ISS NATIONAL LABORATORY PROJECT CONCEPT SUMMARY

In-Space Production Applications: Advanced Materials and Manufacturing

ISS National Lab Research Announcement 2023-6

(Do not exceed 3 pages when complete)

<table>
<tr><td colspan="3">Proposed project name: Studying the fundamental physics of optical phenomena in microgravity environments, such as Bose-Einstein condensates, to better understand the behavior of matter and light in space.</td></tr>
<tr><td colspan="2">Principal investigator (PI): ILAKKUVASELVI MANOHARAN</td><td>Project type: ☒ Flight ☐ Ground ☐ Other</td></tr>
<tr><td colspan="2">Email address: ilakk2023@gmail.com</td><td>Space experience:☐ High ☐ Low ✔ None</td></tr>
<tr><td colspan="2">PI citizenship status:
☐ U.S. citizen ✔Permanent resident ☐ Non-U.S. Person</td><td>PI country of citizenship (if non-U.S.):
India</td></tr>
<tr><td colspan="3">Organization legal name: Bubbles & Cafe Inc</td></tr>
<tr><td colspan="2">Organization status:
✔ U.S. Entity ☐ Non-U.S. Entity</td><td rowspan="3">Organization address:

990 Shoreline dr
Aurora, IL 60504</td></tr>
<tr><td colspan="2">Organization type:
✔Commercial ☐ Academic ☐ Government ☐ Nonprofit</td></tr>
<tr><td>Organization Unique Entity ID:
C7Y5XP1FBXY7</td><td>Organization CAGE code:
April 3, 2023</td></tr>
<tr><td colspan="3">Is this research or technology subject to U.S. export laws and regulations? ✔No ☐ Yes, explain below</td></tr>
<tr><td colspan="3">How did you hear about this research announcement?
☐ISS National Lab website ☐ Email ☐ News article ✔ Advertisement ☐ NASA ☐ NSF
☐ ISS Research and Development Conference ☐ Other conference ☐ Other (please describe):</td></tr>
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Objectives:

In this section, summarize the project. Explain the project vision and rationale and how it demonstrates effective use of the International Space Station (ISS) National Laboratory. Include goals and deliverables.

Optical phenomena in microgravity environments refer to the behavior of light and matter in the absence of gravity or with a weak gravitational field. Studying these phenomena, particularly the Bose-Einstein condensates (BECs), can provide a unique understanding of the fundamental physics of matter and light interactions in space.

BECs are a state of matter that occur when a group of bosons, a type of subatomic particle, are cooled to near absolute zero, causing them to lose their individual identities and behave as a single entity. This state of matter has unique optical properties that can be studied in a microgravity environment, such as on the International Space Station.

By observing and analyzing the behavior of BECs in microgravity environments, scientists can gain insight into the underlying physics of light and matter interactions. For example, experiments with BECs have led to the development of more precise atomic clocks and advanced technology for sensing gravitational waves.

Overall, studying the fundamental physics of optical phenomena in microgravity environments has significant implications for both basic science and practical applications, particularly in space exploration and technology development.

- **State the project objectives, the starting and ending technology readiness level (TRL), and the starting and ending manufacturing readiness level (MRL), if applicable.**
  The objective of this project is to study the fundamental physics of optical phenomena in microgravity environments, particularly Bose-Einstein condensates, to gain a better understanding of the behavior of matter and light in space. This research aims to develop new insights into the underlying principles of the universe and potentially lead to new technologies and applications in fields such as materials science, quantum computing, and space exploration.
  Project TRLs: Starting TRL 3-4; Ending TRL 6-7. MRLs are not applicable as the focus is on scientific research, but the project could lead to the development of new technologies requiring manufacturing and commercialization efforts.

- **Describe how the project utilizes the conditions of a space-based laboratory or environment (e.g., extended access to microgravity, extreme environmental conditions).**

Microgravity can help eliminate the effects of gravity on the behavior of matter and light, allowing for more precise observations and measurements. Additionally, the extreme environmental conditions in space, such as the vacuum of space and extreme temperatures, can also be advantageous for studying the behavior of matter and light. For example, in the case of Bose-Einstein condensates, the extreme cold of space can be used to create and maintain the ultra-cold temperatures necessary for the formation of the condensates.
By utilizing the conditions of a space-based laboratory or environment, the project can advance our understanding of the fundamental physics of matter and light interactions in ways that are not possible on Earth. The insights gained from these experiments could have significant implications for both basic science and practical applications, particularly in space exploration and technology development.

- **Describe how the project's outcome will further technology development in in-space production and ultimately lead to a commercial offering.**

The insights gained from studying optical phenomena in microgravity could inform the development of technologies for in-space manufacturing and production. For example, the understanding of the behavior of matter and light in microgravity could inform the design of 3D printing technologies that function in microgravity environments. The extreme environmental conditions in space, such as the vacuum of space and extreme temperatures, could also be utilized in the development of materials with unique properties, such as stronger or more heat-resistant materials.
The project's outcome of advancing our understanding of the fundamental physics of optical phenomena in microgravity environments could contribute to the development of in-space production technologies, which could ultimately lead to commercial offerings in space exploration and activities.

Concept of Operations:

- **Provide a basic description of the project's in-orbit requirements and experimental setup.**

In terms of in-orbit requirements, the project will need access to a microgravity environment, which can be achieved by conducting experiments in space or aboard aircraft that fly parabolic trajectories. The microgravity environment is necessary because it allows for the observation and manipulation of Bose-Einstein condensates in the absence of gravitational forces. Additionally, the experiment will require stable temperature and pressure control to maintain the Bose-Einstein condensate. As for the experimental setup, it will likely involve the use of lasers to manipulate and observe the Bose-Einstein condensates. The experiment may require the use of specialized equipment such as an atom trap or an optical cavity to create and observe the Bose-Einstein condensate. The experiment will also require precise control and monitoring of environmental factors such as temperature, pressure, and vibration to ensure the stability of the Bose-Einstein condensate. Finally, the data collected during the experiment will need to be transmitted back to Earth for analysis.

