ISS NATIONAL LABORATORY PROJECT CONCEPT SUMMARY

Igniting Innovation: Science in Space to Cure Disease on Earth

ISS National Lab Research Announcement 2023-10

(Do not exceed 5 pages when complete)

Proposed project name: Leveraging Spintronics, Spin-Based Quantum Sensors, and Optimization of Fluid Dynamics for Enhanced Nanomaterial Growth in Microgravity.	
Principal investigator (PI): ILAKKUVASELVI MANOHARAN	**Project type:** ✔ Flight ☐ Ground ☐ Other
Email address: ilakk2023@gmil.com	**Space experience:** High ✔ Low ☐ None
PI citizenship status: ☐ U.S. citizen ✔ Permanent resident ☐ Non-U.S. Person	**PI country of citizenship (if non-U.S.):** India
Organization legal name: Bubbles & Cafe Inc.	
Organization status: ✔ U.S. Entity ☐ Non-U.S. Entity	**Organization address:** 990 Shoreline dr Aurora IL 60504
Organization type: ✔ Commercial ☐ Academic ☐ Government ☐ Nonprofit	
Organization Unique Entity ID: C7Y5XP1FBXY7 / **Organization CAGE code:** 9N9U6	
Is this research or technology subject to U.S. export laws and regulations? ✔ No ☐ Yes, explain below	
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):	

Project Overview:

Revolutionize nanomaterial synthesis in microgravity using spintronics, quantum sensors, and fluid dynamics optimization.
Achieve precise control over nanomaterial properties (size, shape, composition) under microgravity.
Integration of cutting-edge technology and advanced control strategies.

Key Objectives:

Conduct nanomaterial synthesis experiments in microgravity.
Optimize fluid dynamics for uniform mixing and temperature control.
Utilize spintronics and quantum sensors for real-time monitoring and control.
Develop a closed-loop feedback control system.
Create specialized spin labels for targeted manipulation.
Explore integration with other sensing modalities.

Expected Outcomes:

Precise control over nanomaterial properties for high-tech applications.
Enhanced reproducibility of nanomaterial synthesis.
Insights into microgravity's impact on fluid dynamics.
Potential breakthroughs in spin qubits and quantum sensors.
Potential breakthroughs in technologies for cancer detection and cure.

Impact:

Transform nanomaterial synthesis for advanced technologies and space applications.
Drive innovation and economic growth.
Broad implications for understanding fluid behavior in space.

Deliverables:

Design experimental setup for microgravity nanocrystal and nanomaterial growth.
Integrate Spintronics and Quantum Sensors for real-time monitoring.
Create advanced fluid dynamics optimization algorithms.
Establish nanocrystal and nanomaterial growth protocols for microgravity.
Develop in-situ monitoring and analysis tools.
Generate proof-of-concept nanocrystal samples.
Provide a comprehensive progress report.
Create technical documentation.
Evaluate feasibility for larger-scale production in LEO.

State the test objective and the starting and ending technology readiness level (TRL): **Starting TRL : 3; Ending TRL: 9**

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

Microgravity Effects on Nanocrystal and Nanoparticle Synthesis:

Diffusion Dominance: In microgravity, the absence of buoyancy-driven convection allows for more precise control over the distribution of reactants. This can lead to better mixing and homogeneity in the reaction mixture.

Reduced Sedimentation: Nanoparticles and nanocrystals often involve suspended particles in a solution. In microgravity, sedimentation is significantly reduced, which means that particles are more evenly distributed and do not settle at the bottom of the reaction vessel. This can lead to more uniform particle size and distribution.

Quiescent Fluid Environment: Microgravity provides a quiescent fluid environment with minimal disturbances, resulting in fewer nucleation sites for crystal or particle formation. This can lead to the growth of larger, more well-defined nanocrystals or nanoparticles.

Enhanced Self-Assembly: In the absence of gravity-induced settling, nanoparticles can exhibit enhanced self-assembly behavior, allowing for the formation of complex nanostructures and assemblies with improved precision.

Gravitational Reduction: Microgravity reduces or eliminates gravitational forces, facilitating controlled experiments.

Novel Growth Strategies: Researchers can explore innovative approaches for nanocrystal growth due to the unique fluid dynamics in microgravity.

Bubble Formation Impact: Microgravity alters bubble behavior, influencing reaction kinetics and gaseous byproduct removal. Proper gas-liquid interaction is vital for reaction control.

Precise Control: Microgravity environments offer precise control over reactant mixing, temperature, and other parameters, enabling tailored nanocrystal properties.

Reduced Agglomeration: Nanocrystals are less likely to agglomerate or clump together in microgravity, resulting in uniform and well-dispersed particles.

