PLASMA VORTEX APPLICATION

TECHNICAL DATA AND INSTRUCTION SHEET

Investigation of the Effects of Sound on Noble Gases used in Electronic Propulsion Devices.

Undergraduate Research 294
Winter 2018 Quarter Research Proposal (ENGINEERING REVISION 1)
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I. Introduction:

The field of electronic propulsion is critical to human spaceflight and our ability to conduct further space explorations which enhance our scientific knowledge of the future. When dealing with an issue in the scientific community that has the potential to rescue and save the human species from problems such as planet overpopulation and extinction level events we must be willing to research any new hypothesis which has the possibility of teaching us something which could help us learn about achieving propulsion through transfer of energy. In the field of electronic propulsion, we are faced with two major obstacles, manufacturing robust hardware for deep space missions and increasing the ratio of thrust generated from electricity vs relying on chemical fuel for thrust. *-Robertson, G. A., & Webb, D. W. (2011)*

The goal of this proposal is to re-introduce a scientific approach to the way we handle space propulsion sciences, specifically increasing thrust density in electronic propulsion. The function of this proposal is to introduce an experiment that combines physics, chemistry, engineering, sound, electricity, and magnetism. Experiments in sound created by scientist Hans Jenny *-Jenny, H. (2001)*, as well as current curriculum taught in Physics -Knight, R. D., Jones, B., Field, S., & Knight, R. D. (2014), Chemistry, EET and Math classrooms at North Seattle College will be Investigated. This experiment is unique in using sound to create a rotating vortex in a noble gas used for space propulsion. Current Textbooks and faculty support will be utilized during planning and execution of this experiment.

II. Research Question:

"Can Sound Be Used to Create Vortex Patterns in Plasma Gas Used in Space Flight Applications?"

In nature we see many vortexes, contained within solids liquids and gas. In the observation of these vortex we notice many things in common. In many common vortex formations in nature we observe harmonic motion in the three dimensions. We observe sinusoidal motion, with an axis which is in a spherical formation that carries motion in three dimensions which we can measured and investigated. Within the three-dimensional rotational forms created by substances which carry the qualities of a vortex, we find an increase in Kinetic Energy within their structures which we can quantify through measuring the mass and velocity of particles within a vortex in three dimensions.

The purpose of this investigation is to determine how sound waves affect the shape and formation of a gas cloud which will be used as an electronic propellant for use in a spaceflight vehicle. Experiments done with lycopodium; a gas like particle used in physics have been done which produce a spherical vortex formation when under specific ranges of tones and frequency. In this experiment, we will attempt to create these formations, adding to the body of knowledge on the effects of soundwaves on matter through modification of Hans Jenny's experimentations with sound by using noble gases which are commonly used in electronic propulsion devices.

III. Methods:

Part 1: Construct Lab Environment for oscillation of reagents using SHM.

For this experiment, a modular testing environment will be designed and constructed which will allow us to test various mediums under SHM (Simple Harmonic Motion) in the form of sound. The lab environment for this experiment will consist of a pressurized chamber with an imbedded wave driver and a modular platform which will allow for the use of diaphragms of various materials for resonance experimentation.

Lab Environment Physical Specifications:

QUALITY	MEASUREMENT
CHAMBER DIAMETER	~200mm
CHAMBER DEPTH	~150mm
HORIZONTAL AREA	~3.1416e^{4} mm^{2}
CHAMBER VOLUME	4.71239e^{6} mm^{3}
SPEAKER VOLUME	
TOTAL ENVIRONMENT VOLUME	

This lab environment will support the following experimentation:

- Oscillation of Lycopodium with a diaphragm of stretched paper
- Partial/Total Pressure Experimentation of Gases under SHM
- Experimentation of Plasma Ionization under SHM
- Investigation of wave path using rubber diaphragm, mirror and laser.

Part 2: Calibration of Frequencies using Lycopodium

In this portion of this experiment, methods published by Hans Jenny -*Jenny, H. (Director). (2006). Cymatics Soundscapes* on the investigation on the effects of sound on matter will be used to generate frequencies that produce vortex patterns in matter. For the calibration, Lycopodium powder on an oscillating diaphragm will be used to simulate a layer of gas within the SHM experimentation chamber.

