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**Poster 13: Developing Methodologies for Wet-Sample Electron Microscopy Imaging**

**Student Researcher:** Daniel Terrano (CSU)

**Faculty Advisors:** Kiril A Streletzky, PhD; Petru F. Fodor, PhD (both Physics)

Scanning Electron Microscopy (SEM) is widely used to analyze the size, shape, and composition of material systems. However, using this tool for analyzing systems such as particles suspended in solution requires drastic sample alterations, such as precipitation and fixation. Besides altering their environment, this exposes the particles to the harsh conditions within an electron microscope, such as high vacuum and electron beam exposure. To this end, the first goal of this study was to develop methodologies for imaging wet samples using electron microscopy. This is realized by creating a sandwich structure containing the solution of interest between a partially electron transparent window and the aluminum stub. The ability of the developed imaging cells to provide good imaging conditions is demonstrated with a variety of samples including polystyrene spheres, polymeric microgels, and spindle-shaped nanoparticles. As some of the systems investigated are temperature sensitive, the second goal of the project was to develop a temperature controlled stage that can be integrated with the SEM. In the future, this heating stage will be used alongside the wet samples to image microgels above and below their critical solution temperature.
Organic materials are used in traditional solar cells and in flexible electronics. Unfortunately, the conductivities of organic semiconductors are significantly lower than their inorganic counterparts. This project examines the crucial first steps to enhancing the conductivities of these organic materials by crystallization via surface reconstructions. For this, the surface must be not only atomically smooth, but also atomically clean because there must be both enough room for the molecule to lie on and no possible adsorbates for the deposited material to react with. In this work, we looked at two substrates, gold and silicon. For the gold, we examined two annealing methods: hot plate and flame annealing. The hot plate method is the more viable, producing terrace widths of ~150nm, which is 50nm wider than achieved by flame anneal. For the silicon, a simple cleaving method in a nitrogen environment produced step edges of width ~20nm. These surfaces are characterized with Scanning Tunneling Microscopy (STM), however, atomic resolution has yet to be achieved in either case, possibly due to other adsorbates obscuring the surface. For the best STM images, we also need an atomically sharp, conductive tip. To achieve this, we used a two-step procedure for electrochemically etching platinum-iridium wire. The final step is a micro-polishing etch which utilizes H2SO4 to finely etch the tip down to exhibit radii of curvature of 70-100 nanometers with completion determined visually. In order to improve on this process, we are currently developing a circuit that will electrically determine completion which will result in more reproducible tips.
Poster 2: SPS Physics Fridays at Campus International School

Student Researchers: **Samantha Tietjen** (CSU), James Pitchford, B.S. (CSU), Krista Freeman, M.S. (Carnegie Mellon)

Faculty Advisor: Kiril A Streletzky, PhD (Physics)

Cleveland State University’s (CSU) chapter of the Society of Physics Students (SPS) runs an outreach program known as Physics Fridays at the Campus International School (CIS). In this program CSU students and alumni go to CIS once a month for an interactive physics exploration session with 30 to 50 of the school’s K-8th graders during CIS’s afterschool program. This program’s engaging lessons are designed around large and small group demonstrations and activities led by CSU students. The theme for the 2016-2017 session of Physics Fridays is “Sounds and Its Sources Around Us” and includes key lessons on: noise versus sound, sound as a wave, basic music theory, sound recording techniques, and the final Physics of Sound Day. The program promotes CSI kids’ excitement about science and interest in exploring it. On the other hand, preparation and delivery of the lessons give CSU students an opportunity for hands-on exploration in varying simple topics in physics in a fun but accountable environment, which better their own understanding of physics. SPS Physics Fridays at CIS has now won seven consecutive yearly *Marsh W. White Awards* (2011 - 2017) through the National SPS Office, an organization of the American Institute of Physics.