Improved Reaction Kinetics: Homogeneous mixing of reactants is crucial for many chemical reactions. When reactants are uniformly distributed, they have a higher probability of encountering each other, leading to increased collision rates and a greater chance of successful reactions. This can enhance reaction kinetics, including reaction rates and yields.

Describe how the project's outcome will further technology development that will ultimately lead to a commercial product or solutions offering.

Nanocrystals and Nanoparticles in the Cancer Moonshot Initiative:

Quantum Dots for Cancer Detection: Enable precise cancer cell identification, paving the way for early diagnosis and commercial diagnostic kits.

Liposomes: Encapsulate and deliver drugs to cancer cells, reducing toxicity.

Polymeric Nanoparticles: Biocompatible carriers for slow drug release to increase exposure.

Gold Nanoparticles: Utilized in photothermal therapy to selectively kill cancer cells with laser light.

Iron Oxide Nanoparticles: Enhance MRI contrast and serve as drug carriers for targeted therapy.

Carbon Nanotubes: Deliver drugs, offer imaging, and support photothermal therapy.

Silica Nanoparticles: Biocompatible carriers for drug delivery and cancer imaging.

Dendrimers: Branched polymers carrying drugs or imaging agents for targeted delivery.

Nanoparticle-Drug Conjugates (NDCs): Conjugated with drugs or antibodies for targeted delivery, minimizing off-target effects.

Carbon Nanoparticles: Used in photodynamic therapy (PDT) to destroy cancer cells with light.

Albumin Nanoparticles: Optimize drug delivery for improved solubility and efficacy, potentially leading to better cancer treatment formulations.

Drug Delivery and Medical Imaging: Improve drug delivery systems and enhance MRI/CT scan accuracy, benefiting the pharmaceutical and medical technology sectors.

Biomaterials and Tissue Engineering: Advance tissue engineering with nanoparticle-based biomaterials, providing innovative solutions for regenerative medicine.

Nanocrystals and Nanoparticles in the Chips Initiative:

Silicon Quantum Dots: Integrate into semiconductor chips for faster and more efficient quantum computing technologies with commercial applications.

Semiconductor Nanowires: Enhance chip-based electronics for commercial electronic components with superior performance and energy efficiency.

Topological Insulators: Enable specialized quantum processors for commercial quantum computers, impacting fields like materials science, drug discovery, and cryptography.
Silicon Carbide (SiC) Defect Centers: Contribute to the commercialization of quantum computing systems for logistics, cryptography, and simulations.
Nanomaterials for Cooling: Extend the lifespan and enhance efficiency of microprocessors in electronic devices, benefiting consumers and the electronics industry.
The integration of nanocrystals and nanoparticles in these initiatives extends beyond their primary focuses, offering broader applications:
Quantum Technologies: Quantum dots, silicon quantum dots, and topological insulators advance quantum computing and processors, benefiting industries like finance, cryptography, and simulations.
Sensors: Nanoparticles enhance sensing capabilities, leading to more accurate and versatile sensor technologies for applications in environmental monitoring, healthcare, and security.
Medical Devices: Nanoparticle-based advancements contribute to more precise and efficient medical devices, improving patient care and diagnostics in areas like imaging, drug delivery, and regenerative medicine.
Advanced Electronics: Semiconductor nanowires and nanomaterials for cooling drive innovation in electronics, leading to more energy-efficient and reliable consumer and industrial devices.
Interdisciplinary Innovation: Cross-sector collaboration and technology transfer foster innovation by addressing complex challenges and pushing the boundaries of various fields, leading to novel solutions for a wide range of industries.

Concept of Operations:

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

Phase 1 (Duration: 36 weeks): Nanocrystal Growth Experiments in the ISS. (Optional)
*Option A *Option B *Option C
Phase 2 (Duration: 36 weeks): Nanocrystal Growth Experiments in the ISS (Optional)
*Option A *Option B *Option C
Phase 3 (Duration: 36 weeks) Feasibility Study and Reaction Vessel Testing on the ISS (Required) *Option A *Option B *Option C

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*Option A
The developed prototype could be tested as an attachment to the implementation partner's equipment or a removable customization could be added to the implementation partner's equipment.
*Option B
The developed prototype could be packaged as an independent unit.
*Option C
Nanocrystal Growth Experiments can be carried on using the implementation partner's equipment to test the developed strategies.
See the implementation partner's documentation

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

Tec-Masters, Inc. (TMI)'s Microgravity Research for Versatile Investigations (MaRVIn) system installed in the MSG facility. - Refer to the attached document by Tec-Masters, Inc.

Define the logistical support and payload return requirements.

Refer to the attached document by Tec-Masters, Inc.

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.

Please refer to the attached documents from the implementation partners.

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

Please refer to the attached documents from the implementation partners.