While observing the Lycopodium test medium, frequencies which produce vortex formations will be recorded. Recorded frequencies will then be observed under varying amplitudes to calibrate which frequency offers the most structural stability under high amplitude vibration. Higher amplitudes of oscillation within our vortex pattern will give us a higher transfer of energy into our propellant gas from our wave driver.

Step 1: Add Thin layer of Lycopodium powder to paper diaphragm of experimentation environment.

Step 2: Begin testing full range of frequencies, adding additional lycopodium powder to increase visualization area and replaced initial volume lost during fallout during oscillation.

Step 3: Find vortex patterns and experiment on stability with adjustment of frequency and amplitude.

Step 4: Measure vortex diameter, height and angular velocity of vortex

Step 5: Use amplitude and frequency adjustment to scale vortex size to fit inside gas oscillation chamber

Step 6: Record calibration results, plot data and look for trends in calibration results.

Part 3: Testing Calibrated Vortex Frequencies using SF_6

After vortex pattern forming frequencies have been recorded and tested, various amplitudes will be used on Sulfur Hexafluoride, and affordable substitute for attaining proof of concept for creating a vortex formation in Xenon gas. Experimentation for this portion of this investigation will consist of loading the SHM chamber with incrementally increasing partial pressures of SF6, and observing vortex formations created by sound. Observations will be conducted using miniature ping pong balls which will float above the layer of SF6 and allow for tracking of changes in velocity, acceleration and force.

Sulfur Hexafluoride vs Xenon Comparison

QUALITY	XE	SF_6
DENSITY (STP)	5.761 kg/m^3	6.164 kg/m^3
MOLECULAR MASS	131.29 g/mol	146.055 g/mol
INERT	YES	YES

Sulfur Hexafluoride & floating orbital Experiment

10mm Ping Pong Balls will be used to visualize patterns of movement in gas by floating on SF6 layer and moving with vortex formation. By recording the mass of a single ping pong ball and finding it's acceleration, the force of the gas vortex can be calculated.

The system pressure of the SHM testing chamber before application of sound will not exceeded 1 Atm, which is the common range of an electronic thruster. Depending on the physical limitations of the containment vessel, a vacuum environment will be attempted in range of 0.3 Atm and 1.0 Atm. Lower pressure will allow for a closer replication of pressures used in modern electric propulsion devices and will also allow for visualization of low pressure Noble gases when ionized.

Step 1: Measure Ping Pong Ball Mass with Uncertainty

Step 2: Add Ping Pong Balls to SHM Experimentation Chamber

Step 3: Fill SHM Experimentation environment with desired of concentration of SF6. Use visualization of gas level (ping pong balls) or gas flow rate to calculate concentration levels.

Step 4 (Vacuum Experiment Only): For Vacuum Experimentation at .66 Atm, fill the chamber with 33% SF6 and 66% air, then pump out 1/2 of the volume of air from the top gas port to achieve a 50/50 mixture.

Step 4 (Vacuum Experiment Only): For Vacuum Experimentation at .5 Atm, fill the chamber with 25% SF6 and 75% air, then pump out 2/3 of the volume of air from the top gas port to achieve a 50/50 mixture.

RUN	SF_6 %	Air %
#1	20%	80%
#2	35%	65%
#3	50%	50%
#4	75%	25%
#5 w/ Vacuum (.66 Atm)	50%	50%
#6 w/ Vacuum (.50 Atm)	50%	50%

Step 5: Oscillated SF6 air mixture with calibrated frequencies and observe patterns. Record Angular Velocity, Linear Velocity, Angular Acceleration, Linear Acceleration and use this data to calculate the force of the vortex using the mass of the Ping Pong Balls.

$$F_{vortex\ (torque)} = (m_{ping\ ping\ ball})(a_{linear})$$

$$a_{linear} = (r_{vortex})(a_{angular})$$

$$(a_{angular}) = (\Delta v_{angular})(\Delta t)$$

$$(v_{angular}) = (\Delta\theta)(\Delta t)$$

“As we use sound to excite gas particles and began to form a vortex we will monitor changes in energy via infrared thermometer devices and changes in pressure within our container. Once we observe the form of a vortex within our experimental chamber we will then continue the experiment with increased amplitudes while constantly observing temperature and pressure changes.

