SOCIETY OF PHYSICS STUDENTS
An organization of the American Institute of Physics

Marsh W. White Award Proposal

Project Proposal Title	Edible Laser
Name of School	Appalachian State University
SPS Chapter Number	Z5-0216
Total Amount Requested	$500.00

Abstract

The Appalachian State University Society of Physics Students Chapter proposes designing and building a laser with an edible gain medium for teaching and outreach.

Edible LaserProposal Statement

Overview of the Proposed Project

The proposed project is to build a lasing cavity using edible material. The edible laser will be an educational tool not only for the students and faculty at Appalachian but also for outreach to the general public in the surrounding area. We propose an especially visible, simple, and portable design that can be used as an educational tool. The inside of the laser will be visible so that students may learn about atomic physics, optics, and laser science. The housing will be designed so that the edible laser system will be safe for students and outreach participants. This provides a good opportunity to use the system to also teach laser safety. Lastly, the lasing material will be edible, generating interest for participants, and for reminding young students that science is fun.

The intial design will use a pump laser and collimating lens, two concave mirrors, and an end mirror to create a resonant cavity. An edible gain medium will be placed in the focus of the pump laser beam within the resonant cavity, and will produce laser light which will exit the system for observation. The edible gain medium will be liquid and will move through the laser focus within a flow cell so that the edible material may be consumed.

For professors and students at Appalachian, the edible laser can be used for teaching atomic physics and optics principles, including fluorescence, population inversion, and geometric and Gaussian optics. The SPS chapter at Appalachian also has committed to using the edible laser for measurements of laser effiecincies of edible materials and non-edible household products to find the ideal gain media and optimizing the design to be easy to teach other students about optics and fundemental physics.

The SPS chapter students building the laser will gain hands on experience in bench optics, atomic physics, and quantum mechanics principles. Once optimized, the Department of Physics and Astronomy will use the edible laser for demonstrations and for other educational applications. The Physics and Astronomy club and SPS chapter in addition to the Chemistry club will use the edible laser for multiple annual outreach events to encourage interest in the physical sciences.

How Proposed Activity Promotes Interest in Physics

The edible laser will attract new SPS chapter members interested in lasers, optics, atomic physics, and spectroscopy who will then participate in teaching and outreach with the edible laser. SPS chapter members will use the edible laser to promote interest in physics amongst the chapter and throughout the department. In addition, this project will serve as a demonstration for promoting interest in lasers, optics, and physics to the public at regular annual events including the NC Science Festival, Buildfest, Hardin Park School STEAM day, the NC Region 7 Science and Engineering Fair, among others. The edible laser will be integrated into a home-school demonstration document so that home-schooled students can build their own edible laser. This document will also be shared on the SPS chapter and Physics and Astronomy club website. Having an exciting project will have a strong impact in the community and will prove that science is enjoyable.

The community we will reach is in and around Boone, NC, where Appalachian State University is located. Boone is located in Watauga County in the rural Appalachian Mountains. In this region of the state, about 22% of the population live in poverty (compared to 17% in NC and 15% in the nation), only 79% finished high school (compared to 85% in NC and 86% in the nation), and only 19% have a Bachelor's degree or higher (compared to 27% in NC and 29% in the nation). This region is in great need of economic development. The work proposed here would allow for outreach to these underserved populations which should help to generate an interest in science and technology, leading to eventual economic, technological, and educational development for future citizens of these counties.

Plan for Carrying Out Proposed Project

The edible laser as detailed in above sections will be an outreach and education tool to demonstrate the fundamental design and theory behind lasers. The design and development of the project is led by Dr. Brooke Hester and co-advised by Dr. B. Lauren Woods. Dr. Hester is the current SPS advisor at Appalachian and has an extensive background in laser science and the development of instrumentation. Dr. Woods is the current co-advisor to the American Chemical Society club (ACS) and also has expertise in laser spectroscopy and instrumentation design.