Successive Experiments for Iterative Microgravity Studies:

Phase 1: Nanocrystal Growth Experiments in the ISS with fluid dynamics optimization.(Optional)
Phase 2 : Nanocrystal Growth Experiments in the ISS with spintronics and/or quantum sensors integration.(Optional)
Phase 3 : Feasibility Study and Reaction Vessel Testing on the ISS (Required)

Benefits/Business Case:

Why this proposed project is important?:

The project pioneers nanomaterial synthesis in microgravity for precise property control; Enhances reproducibility in nanomaterial synthesis, ensuring consistent quality; Offers insights into microgravity's impact on fluid dynamics and nanomaterial growth; Integrates state-of-the-art spintronics and quantum sensors for

potential quantum control breakthroughs; Potential applications in space exploration and biomedical research for technological advancement and economic growth; Expands our understanding of materials in space environments.

The proposed project can lead to disruptive products and services:

Key Market Drivers:

- Increasing demand for advanced materials
- Growing emphasis on high-performance technology
- Expanding applications in various sectors
- Advancements in nanotechnology research

Key Takeaways:

- The nanocrystal market offers substantial growth prospects.
- Diversification across industries reduces risk.
- Innovation in nanomaterials is critical for future technologies.

The products resulting from this proposed project will be used by:

Nanomaterial synthesis caters to a broad customer base:

- Research Institutions: Supporting fundamental research.
- Pharmaceutical, Electronics, and Energy Industries: Enhancing drug delivery, semiconductor components, and energy storage.
- Materials and Coatings, Environmental Tech, and Consumer Electronics: Developing advanced materials, green technologies, optics, and displays.
- Medical Device, Government, NASA, ISS, Space Tech, and Startups: Enabling innovation in imaging, space exploration, and various nanotech applications.
- Quantum Technology Providers: Collaborating with quantum technology companies to integrate nanocrystals into quantum computing and sensing applications

Estimating revenue from this proposed project includes:

Revenue Projections (5-Year Estimate):

Short-term (0-2 years): 2M in research grants and seed funding.

Mid-term (Year 3): 4M from partnerships, Technology licensing, consulting services and early-stage product development.

Mid-term (Year 4): 5M from pilot product sales and licensing agreements.

Mid-term (Year 5): 20M through expanded product offerings and industry partnerships.

Long-term (5+ years): 50M+ as market adoption grows.

The global nanomaterials market is expected to attain a valuation of US$ 12.6 billion in 2023 and is projected to reach US$ 51.5 billion by 2033, trailing a CAGR of 15.1% during the forecast period.

Bubbles & Café Inc is aiming to capture 5-10% of the market by 2033 which would account for minimum market share of US$ 2.575 billion and maximum market share of US$ 5.15 billion.

How the commercialization efforts may be funded?:

Bubbles & Café is committed to commercialize the resulting products.

Additionally, Bubbles & Cafe is also open to raise funding through a combination of these sources to support the successful commercialization of the research outcomes: University or Research Institution; Private Quantum Technology Company; Startups and Entrepreneurial Ventures; Joint Ventures and Partnerships; Government and Space Agencies; Industry Collaborators and Investors; Technology Licensing and Royalties; Government Grants and Funding Agencies.

Budget and Funding Sources:

For funds being provided by the offeror's organization, please indicate whether the funds are currently available, and if not, state when they will become available and from what source. Funds are currently not available. Funds are expected to be raised through federal grants, venture capital and angel investors, industry collaborations, joint ventures and partnerships**.** The funds are expected to be available in the 3rd quarter of 2024.

For funds received from an external source, identify the source organization and funding amount. Currently no funds are received from external sources. Funds are expected to be raised through federal grants, venture capital and angel investors, industry collaborations, joint ventures and partnerships**.**

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? Bubbles & Café Inc is committed to commercialization of the product outcomes.

Item	Description	Amount ($K)
1	Project Costs (all phases)	700000
2	Implementation Partner (Mission Integration & Operations) Costs (all phases)	344003
3	**Total Project Funding Required (1 + 2)**	1044003
FUNDING SOURCES		
4	Funds Provided by PI's Organization	400000*
5	Funds Requested from CASIS (5a + 5b)	644003
5a	Project Funding Requested from CASIS	300000
5b	Implementation Partner (Mission Integration & Operations) Funding Requested from CASIS	344003
6	Funds Provided by Other Sources	
7	In-Kind Contributions	
8	**Total from All Funding Sources (must equal Item 3)**	1044003

*Funds Provided by PI's Organization - Funds are expected to be raised through federal grants, venture capital and angel investors, industry collaborations, joint ventures and partnerships. The funds are expected to be available in the 3rd quarter of 2024.

Signature: 

Prepared By: ILAKKUVASELVI MANOHARAN

Title: CEO, Bubbles & Cafe, Inc.

Date: 09/24/2023