We will experiment with different ranges and frequency container arrangements noble gases in amplitude in order to form the most measurably and observably stable vortex possible within our physical limitations.” - Cory Hofstad, Vortex Plasma Theory

Methods, Part 3-B: Visualizing Calibrated Frequencies with CO2 vapor
(ONLY IF SAFE FOR TEST ENVIRONMENT)

For further visualization of a gas vortex, gas created by placing dry ice in a measuring cup filled with hot water will be poured into the SHM experimentation chamber during oscillation of vortex frequencies. This experimentation is optional and is only for visualization purposes. observations such as shape and size may be able to be calculated, but velocity, acceleration and force will be difficult to determine without measurable particles.

!!!ENSURE TEMPERATURE OF CO2 IS NOT DAMAGING TO SHM CHAMBER!!!

Step 1: Initiate calibrated frequencies with open container

Step 2: Place Dry Ice in pouring vessel with warm water.

Step 3: Carefully without allowing liquid to fall, pour CO_2 gas into active SHM chamber.

Step 4: observe CO_2 gas cloud, find diameter, height and shape of vortex formation.

Step 5: Record all observations for later investigation

Methods, Part 4: Create Plasma Vortex Using Xenon and Sound

Once the needed conditions for a stable vortex have been obtained and recorded using calibrated sound frequencies from Part 2, and Part 3, data will be used to induce a vortex in Xenon gas which will be excited by external electrode to create a plasma state.

Step 1: Fill SHM Chamber with Desired pressure and concentration of Xenon gas.

"Start Low, Add More Approach"

This portion of the experiment will start with the lowest concentration and lowest pressure combinations which achieved vortex formations in step 3. Starting with lower concentrations and lower pressures will allow for incremental amounts of Xenon gas to be added to the testing environment without risking the chance of trying to remove expensive Xenon gas to lower levels. At this stage of experimentation, an experimental Xenon lamp will be created which will be oscillated using SHM.

The following data table will be created for every concentration & pressure combination tested.

State	Temp K	Total Pressure Atm	Partial Pressure Xe
Enclosure with gas at rest			
Enclosure with Gas under SHM			
Enclosure with Gas in Plasma State at rest			
Enclosure with Gas in Plasma state under SHM			

Step 2: Begin oscillation of Xenon gas to induce a vortex

Using measurements and data collected in Part 2 for effects of SHM on SF_6 gas, Xenon gas will be brought to a stable vortex formation with the wave driver in the gas chamber. Steps taken in Part 2 and Part 3 will allow for detailed gas concentration, frequency and amplitude calibrations which will give us data on the shape of our Xenon gas cloud in our chamber.

As Xenon is VERY expensive, required must begin immediately after filling the chamber with Xenon in order to minimize loss from leakage in our system. Ping Pong balls will not be added for visualization to ensure minimal handling of Xenon gas before vortex and plasma experimentation begins.

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Step 3: Introduce external electrode to Xenon under SHM to create plasma vortex.

