Annoucements/Updates

CME
NASA STEM
SYMPOSIUM
August 14-15th, 2023

Presentation Title: Chemistry Beyond Gravity: Unlocking the Potential of Space Chemistry for Exploration and Industry
Time: August 15th, 11:30-12:00 PM PDT
Event Type: In-Person/Virtual?
Location: SF Marriott Marquis (780 Mission St., San Francisco, CA) Room – Salon 7

CME
NASA STEM
SUSTAINABILITY
August 16th, 2023

Event Title: Space Chemistry Roundtable
Time: 8 AM – 12 PM PDT
Event Type: In-Person/Virtual
Location: SF Marriott Marquis (780 Mission St., San Francisco, CA) Room - Golden Gate A
Registration: ACS will only allow ACS-registered individuals at the San Francisco Marriott Marquis.

Registration Link: https://www.acs.org/meetings/acs-meetings/fall-2023/attend/registration.html
Hotel Link: https://book.passkey.com/event/50533785/owner/6893/home

In-Space Production of Molecular Therapeutic Crystals

Proof of Concept Overview

Enable therapeutic development by building orbital drug processing and manufacturing systems for small-molecule and biologic crystallization. Study will support the development of hardware and techniques for the execution of this program as well as target identification and commercialization efforts.

Goal Alignment

Production of pharmaceuticals and related materials produced in microgravity but for earth-based applications to demonstrated the economic viability and benefits in the form of unique outcomes not possible terrestrially.

Next Steps

We will collaborate with leading biopharma organizations, experts in parallel industries, academics and public health agencies. The funding will support the discovery, development, and manufacturing of novel forms, formulations and morphologies improving patient outcomes and with applications to other industries.

Experimental Plan Overview

1 Hypothesis

Microgravity processing enables the creation of unique small molecule and biologic forms ad formulations by removing influences such as natural convection and sedimentation. This will lead to enhanced bioavailability, extended shelf-life, novel intellectual property, and alternative routes of administration.

2 Capabilities Needed

The development of orbital drug R&D and manufacturing platforms and the execution of the studies to demonstrate the benefits of doing this work in space demands collective effort. Pooling resources from both private and public sectors will be necessary to develop the required automation, analytical hardware/expertise and software, and to provide logistical support for increasing flight cadence and capacity.

3 Success Criteria/Risks

Demonstration of small and large molecule therapeutics in space could revolutionize drug quality, cost, and patient compliance. However, the complexity of this multidisciplinary and costly initiative necessitates strong partnerships between aerospace, biopharma companies, and health regulatory agencies. New crystal morphologies can be evaluated for structure, but the value and applicability is something that is evaluated by customers (our partners) and access to markets.

Funding/Resource Needs

- What is the expected cost of executing this experiment? ($200K, $500K-2Mil, $250K, $100K-$7 mil, $200k-1Mil).
- What resources are needed to execute (resources external to the space chemistry roadmap)
- - Experiment Preparation and Setup, Hardware Development, Payload Development, Flight, Analytical and Application Evaluation.
- Funding opportunities already identified? [Yes] – CASIS (NLRA), NASA (InSPA),

In-Space Production of Semiconductor Crystals

Proof of Concept Overview

Fuel the development of a LEO market for semiconductor technologies by enabling R&D demonstrations of semiconductor crystal synthesis, growth, and performance. These include the development of processing and metrology capabilities capable of harnessing microgravity conditions for developing the next generation of semiconductor technologies only possible in microgravity; and the identification of profitable applications and commercialization efforts in support national needs.

Goal Alignment

Production semiconductor crystals and related technologies produced in microgravity for earth-based applications to demonstrate the economic viability and benefits in the form of unique outcomes not possible terrestrially.

Next Steps

We will collaborate with semiconductor industry and organizations (SRC, NIST), academics, ISS National Lab, NASA, and space industry partners. The funding will support novel materials R&D, manufacturing R&D, and infrastructure development.

