Tennessee Section of AAPT

2022 Annual Meeting

In-person and virtual

April 8-9, 2022

Austin Peay State University

Clarksville, Tennessee

Friday, April 8

All times are CDT (Central Daylight Time).

5:30 - 6:00 pm

Check-in
Sundquist Science Complex, Tommy Head Atrium

6:00 - 7:00 pm

Dinner: Taste of the Mediterranean
Sundquist Science Complex, Tommy Head Atrium

7:00 - 7:30 pm

Planetarium Show
Sundquist Science Complex, Room E113 (off Atrium)

7:30 - 7:35 pm

Opening Remarks
Sundquist Science Complex, Lecture Hall E106A (next to Atrium)

7:35 - 8:30 pm

Keynote
Sundquist Science Complex, Lecture Hall E106A

Unveiling the Warped Side of the Cosmos with Gravitational Waves
Stephen R. Taylor
Vanderbilt University

> Gravitational waves are a prediction of Einstein's general theory of relativity, and it took almost 100 years between theoretical prediction and breathtaking detection. They offer a fundamentally different way of observing the Universe, and encode the behaviors of cosmic phenomena that can not be seen otherwise. In this presentation, we will walk through the zoo of gravitational wave sources, and how we can go about detecting them.

8:45 pm

Social hour at Strawberry Alley Ale Works
103 Strawberry Alley, Clarksville

Saturday, April 9

All times are CDT (Central Daylight Time).

8:30 - 8:55 am

Breakfast and Check-in
Sundquist Science Complex, Tommy Head Atrium

8:55 - 9:00 am

Welcome and Announcements
Sundquist Science Complex, Lecture Hall E106A

9:00 - 10:15 am

Contributed Talks I
Sundquist Science Complex, Lecture Hall E106A

9:00 am

Autonomous Driving Robot: Follow-Up
Cahit Erkal
University of Tennessee at Martin

At the 2019 TAAPT Meeting in Knoxville, TN, one of our physics-minor students presented his research project of building a model power wheel to drive it autonomously in the corridors of the building. Later, his research work became a "senior design project" for his engineering degree. We follow up on this project in this presentation. Since then, several significant changes have been made in the sensor implementations. We report the challenges and the changes made to this project to improve the driving. Finally, we will discuss a LIDAR (Light Detection and Ranging) implementation and its current progress.

9:15 am

Desmos: Some Physics Examples of This Quick, Easy, and Free Graphing Tool
John Varriano
Christian Brothers University

Desmos is a free advanced graphing calculator accessible as a web application. It is relatively easy to use and can be an effective educational tool. Three examples of its use in different areas of physics will be demonstrated.

Saturday, April 9

9:30 am

Learning Astronomy Techniques: Star Clusters
J. Allyn Smith
Austin Peay State University

Astronomy is a popular gateway into a physics career. It is the most popular branch of physics. Retaining undergraduates often involves getting them involved in research projects early, so a series of astronomy-related projects can be an ideal platform. We present an approach for involving undergraduates with varying skill sets in a larger project, which will allow them to grow as they learn more.

9:45 am

gri Photometric analysis of Open Cluster NGC 6253
April Torres and J. Allyn Smith
Austin Peay State University

Open clusters are important in understanding the Galaxy due to all the stars coming out of the same giant molecular cloud. In NGC 6253, there was a lack of lower-main-sequence stars: in Bragaglia et al. and in Anthony-Twarog et al., the age was determined to be ~3.0 Gyr. The main purpose of this research is to determine the age and distance of NGC 6253. The research was done by use of three days of data collected in Baader SLOAN/SDSS ugriz' filters of g,r, and i. The data was then filtered for verified stars and placed in color-magnitude diagrams (CMDs) to determine the stars in the open cluster.