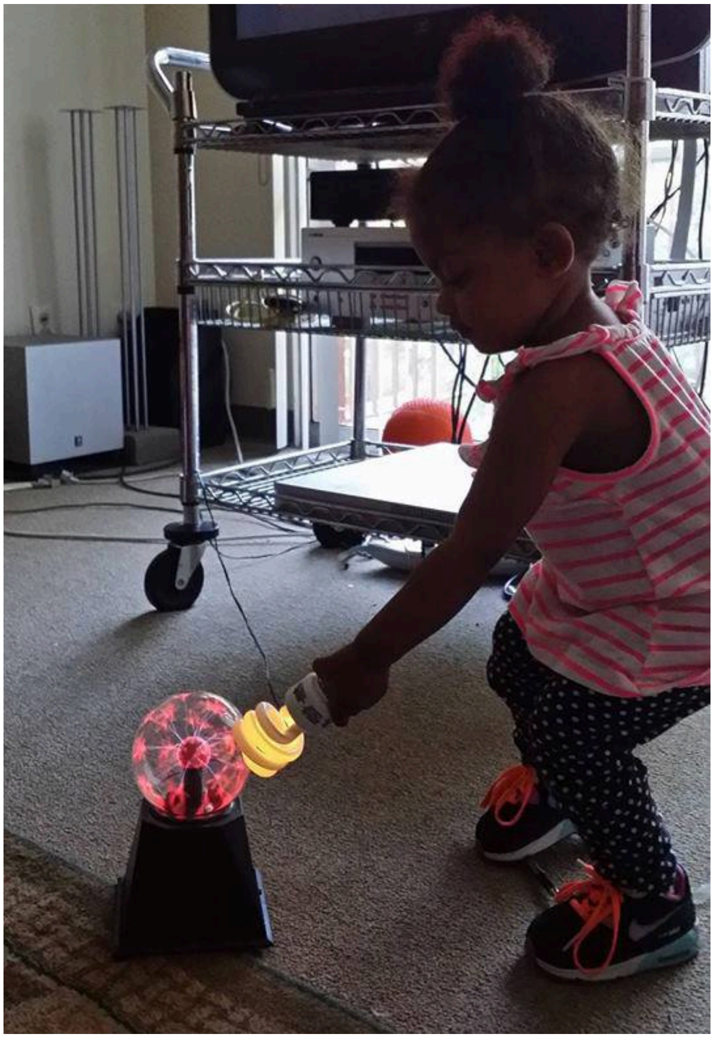

Image 1: "Olivia safely ionizing a contained gas with an external electrode". Image by Cory Andrew Hofstad

In a similar fashion to the figure (Figure 3), we will introduce the contained gas to an external electrode and inherent magnetic field. The gas will remain contained within the vessel and will not come in contact with the electromagnetic device, but will come in direct contact with the field it produces.

Experimentation will start with the electrode at an extreme distance from the gas container. The electrode will then be incrementally moved toward the gas chamber while constantly monitoring temperature and pressure within the gaseous container.

Tuning of an electrode power, distance, sound amperage and frequency will be made in order to attain the most stable plasma vortex. Stability of the vortex cloud will also be monitored throughout the process of introduction to electronic field by looking for abnormalities in the shape and configuration of the vortex.

Adjustments may need to be made to the amplitude and or frequency to ensure vortex stability (avoiding spikes and jagged areas in vortex) throughout the introduction of the electrode.

At this stage data will be recorded, calculations of measurable observations will be made and a scientific journal will be written with our findings. We will move beyond the stage of creation of a plasma vortex once we have observed and recorded data and video footage for scientific review to verify our findings.

IV. Equipment, Reagents, Supplies and Other Needs:

GREEN = AVAILABLE ON CAMPUS
PURPLE & GOLD = POSSIBLE ACADEMIC LOAN
RED = LOOKING FOR AT LIBRARY
GREY = SOURCE AFFORDABLY

A. Hard Copy of Critical Reference Materials:

Cymatics Soundscapes: And Bringing Matter To Life With Sound... DVD	Available on Amazon	DVD Set with experimentation videos and data	$30
Cymatics: A Study of Wave Phenomena & Vibration Hardcover – July 1, 2001	Available on Amazon	Full color reference material and instructions.	$58

B. Hardware Required for Recording and Documenting Experiments:

DSLR Camera (x2)		Allows for multiple angle recording of substance shapes and wave path shape of laser.	$4000 for 2 and lenses
Infrared Thermometer	Available on Pasco & Multiple Locations	non-contact infrared thermometer measures up to 752°F (400°C) with built-in laser pointer to identify target area	$75
Laser Switch	Available on Pasco	Laser timing sensor which will be used with the laser and rubber diaphragm experiment to calculate the period of oscillation using a single point in path of motion.	According to Pasco website, photogates used in NSC physics labs should work as laser switch.
Visible Laser Diode Mirror (x3)	Available at Edmund Optics	specially coated to attain maximum reflection of visible laser diodes.	$54 for 3
Slow Motion Camera	Available at Adorama	Will allow us to view the path of the laser using the rubber diaphragm and mirror. Will allow us to look for vortex inconsistencies in later experiments	$10,000
Wireless Pressure Sensor	Available on Pasco	Make accurate and consistent measurements of gas pressure, regardless of ambient conditions, and explore how chemical reactions affect gas pressure.	$69
Digital Sound Level Meter	Available at Pasco and everywhere where else	provides greater accuracy and more sophisticated measuring capabilities than an analog meter.	$75

