SOCIETY OF PHYSICS STUDENTS

An organization of the American Institute of Physics

SPS Chapter Research Award Proposal

Project Proposal Title	Development of an Acoustic Holography Demonstration
Name of School	San Diego State University
SPS Chapter Number	6338
Total Amount Requested	$2,000.00

Abstract

San Diego State University's Society of Physics Students proposes to develop an acoustic holography demonstration kit.The demonstration is made using 3D printed materials and ultrasonic transducers. The final product will be distributed at k-8 outreach events and will include learning material that's easily understood by people of all backgrounds.

Proposal Statement

Overview of Proposed Project

- **Research question** – This project aims to address the possibility of creating a cost efficient, safe, and reliable acoustic holography kit for STEM outreach.
- **Motivation** – This research project is important for the field of STEM as whole because of its community engagement. We hope to engage the community on the matters of acoustic physics, by relating its credibility, relevance, and reliability. Another motivation for this project is to aid in the re-establishment of trust, communication, and comprehension of people who are not actively in STEM.
- **Brief description** – This research project entails the development of an acoustic holography demonstration kit using ultrasonic speakers and 3D printed hologram plates. Students will work together in teams to design theoretical models and build the hardware necessary to complete the project.
- **Research goals of the project** –This project will accomplish the design and construction of an acoustic holography demonstration kit that will be distributed for outreach events. The goals of this project are as follows:
  Safe. While ultrasonic waves have not been proven to be harmful to human care, an enclosed environment will be made to contain the transducers and particles used.
  Cost efficient. While most of the software and hardware for acoustic holography, used in professional settings, can range from $3,000- $10,000, a top of the line apparatus may not be needed for demonstration purposes. We hope to build a kit that may be distributed for less than $100.
  Easy to comprehend. Accessible materials for assembly and conceptual understanding will be included in the kit.
- **SPS connection** – We believe that this project aligns well with the Society of Physics Students mission statement of helping "students transform themselves into contributing members of the professional community". This project is open to students of all STEM backgrounds. Non-physics students will see this project as an opportunity for academic and professional growth. Students participating in this project will leave with the skills of conducting group research, presentation experience, and various computational & laboratory techniques. By the end of this grant, we will provide the Society of Physics Students with an outreach kit for acoustic holography.

Background for Proposed Project

The basis of acoustic holography is the assembly of 3D matter into objects. Similar to optical traps, this method is useful because it uses sounds to levitate and move very delicate objects. Most acoustic holography applications use ultrasound as their wavelength of choice. In medicine, doctors use ultrasound to relieve pain, monitor the growth of fetuses, promote tissue healing, and much more. This technique can prove to be extremely useful in medicine, it may help healthcare workers focus the ultrasound pattern precisely to where it is needed.

This proposed work adds to the existing knowledge and literature of the field by developing a fun and engaging way to make ultrasonic education more accessible to the public.

Expected Results

We expect to be able to acoustically produce holographic images and designs. We also expect to condense the cost of a demonstration kit to be sold under $100. Emphasis will be placed upon the quality of the development, as well as its accessibility to the public.

Description of Proposed Research - Methods, Design, and Procedures

Methods:
We will use the principles of acoustic levitation and standing waves as the basis for this project.

Research Group Structure:
The structure of this project will be split into several small teams that fall into two larger assemblies. The two larger assemblies will make up the **experimental** and the **theoretical group.**
-The theoretical group will be responsible for the model design and programming of the transducers.
-The experimental group will be responsible for the physical assembly and construction of the system architecture.

Weekly group meetings will be held so that members will be able to share updates as well as provide feedback and support where it is needed.

System Design:

- A 3D printed, enclosure will serve as the desirable environment for the demonstration to be held. The bottom surface of the container will contain an array of ultrasonic speakers, all pulsing at the same frequency.
- Placed within the enclosure is a free-roaming particle (a glass bead in this case).
- Facing the ultrasonic transducers, at the ceiling surface of the enclosure, is a hologram plate. A 3D printed disk with ridges and curves specific to an intended design. The hologram plate will act as a reflector.
- While the transducers are pushing the medium in such a way that levitates the particle, the hologram plate creates ridges in the medium, causing the particle to move in a pattern similar that is seen on the plate.
- For example, if the plate has ridges that are designed in the shape of bird, then the particle will move in that pattern, creating an image that will take the shape of that same bird.

Plan for Carrying Out Proposed Project

- Personnel – Undergraduate members of the SDSU SPS chapter as well as other students who are interested in STEM research.
- Expertise – This project is supported by the entire physics department at SDSU. Our faculty advisor, Dr. Matthew Anderson, has an extensive background in applied physics and has proven to be a very capable source of help and guidance.
- Research space – Our department has granted us various spaces to store equipment and conduct experiments.
- Contributions of faculty advisors or the department (equipment, space, etc.)- The SDSU physics department has provided license agreements for various modeling software's. The software's in mind for this project are MATLAB and Autodesk NetFabb

Project Timeline

- January: Literature review, purchase of equipment.
- February- May: Develop theoretical framework for the system using modeling software's.
- May: Write an interim report that provides an update on the progress of the project, as well as any variations/changes that may be added to the project design.
- June: Begin demonstration construction.
- July- November: Complete all hardware & software development.
- December: Write final SPS report and prepare a conference talk for the project.

Budget Justification

The materials below make up the bulk of our demonstration. Because we are building the kit from scratch, we will be allocating the majority of the funds to these materials in case there is a need for supplemental supplies. This may be caused be equipment falure, low inventory, changing plans, etc.
3D Printer: The printer will produce a costume enclosure for the product as well as hologram plates with varying designs.

Ultrasonic Transducers: These transducers produce the necessary wavelength to grant us access to the acoustic levitation phenomena. These particular transducers are helpful because they can be tuned and modulated simultaneously.

Arduino Boards: Allows us to program the ultrasonic transducers to behave in however way is most desirable of the success of this project.

Bibliography

Hirayama, R. (2022). High- speed acoustic holography with arbitrary scattering objects (Vol. 8). Science. https://www.science.org/doi/10.1126/sciadv.abn7614

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