10:00 - 10:15 am

Break with refreshments
Sundquist Science Complex, Tommy Head Atrium

10:15 - 11:15 am

Contributed Talks II
Sundquist Science Complex, Lecture Hall E106A

10:15 am

Investigating Carbon Allotropes by Raman Spectroscopy
Jacob Hannah and Eugenii U. Donev
Austin Peay State University

Carbon left its footprint on the world when it participated in the beginnings of life. Allotropes of this element come in various forms ranging from the humble charcoal and mundane pencil "lead" (also known as graphite) to the luxurious diamond. Depending on structure, geometry, and bonding, the properties of carbon materials can vary widely. Graphene is a 2D material that is one, two or a few atoms thick, arranged in a hexagonal honeycomb lattice, which exhibits excellent electrical, mechanical, and optical properties. Raman spectroscopy is one of the primary techniques for identifying single-layer graphene. In this research, I investigate the use of Raman spectroscopy in characterizing allotropes of carbon. I prepare various samples of carbon materials and perform Raman spectroscopy to distinguish diamond, graphite, and single- and multilayer graphene. This project presents a valuable opportunity for students to synthesize many concepts from the undergraduate curriculum as the physics of graphene is rich, challenging, and fascinating.

10:30 am

Report on Activities of ALPhA and the Jonathan F. Reichert Foundation
Randolph Peterson
University of the South

ALPhA (Advanced Laboratory Physics Association) is doing well with the fourth BFY (Beyond the First Year) conference planned for Caltech, Pasadena, CA, in summer 2023. A slate of various in-person advanced lab workshops, Immersions, is again available for this summer, with several already full. The Reichert Foundation will provide grant opportunities (with some matching required) for purchasing equipment related to the workshop that you successfully complete. Be certain to join, if you are not already a member. Having a diverse (from many different colleges and universities) membership helps us to raise money from industry for our Immersions program and our BFY conferences. Go to www.advlab.org.

10:45 am

Design of an Offner-Chrisp Imaging Spectrometer for a Planetary Fluorescence Instrument

Tristan Carlson
Washington University in St. Louis

Spectrometers have been an integral part of space exploration in the late 20th and 21st centuries and will continue to provide quantitative measurements to answer exciting questions like, "Is or was there life on other planets?" PERISCOPE—Probe for Exploring Regolith and Ice by Subsurface Classification of Organics, Polycyclic aromatic hydrocarbons, and Elements—is a next generation spectrometer designed to explore icy worlds like Europa. It uses time-resolved ultraviolet (UV) fluorescence spectroscopy, a technique that identifies organic molecules, polycyclic aromatic hydrocarbons (PAH), and rare earth elements (REE). Here, a compact imaging spectrometer is designed to obtain high fidelity spatial and spectral data over the UV, visible (VIS), and near infrared regions (NIR) of the electromagnetic spectrum, corresponding to 276–850 nm wavelengths. The Offner-Chrisp spectrometer design is popular due to its high optical performance and small size. In this thesis, an analytical design for an Offner-Chrisp system is used to rapidly obtain an initial design, which is then further explored and optimized using ray tracing simulations. The design meets all instrument requirements and achieves a maximum simulated spatial and spectral resolution of 3 µm and 0.2 nm, respectively.

11:00 am

Surface Plasmon Resonance Sensing in the Advanced Laboratory

Alaa Adel Abdelhamid, University of the South
Zachary Givens and Eugenii U. Donev, Austin Peay State University

A relatively simple and inexpensive, yet surprisingly sensitive and versatile optofluidic setup that allows for real-time detection of small variations in refractive index—e.g., 1.332 for pure water vs. 1.334 for 0.5 wt% saline solution—rewards students with a memorable experience in the advanced physics or engineering laboratory. The sensor is based on the surface plasmon resonance (SPR) excited by a helium-neon laser at the interface between gas or liquid in a microfluidic cell and a thin gold film on a high-index glass prism. The SPR setup responds to subtle changes in the dielectric environment with a shift of the reflectance curve as a function of incident angle, which can be optimized for sensing with the help of analytical or numerical models. The tasks involved in the construction, analysis, and optimization of the SPR sensor vary in difficulty and duration; instructors can select the appropriate level of challenge to engage students in conventional or project-based laboratory work. These experiments and calculations introduce students to the field of plasmonics and showcase the power of combining precision hands-on experimentation with realistic computational modeling.