C. Materials Needed for SHM Oscillation of Reagents

Function Generator	Available NEW from Pasco. Available USED, everywhere else.	Outputs sine, square, triangle, positive and negative ramps with a frequency range of 0.001 Hz to 150 kHz in addition to DC	$775 Available ON CAMPUS! For FREE
Reagent Grade Lycopodium Powder, 500g	Widely available	Small, gas like particles Used in physics to visualize sound waves and electrostatic charge.	$100
Sulfur Hexafluoride SF6			
CO2 Gas / Dry Ice	Widely Available	Gas which is safe and visible	
JL Audio M8IB5-SG-WH 8.8" marine subwoofer	JL Audio	Can be used to create pressurized sound chamber for gas/plasma and lycopodium testing at midrange frequencies.	$199
Acrylic Cylinder	ePlastics	Plexiglass - Clear Cast Acrylic Tube 8.000" OD x .375" Wall Cast Acrylic Tube Item ID: ACRCAT8.000ODX.375	$93
Acrylic Cylinder Sheath	ePlastics	Plexiglass - Clear Cast Acrylic Tube 8.500" OD x .250" Wall Cast Acrylic Tube	$122
Acrylic Sheet (x2)	Delvie's Plastics	Cast Plexiglass Sheet, will be used for cap to testing environment	$30
Valves, Piping and gas components			$50
Screws and Fasteners		Attaching and mounting components for Enclosure	$50
Gasket Material for top Sealing			$25
Paper Diaphragms of Varying Sizes (x2) *Possibly Drumheads*		Will be used for replication of Hans Henny experimentation & Calibration.	$30
Rubber Diaphragms (x2)		Will be used to record the sound and graph of physical sound wave.	$10
Mounting Hardware			$30
1 Pint of Weld-On 4	Widely Available	Used to Fuse Acrylic surfaces together (literally a chemical melting and hardening process) in order to maintain a vacuum.	$20
Joint Sealing Compound (x5)	Global Industrial	Use with pressures to 10,000 PSI to full vacuums. Safe with most chemicals and gas.	$30 for 5 packs
Shop and Machining Resources @ NSC		Will need to use certain cutting equipment, sanders and drill press for engineering of gas/plasma chamber and lycopodium testing chamber.	

Timeline:

ORANGE = BEHIND SCHEDULE

Period	In Class	At Home	Goals
Week 1			
Week 2			
Week 3	• Shopping for hardware required for assembly of experimentation equipment. • Overviewing Designs and methods • Work with Physics Instructors for relevant Equations • Work with Chemistry Instructors for relevant chemistry Equations • Work with Math instructors for measurement and calculation methods	• Shopping for hardware required for assembly of experimentation equipment. • Networking with campus faculty for assembly assistance. • Preparing home environment for at home assembly work. • Researching known frequency ranges and combinations of tuning methods. • Reading Hans Jenny Material and Videos • Working on Design Features • Consulting with audio professionals, Chemistry and physics faculty. • Start working on abstract • Write Abstract	1. Acquire Equipment 2. Complete Measurements for chamber construction 3. Publish Proposal as new Plasma Vortex Theory 4. Home Lab Setup
Week 4	• building acrylic pressure chamber • Frequency Calibration • Recording Data and Video of Frequency Calibration. **Abstract Writing Workshop** • Edit Abstract	• Engineering Test Environment - Changes & Problems • Calculations related to Frequency Calibration • Organizing Video Sequences for Documentation. • Discussing Results with peers • Reading and Watching Similar Research Projects	• Start Testing with Wave Driver
Week 5	• Testing Noble Gas Ampoules / Micro Vortex Possible? • Finishing Chamber • Pressure Test Chamber • Lycopodium testing • Work on Abstract **Optional Draft Abstract Due to instructors (in Canvas)**	• Work on Abstract • Promote Vortex Theory • Watch and Edit Recorded Video for Report • Work on Report Journal	• Attain Vortex Formation with Lycopodium
Week 6	• Test Noble Gas and Sound in Completed Chamber	• Make Hardware Adjustments • Work on Abstract	• Finish Abstract