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Poster 11: Characterizing the Turbulent Structure of the Atmospheric Boundary Layer Using Large Eddy Simulations

Student Researchers: **Justin C. Flaherty** B.S. (CSU) Robert W. White B.S. (CSU), **Vladimir P. Sworski** (CSU)

Faculty Advisor: Thijs Heus, PhD (Physics)

The height of Atmospheric Boundary Layer (ABL) is dynamic throughout the day, and its behavior depends on numerous conditions that can be modeled with Large Eddy Simulations (LES). In comparison with many days of observations over the Department of Energy’s Southern Great Plains site, we find that our model is capable of accurately simulating the humidity distribution in the ABL. However, we find a discrepancy between temporal and spatial calculations of the humidity, especially in the entrainment zone. We show that this is likely due to persistent downdrafts of dry air that are into penetrating into the ABL from aloft.
**Poster 10: Using Modified Dean Flow Designs to Increase Mixing Performance**

Student Researcher: **Joshua Clark** (CSU)

Faculty Advisors: Chandra Kothapalli, PhD (Chemical/Biomedical Engineering) and Petru S. Fodor, PhD (Physics)

We are using numerical solutions for the Navier-Stokes equations and the concentration-diffusion equation to model fluid flow and reactant distribution in serpentine type channels for micromixers/microreactors development. These mixers exploit centripetal forces on the fluid to induce cross-sectional fluid mixing, aka Dean flows. Various modifications are used to increase the mixing character of these cross-sectional flows. We found that the performance of these mixers exceeds that of unmodified channels and we currently assess their performance relative to other state of the art methodologies used to induce mixing on the microscale.

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**Poster 3 (REU): Optimizing the Direct Visualization of HPC Microgels via Scanning Electron Microscopy**

Student Researcher: **Tony Dobrila** (CSU)

Faculty Advisors: Kiril A Streletzky, PhD; Petru S. Fodor, PhD (Physics)

To further understand the dynamics of microgels in solution, and correlate information on individual particles with Dynamic Light Scattering data on assemblies, a variety of imaging techniques were developed using scanning electron microscopy. Since high-resolution SEM requires high vacuum, accurate imaging of such systems pose a challenge as samples of HPC microgels lose water content under those conditions. As a preliminary measure to address these issues, a controlled environment chamber was developed, allowing the microgels to relax and dry over a longer period of time. Samples are dried at higher humidity levels than standard room conditions, allowing soft matter systems to better maintain their true structure whilst imaging. Using this humidity drying method gave microgel size distributions more consistent to that of DLS data below and above the transition temperature. A second method for imaging such systems was also developed by suspending microgels in ionic liquids. Due to their low vapor pressures and high ionic concentrations, these suspensions allowed us to capture real-time dynamics of swollen microgel interactions. It was observed that in such suspensions, some microgels were observed to be smaller than expected, whilst maintaining uniformity. Samples with hydrodynamic radii smaller than 450 nm, however, were not observed when suspended in ionic liquid. Such observations could be due to charge screening or the increased salt concentration due to the presence of ionic liquid.
**Poster 4 (REU): Design & Synthesis of Elastin-Like Polypeptide Diblock Copolymers for Biomedical Applications**

**Student Researchers:** Biaggio Uricoli (Rowan University), Richard Schmidt, B.S. (CSU)

**Faculty Advisor:** Nolan Holland, PhD (Chemical/Biomedical Engineering)

We have designed a DNA sequence that codes for a diblock copolymer consisting of two elastin-like polypeptides (ELPs) that are intended to reversibly assemble into micelles above 30°C, driven by the aggregation of a hydrophobic block at its transition temperature ($T_t$). Our goal was to verify the thermal responsive properties of these diblock copolymers and use them as building blocks for hydrogel-forming triblock copolymers. The ELP sequences (VFVFV)$_3$ and (IIIFII)$_3$ were both found to be suitable for the hydrophobic region, as they theoretically possess a $T_t$ of 30°C at a desired length of 15 pentapeptides. Furthermore, the DNA sequence for the diblock copolymer was designed to allow insertion of different hydrophobic ELP coding sequences via digestion and Gibson Assembly, or elongation of either the hydrophobic or hydrophilic region. This design allows for tunability in responsiveness to changes in the diblock copolymer's environment, such as shifts in temperature, pH, or salt concentration. This degree of control over the copolymer's properties holds promise for its use as a material in various biomedical applications, including drug delivery and 3D-bioinks for tissue engineering. Synthesis of the first component of the DNA sequence was also conducted; from gel electrophoresis and DNA sequencing, we confirmed that this component of our diblock copolymer had been inserted into a pET-20b plasmid.