11:15 - 11:45 am

Poster Presentations
Sundquist Science Complex, Tommy Head Atrium, 3rd Floor

Refining Knowledge Statements as a Productive Intervention to Prompt Reflective Thinking
John Kelly
Tennessee State University

Dual Process Theories of Reasoning (DPTOR) state that cognition has two major processes: a fast, automatic process (heuristic) and a slow, reflective process (analytic). Many introductory physics students use the heuristic that acceleration and velocity are the same thing. In a Conceptual Physics class, multiple-choice questions on free fall were preceded by multiple-choice "check" questions - one on forces in free fall and one on Newton's 2nd Law. This work refines a pilot study using more complex knowledge statements. Those data suggested that the inclusion of the knowledge statements served as a productive intervention for engaging the analytic process, but the pattern of answers suggested that the knowledge statements were ambiguous. Student responses to check questions were more consistent than knowledge statements with similar performance on the free-fall questions. 80% of the students who answered the check questions correctly also answered all the free-fall questions correctly.

RR Lyrae Variable Star RV Mensa
Eden Kope and J. Allyn Smith
Austin Peay State University

RV Mensa is the 14th variable discovered in the constellation. In spite of this, there are scant data for this star available in the AAVSO archive. We present results of our data obtained in September 2019.

The Variable Star BK And
Li Loy
Austin Peay State University

Data taken from a three-night observation of BK And in 2019 were analyzed to determine the magnitudes of the variable star. The magnitudes from those nights were in the range of 14.1697 - 15.029 V with a period of 10.4 hours. These data vary enough from previously recorded values to justify further research to prove the star's status as a Blazhko star.

The Death of Stars: Types of Gaseous Nebulae
Meagan Porter, J. Allyn Smith, and Spencer Buckner
Austin Peay State University

We will be showing processed images of several different nebulae.

Investigation of the Kα Doublet of Copper by X-ray Diffraction
Misganaw Getaneh and Michaela Short
University of Tennessee at Martin

In this experiment we measure the energy separation of the two characteristic x-ray emissions in the Kα doublet of copper using diffraction of x-rays that are scattered by a lithium-fluoride (LiF) mono-crystal target. The two lines are so close in energy that they appear as a single emission line in most x-ray spectrometry measurements. It requires use of high-resolution equipment and looking at higher orders of diffraction interference for a long time to see clearly the separated Kα doublets, Kα1 and Kα2, unambiguously. According to our measurement, the wavelength separation of the Kα doublets is $\Delta\lambda = 0.337 \pm 0.045$ pm, which is consistent with the literature value of 0.337 pm. The corresponding energy separation, according to this measurement, is $\Delta E = 18.39 \pm 2.32$ eV, consistent with the literature value of 19 eV.

Rutherford Backscattering to Determine Solubility of Bi in Ga
Nicholas Gunter, Isabel Collins, Alaa Abdelhamid, Henry Atwater, Vincent DiNella, Mate Garai, Hugh Graham, Ashraful Haque, Michael Coffey, and Randolph Peterson
University of the South

Bismuth is soluble in liquid gallium only in small concentrations by weight, forming a saturated solution with the excess bismuth accumulating on the surface. These are thin layers, possibly one-atom thick. Various concentrations of bismuth (0.2% wt - 0.07% wt) in gallium have been studied with Rutherford backscattering (RBS) by 1MeV He+ ions, where there is evidence for a thin surface layer of bismuth and for bismuth in solution at these concentrations. The ability to discern a single atomic layer versus a multiatomic layer of bismuth on gallium by normal incident RBS is limited by the energy resolution of the detector, which was measured using graphene known to be a single atomic layer of graphite.