The design and development of the laser will be led by two student members of the SPS chapter, and the advisors will oversee the work and ensure the proper safety protocols are followed. This project is geared to be student friendly and feasible even with a limited amount of experience in laser design. The lead SPS chapter members are responsible for the purchasing of equipment, overall design, and overseeing the other students who will join the project in the spring 2017 semester.

Students from physics, astronomy, and chemistry are encouraged to participate. The chemistry students are currently already developing a demonstration document to distribute among local homeschool teachers to provide laboratory experiences for homeschool students. Upon completion of the edible laser, the students involved will write up the procedure, materials list, and safety instructions for this homeschool demonstration document, and which will also be used for sharing with faculty and staff at Appalachian.

The outreach and learning capabilities of the project are multilevel. In its initial state, the target audiences are college students interested in physical sciences. Whether the students advance to graduate school or industry, this project will help the students develop critical thinking skills, time and budget management, teaching skills, along with technical skills in optics. Once the laser is built, the target audience broadens to include the general public reached through outreach activities in North Carolina, as outlined in the Project Timeline section and for educational development. Appalachian State University has a working relationship with many schools in the community, in addition to the homeschooled, and neighboring counties.

While only a limited number of students will directly participate in the design and development of the edible laser, there are many opportunities for the SPS chapter students to volunteer to promote interest in physics K-12, undergraduates, and the general public with the edible laser.

Project/Activity/Event Timeline

The edbile laser will be operational in 2017, once the funding is obtained. The self-imposed deadline is April 8th in order for the students to utilize the edible laser in the North Carolina Science Festival. In the spring semester of 2017, the two lead SPS chapter students will be joined by one or two chemistry students to assist in building the set-up, writing the procedure for the demonstration book and for submission of a manuscript in The Physics Teacher journal.

The students have several designs developed for the laser cavity and await funding to purchase the needed materials. The optimization of the cavity design will be conducted using known laser gain media. Once the optimization is complete, students will test out household media, including riboflavin (vitamin B) and quinine (found in tonic water), among others, to test their laser efficiencies.

Below are annual activities in which the SPS and ACS students will demonstrate the edible laser for outreach and educational purposes. In addition to outreach activities, the SPS chapter wishes to use this fun and educational project to develop a laboratory experiment for Introduction to Physics courses.

Event	Semester	Target audience
Hardin Park Science Day	Fall	K-5
ACS Demo Day	Fall/Spring	Undergraduates
ASU Open House	Fall/Spring	Potential Undergraduates
NC Science Festival	Spring	K-12, Undergraduates, and general public
Avery County Homeschooler Science day	Spring	K-8
ASU Science Expo	Spring	Middle school
Children's Playhouse Buildfest	Spring	Ages 2-12
NC Region 7 Science and Engineering Fair	Fall	K-12

Activity Evaluation Plan

The laser's success will be determined by members of the club. Members will complete a survey on their interest and on learning outcomes. Next, this would be repeated at a small outreach event to gauge the reaction from a younger audience. There, we may also test the portability and practicality of bringing the edible laser to outreach events. A report will be written based on the survey responses, and the edible laser would be modified as needed. This algorithm would then be repeated at each outreach event at which the edible laser is used.

Budget Justification

All of the materials in the budget are essential for project completion. The rotating bread board and optical post are needed for finding the ideal polarizing angle by allowing motion in the x, y, and z direction of the plane of incidence. The mirror mounts are needed to hold and position the mirrors already in our possession to create the resonant cavity. The lens holders are needed to adjust the pump laser (also already in our possession) beam in the ideal state for allowing lasing of the gain medium. The protective goggles are for the eye safety and for teaching laser safety. Other materials are being

provided by Dr. Hester and Dr. Woods while other sources of funding are being sought. Recently, we were awarded $500 for optical supplies but will not be able to cover all our needs. Any amount of funding is appreciated and will be used for this important and exciting project.