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**Poster 9: Light Scattering Study of the Size and Shape of Mixed Elastin-Like Polypeptide Micelles**

**Student Researchers:** Ilona Tsupper (CSU), Daniel Terrano, Bryce Noe, Richard Schmidt, B.S. (all CSU)

**Faculty Advisors:** Kiril A Streletzky, PhD (Physics), Nolan B. Holland, PhD (Chemical/Biomedical Engineering)

Elastin-Like Polypeptides (ELP) can be used to form thermoreversible vehicles for drug delivery systems. The ELP nanoparticles are composed of three-armed star polypeptides. Each of the three arms extending from the negatively charged foldon domain include 20 repeats of the (GVGVP) amino acid sequence. In addition, linear constructs composed of 40 repeats of the same (GVGVP) sequence are introduced into the system. The mixed ELP polymer system is soluble at room temperature and becomes insoluble at the transition temperature (~ 50°C) forming micelles with the foldons on the exterior and linear constructs at the core. Above the transition, the size and shape of the mixed micelles are dependent on the pH of the solution, concentration of the PBS solvent, and the ratio of the linear to foldon concentration. The technique of Depolarized Dynamic Light Scattering (DDLS) was employed to study the structure and dynamics of the mixed micelles at 62 °C and maintained at an approximate pH level of 7.3 - 7.5. The ELP foldon micelles have a radius of 10 nm; the introduction of the linear concentration leads to a growth of mixed micelles at a linear rate, when the PBS and foldon concentrations are fixed. A model explaining this linear growth was developed utilizing the molar volumes of the mixed system. Static Light Scattering results seemingly support this model. However, the apparent VH signal found can indicate elongation in the geometry of the particles or anisotropic properties of the core of the mixed micelle.
**Poster 8 (REU): Mapping Evanescent Wave Scattering from Anisotropic Particles for Total Internal Reflection**

Student Researchers: Theodore Markiewicz (Rowan University), Aidin Rashidi, M.S. (CSU)

Faculty Advisor: Christopher Wirth, PhD (Chemical/Biomedical Engineering)

Total Internal Reflection Microscopy (TIRM) has been developed over the past two decades to directly measure ~kT scale surface interactions between a spherical particle and nearby boundary. However, state-of-the-art TIRM is currently incapable of measuring surface interactions for non-spherical (i.e. anisotropic) particles. This project focused on developing a theoretical framework and experimental technology to extend TIRM for the measurement of anisotropic colloid particle-surface interactions. Initially, evanescent wave scattering was mapped for particles at fixed position and orientation. Sulfate modified polystyrene spheres, 6 μm in diameter, were suspended with anisotropic particles. These suspensions were diluted in high salt concentration >100 mM NaCl to ensure particles would stick to the surface, thereby providing maximum scattering intensity and fixing position. Mapping of scattering from both spheres and ellipsoids revealed a profound difference in scattering morphology for ellipsoids apart from spheres particularly with regards to their orientation. Subsequent experiments observed mobile sulfate modified ellipsoids and *Saccharomyces cerevisiae* BY4741 yeast cells. Solutions comprised of polystyrene spheres and yeast were suspended in 0.5 mM NaCl allowing for the particles to undergo Brownian motion. Upon close inspection, the yeast has been shown to scatter light but much weaker than polystyrene particles. The initial results of this research, as well as the aspects of yeast cell surface mechanisms, are summarized on this poster.