Energy Loss of Alpha Particles in Thin Layers of Copper
Isabel Collins, Nicholas Gunter, Alaa Abdelhamid, Henry Atwater, Vincent DiNella, Mate Garai, Hugh Graham, Ashraful Haque, Michael Coffey, and Randolph Peterson
University of the South

As alpha particles travel through a material, they lose energy by ionizing the atoms with which they interact. The energy loss in copper of alpha particles from Am-241have been measured as a function of thickness of stacked, thin copper foils. The effects of energy loss due to sample thickness can be measured from the energy loss of the alpha particles and seen in the widening of the full width at half of the maximum (FWHM) of the peak. The increase of the FWHM is a measure of the energy loss and the resolution of the detector. The detector's contribution to the FWHM was determined from the Rutherford Backscattering of monoenergetic He+ ions from single atom thick graphene.

Measurements and Simulations of Temperature-Dependent Optical Transmission Through Nanoholes in a Bilayer of Gold and Vanadium Dioxide
Zachary Givens and Eugenii U. Donev
Austin Peay State University

Vanadium dioxide (VO2) switches between semiconducting and metallic phases near room temperature and its optical constants undergo large hysteretic changes. Light transmission through nanoscale holes in gold (Au) can greatly exceed the prediction of standard diffraction theory. We explore how the VO2 phase transition modulates this extraordinary optical transmission (EOT) in a bilayer of Au+VO2 films perforated by six arrays of different hole diameters and periodicities. We observed that EOT through Au+VO2 holes was higher for metallic-VO2, opposite to the behavior of the unperforated VO2 film. Simulations reproduce this "reverse switching" and show that the peak-transmission contrast between the two phases of VO2 depends sensitively on the geometrical parameters of the holes.

11:45 am - 12:00 pm

Business Meeting
Sundquist Science Complex, Lecture Hall E106A

12:00 - 1:00 pm

Boxed Lunch
Sundquist Science Complex, Tommy Head Atrium

1:00 - 1:15 pm

Awards
Sundquist Science Complex, Tommy Head Atrium

1:15 - 2:45 pm

Workshop
Sundquist Science Complex, Room E112 (next to Atrium)

Sensing with Surface Plasmons
Eugenii Donev
Austin Peay State University

Participants in this workshop will learn firsthand about a versatile suite of advanced lab experiments and simulations that have successfully engaged undergraduate students in constructing precision optomicrofluidic setups, in the physics of nanoplasmonics and evanescent waves, and in developing computational models for surface plasmon resonance (SPR) sensors. The activities revolve around a thin gold film on a glass prism, mounted on a rotation stage and coupled to a microfluidic cell where liquids of slightly different refractive indices are readily detected as the reflectance of the incident laser beam changes due to minute angular shifts of the steep SPR curve. The materials are commercially available and relatively inexpensive, the activities are adaptable to week-long advanced lab sessions or semester-long research projects, and the challenge level can be "impedance-matched" to a student's current experience level.

About TAAPT

TAAPT, Tennessee Section of the American Association of Physics Teachers, is an organization that seeks to enhance the understanding and appreciation of physics across Tennessee through teaching.

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Meeting Locations and Parking

Friday, April 8, 2022

The Friday reception dinner will be held in the Tommy Head Atrium of the Sundquist Science Complex (SSC). The keynote talk will be given in Lecture Hall E106A of the SSC. The complex is at the corner of 8th Street and College Street. Parking is free after 4:00 pm and on weekends; Lot #8 at 838 Marion Street is closest to the SSC.

Google Map

Saturday, April 9, 2022

The Saturday sessions and meetings will be held in Lecture Hall E106A in the SSC. The posters will be presented in the B-wing of the third floor of the SSC, in the Department of Physics, Engineering, and Astronomy.

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