- Describe any specific hardware or in-orbit facilities necessary to support this project, if known.

1. The project aims to study the fundamental physics of optical phenomena, particularly Bose-Einstein condensates, in microgravity environments.
2. A microgravity environment is necessary for the experiment, which can be accessed through in-orbit facilities such as the International Space Station, parabolic flight campaigns, or suborbital rockets.
3. An atom trap is an essential component for creating and observing Bose-Einstein condensates.
4. An optical cavity can be used to enhance the interaction between light and Bose-Einstein condensates.
5. Lasers are required to create, manipulate, and observe Bose-Einstein condensates. Different types of lasers may be required, depending on the specific experimental setup.
6. Cryogenic systems are necessary to cool the Bose-Einstein condensates to extremely low temperatures required for their formation and observation.
7. Environmental control systems are required to maintain a stable temperature, pressure, and vibration environment for the Bose-Einstein condensates.
8. A data transmission system is needed to transmit the collected data back to Earth for analysis.
9. The specific hardware and in-orbit facilities required will depend on the experimental setup and research goals.
10. Access to a microgravity environment and reliable data transmission system are critical components of the experiment.

ISS National Lab Use Only:
Complexity: R C A S
IP Portal Needed: Y N

Operations Lead: ____________________
Science Lead: ____________________

- **Define the logistical support and payload return requirements.**

Logistical support and payload return requirements are essential components of any scientific experiment conducted in space. In the case of studying the fundamental physics of optical phenomena, particularly Bose-Einstein condensates, in microgravity environments, there are several logistical support and payload return requirements that need to be considered. These include:

1. Launch and transportation: The experiment will require launch services to get the hardware and equipment into space. Depending on the in-orbit facility used, transportation services may also be required to move the hardware and equipment from the launch site to the in-orbit facility.
2. Power and data communication: The experiment will require a reliable power source and data communication systems to ensure that the hardware and equipment remain operational throughout the experiment, and the data collected during the experiment can be transmitted back to Earth.
3. Crew support: If the experiment is conducted aboard the ISS, crew support will be necessary to install, operate and maintain the experiment. Crew support can also be provided for suborbital missions, such as parabolic flights, where a team of scientists and engineers are needed to conduct the experiment.
4. Payload return: After the experiment is completed, the hardware and equipment will need to be returned to Earth for further analysis and examination. Depending on the in-orbit facility used, the return of the payload may involve reentry and landing on Earth or the return of the payload to a designated recovery site.
5. Safety and security: The experiment will need to comply with all applicable safety and security regulations to ensure that the crew, hardware, and equipment are protected from harm.
6. Ground support: Ground support personnel will be necessary to monitor and control the experiment from Earth, including tracking the equipment and data transmission, analyzing the data, and providing support as necessary.

   In summary, the logistical support and payload return requirements for studying the fundamental physics of optical phenomena, particularly Bose-Einstein condensates, in microgravity environments will involve launch and transportation services, power and data communication systems, crew support, payload return, safety and security, and ground support. All of these components will need to work together seamlessly to ensure a successful experiment and the safe return of the hardware and equipment to Earth.

- **Identify any preliminary discussions the offeror has had with an Implementation Partner, including evidence that the Implementation Partner can meet the proposed technical and schedule requirements.** Currently there are no funds from external sources but the offeror is working on fundraising for the project.

- **If known, provide an in-orbit operations timeframe (i.e., desired launch date and flight duration).** Yes

- **Offerors anticipating the requirement for iterative microgravity studies are encouraged to generally describe those successive experiments, noting whether they could be completed within one flight or whether they would require multiple flights. (Note: Only one flight project at a time will be funded.)** No successive experiments are planned at this time.

Benefits/Business Case: Studying the physics of optical phenomena in microgravity, particularly Bose-Einstein condensates, is a cutting-edge research with implications for materials science, quantum computing, and space exploration. It could lead to new technologies and applications, with the potential to generate billions of dollars in revenue in industries such as finance, medicine, energy, and aerospace. This research is a worthwhile investment for both scientific advancement and economic growth.

Budget and Funding Sources:

Budget Narrative:

- **If the project is receiving funds from an external source, identify the organization and funding amount.** Currently there are no funds from external sources but the offeror is working on fundraising for the project.
- **Does the offeror require support from the ISS National Lab to identify potential investors or to obtain additional funding?** Yes

- **Does the offeror or any funding partners have the intent, resources, or experience to develop and/or commercialize project outcomes?** Yes, the offeror has intent to commercialize project outcomes. During the course of this project, resources, experience and expertise will be gained.

Item	Description	Amount ($K)
1	Project Costs	300,000
2	Implementation Partner (Mission Integration & Operations) Costs	300,000
3	**Total Project Funding Required (1 + 2)**	600,000
FUNDING SOURCES		
4	Funds Provided by PI's Organization	0
5	Funds Requested from CASIS (5a + 5b)	600,000
5a	Project Funding Requested from CASIS	300,000
5b	Implementation Partner (Mission Integration & Operations) Funding Requested from CASIS	300,000
6	Funds Provided by Other Sources	0
7	In-Kind Contributions	100,000
8	**Total from All Funding Sources (must equal Item 3)**	600,000

Signature: M. Ilak

Prepared By: ILAKKUVASELVI MANOHARAN

Title: CEO, BUBBLES & CAFE INC

Date: April 5, 2023