**Poster 5 (REU): Length Distribution of DNA-Wrapped Boron Nitride Nanotubes**

Student Researcher: Johnathan E. Weicherding (University of Wisconsin - River Falls)

Faculty Advisor: Geyou Ao, PhD (Chemical/Biomedical Engineering)

Boron nitride nanotubes (BNNTs) are an emerging nanomaterial with promising properties for applications in elevated temperature and hazardous environments. BNNTs are mechanically robust and have extraordinary thermal and chemical stability. However, the structure polydispersity of BNNTs presents special challenges for its processing and applications. In this work, the length distribution of various aqueous dispersions of BNNTs wrapped by DNA (DNA-BNNTs) is evaluated as a start of its liquid phase processing. Additionally, we performed the length separation of BNNTs using a polymer precipitation method previously developed for carbon nanotubes [1]. The attempt at length separation was done using polyethylene glycol (PEG) as a crowding agent. The PEG concentrations ranged from (1.4 -5.2) % by mass. We used scanning electron microscopy, as well as UV-vis optical spectroscopy to characterize the length distribution of various samples. An average length of 276 nm was found for the initial tip sonicated aqueous dispersions of DNA-BNNTs.

**Poster 6 (REU): Studying the Transition of Polymeric Microgels with Light Scattering**

**Student Researchers:** Samantha Hudson (Hiram College), Samantha Tietjen (CSU), Krista G. Freeman, PhD (CMU)

**Faculty Advisor:** Kiril A Streletzky, PhD (Physics)

Polymeric microgels are being investigated as a future means for processes such as drug delivery because of their ability to reversibly grow and shrink with temperature. This project specifically investigated the behavior of microgels synthesized using hydroxypropyl cellulose (HPC), an FDA approved polymer. The synthesis process included the addition of a surfactant (dodecyltrimethylammonium bromide; DTAB) and a cross linker (divinyl sulfone; DVS) to form monodisperse microgels. The addition of DTAB raises the Lower Critical Solution Temperature (LCST) of HPC, which is the solution’s transition temperature (T). Maintaining this temperature with a water bath is crucial throughout the duration of a 3 hour synthesis. Three separate baths were tested in pursuit of these stable synthesis conditions. The most reproducible microgels were synthesized in a reliable circulating water bath. The synthesis process was varied systematically by changing the amounts of DTAB and DVS used. The resulting microgels were characterized using Dynamic Light Scattering (DLS). Trials across multiple angles at temperatures below and above the transition, and at a single angle with varying temperatures confirmed that spherical microgels were formed and demonstrated that shrink with increasing temperature. Flory-Huggins mean Field theory was then used to describe each Microgel's deswelling with increase of temperature. The theoretical model was fit to the experimental DLS data (hydrodynamic radius, $R_h$ vs. T). Fit results, including enthalpy, entropy, number of polymer chains per Microgel, and a material constant, suggest a dependence on DVS of polymer chain interactions during synthesis. Further development of the Flory-Huggins model is needed to directly account for effect of DVS and DTAB on synthesized microgels.

**Poster 7 (REU): Using a Staggered Herringbone Microfluidic Mixer to Synthesize Gold Nanoparticles**

**Student Researcher:** Jacqueline Matz (Duquesne University), Brian Hama B.S. (CSU)

**Faculty Advisor:** Chandra Kothapalli, PhD (Chemical/Biomedical Engineering)

Microfluidic mixers provide efficient mixing using smaller volumes of reactants than traditional batch reactions. They have additional advantages such as low-cost, control of variables, ease of in situ imaging, and efficient heat transfer. Among them, active micromixers require an external power source while passive micromixers do not require external energy [1]. We recently designed a passive micromixer by patterning microfluidic channels with staggered herringbone ridges; this design relies on chaotic advection and low Reynolds numbers ($Re<100$) to achieve efficient mixing [2]. Simulations using this pattern resulted in a mixing index close to one, within 6 mm length of channel. For further implementation, in this study we aim to produce gold nanoparticles using the micromixer based on the staggered herringbone design. Gold nanoparticles were synthesized by pumping separate solutions of sodium citrate dihydrate and gold chloride trihydrate, at different concentrations, through the micromixer and collecting the resultant solutions. Separately, batch reactions were carried out at the same concentrations to compare outcomes from micromixing. Resulting solutions were characterized using scanning electron microscopy (SEM), ultraviolet-visible spectroscopy (UV-vis), and dynamic light scattering (DLS).