Week 7	• Work on Plasma creating Plasma in the lab • Conduct Laser Experiment **Progress Report Session 1** **UW Abstract Due 2/13**	• Research Electromagnetic Propulsion and Plasma Theories • Make Hardware Adjustments • Work on Abstract	• Edit and Compile Experimental Video Footage •
Week 8	• Writing Results • Recording Video Documentation • Recording Promotional Video **Progress Report Session 2**	• Start Micro Documentary • Create Scientific Pages & Groups	
Week 9	• Recording Interviews of Scientists involved in Project • Introduce Scientific Journal for Publishing	• Work on PPT Presentation of experimental data • Work on Scientific Journal for Publishing **Research Presentation PPT draft due to instructors (in Canvas)**	• Draft Results in Scientific Journal • Demonstrate Plasma Vortex for Scientific Review
Week 10	• Work on Scientific Journal	• Edit Video Footage For Micro Documentary For Presentation and Social Sharing for scientific review. **Rehearsal of Presentation, Peer Review**	• Complete Scientific Journal for Publishing • Complete Micro Documentary
Week 11	**Final Presentations**		

Conclusion:

The most significant challenge to face during this experiment is sourcing hardware which falls within the budget for this project, and a lack of aerospace engineering support within the UGR class. The first problem is directly related to the latter, the small group size for this project severely limits how much can be spent on this project because of the "per student funding" limitations.

Other problems related to lack of engineering support are solved with heavy independent research and consulting with other faculty members on-campus. The group was directed to Physics Faculty member Traci Furutani for consultation of the overall scope of the project and equipment. Tracy has informed the group that while the project looks promising, he specializes in another area of physics than what is being experimented on.

When conducting independent research, consultations on this proposal were made with Davene Eyres, who specializes in this area of physics, when this consultation was made aware to the instructors of UGR, the group was told that it was up to Tracy if this project was even fundable, when in fact he told us in person and via email that this project looked feasible and could be done on campus but he was not an expert in SHM and wave physics, which is what Davene is instructing this quarter.

Other problems have come in attempting to request chemistry support from in-house resources in UGR class. When questions were asked regarding application of basic chemistry principals our group was rejected and told that we were being disrespectful by asking questions to another chemistry teachers, and told that "we could not get all the answers from a doctor of chemistry". After this incident, we attained the information we were looking for with a quick 5-minute conversation with another instructor on campus.

Our group has also been told that we cannot get funded without literature for parts of our proposal which are commonly known data in physics and chemistry. Much of the information used in the research project comes directly from the literature which we are using in class, in combination with our own designs of application which is an acceptable practice in the field of research, development and engineering. If our group can get past some of the conflicting information and struggles which come with working with individuals from different backgrounds, this project should go off without a hitch.

Bibliography:

Jenny, H. (2001). Cymatics: A Study of Wave Phenomena & Vibration (Vol. I & II). MACROmedia Publishing. ISBN:1888138076

Jenny, H. (Director). (2006). Cymatics Soundscapes: And Bringing Matter To Life With Sound. MACROmedia Publishing.

Robertson, G. A., & Webb, D. W. (2011). The Death of Rocket Science in the 21st Century. Physics Procedia, 20, 319–330. http://doi.org/10.1016/j.phpro.2011.08.029

Knight, R. D., Jones, B., Field, S., & Knight, R. D. (2014). *College physics: a strategic approach*(3rd ed.). New York: Pearson.

SILBERBERG, M. (2017). SILBERBERG CHEMISTRY: the molecular nature of matter and change with advanced topics. S.l.: MCGRAW-HILL EDUCATION.

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