Experimental Plan Overview

1 Hypothesis

Microgravity conditions enable the synthesis and growth of larger, defect free semiconductor single crystals by enabling containerless synthesis and growth, and removing influences such as natural convection, density driven segregation and sedimentation. This will lead to increased yield and performance, novel intellectual property, and expansion of technological applications.

2 Capabilities Needed

Industry informed development of orbital semiconductor crystal synthesis and growth platforms and the execution of the studies to demonstrate the benefits of doing this work in space demands collective effort. Pooling resources from both private and public sectors will be necessary to develop the required hardware processing requirements, analytical hardware/expertise, automation, software, and to provide logistical support for increasing supply chain cadence and capacity.

3 Success Criteria/Risks

Demonstration of the synthesis and growth of highly ordered-defect free- stable semiconductor crystals in space, increased yield, superior properties-performance (depending on application), manufacturing feasibility, automation, Earth cost reduction, and potential of breakthrough microelectronics materials. Risk: high dependency on supply chain ecosystem to reach the pace of Earth's 5–10-years technology development cycles, process temperatures, safety guardrails.

Funding/Resource Needs

- What is the expected cost of executing this experiment? ($5Mil-100mil).
- What resources are needed to execute (resources external to the space chemistry roadmap)
- - Experiment Preparation and Setup(Industry/Academia lead), Hardware Development, Payload Development, Flight, Analytical and Application Evaluation.
- Funding opportunities already identified? [Yes] – CASIS (NLRA), NASA (NRA), NIST-CHIPS.

PoC 1: Secure Communcations and Quantum Key Distrobution (QKD) in LEO

Overview

Q-communication utilizes principles of q-mechanics to transmit and exchange information securely to ensure the confidentiality, integrity of data.

A method to transmit entangled particles as information, such as photons, has the capability of detecting eavesdropping.

QKD in LEO satellites and devices is an application of secure communication to extend the range and global coverage including reduced transmission losses and vulnerability to attacks.

Goal Alignment

Maintaining the stability of q-systems in the harsh space environment, dealing with atmospheric disturbances, and overcoming the limitations of **satellite power** and **computational resources** remains a hurdle.

Secure satellite-to-satellite links, inter-satellite communication, and even the establishment of a global q-communication network would lead to the advancement of **NASA exploration**.

Next Steps

Knowledge partnerships with current QKD manufacturers to create workshops and a robust knowledge base of LEO QKD devices is critical for success of enhancing space exploration and terrestrial/extraterrestrial communications.

Experimental Plan Overview

1 Hypothesis

Improving QKD hardware for LEO applications and utility will advance space exploration and secure communications.

2 Capabilities Needed

High precision and stability in the harsh space environment.

Improved satellite power (see PoC 2).

Increase of computational resources (see PoC 3).

3 Success Criteria/Risks

Advancement of sophisticated q-cryptographic techniques and protocols.

Improved integrated systems such as:

classical communication interfaces,

data processing units,

secure key management modules.

Funding/Resource Needs

- What is the expected cost of executing this experiment?
- What resources are needed to execute (resources external to the space chemistry roadmap)
- Funding opportunities already identified?

Prepared by Dr. Keeper L. Sharkey, ODE, L3C, July 2023

PoC 2: Quantum Batteries (QB) for Power in LEO

Overview

A practical QB stores energy in q-states using principles like superposition, entanglement, and coherence, which requires these systems operate at extremely low temperatures to minimize thermal noise.

QBs remains a theoretical construct due to a variety of technological hurdles

Using quantum batteries for powering satellites could be a way to increase the resilience of secure communications within LEO, on earth, and beyond.

Goal Alignment

The equipment necessary to maintain and manage a quantum battery is currently bulky and power-hungry, which would be problematic in space where every kilogram of weight and watt of power is precious.

Next Steps

Experimental Plan Overview

1 Hypothesis

2 Capabilities Needed

Maintaining quantum coherence.

Releasing energy very quickly, in a process called q-supercharging.

A 3-volt, 1-amp battery would deliver 3 joules of energy per second (since 1 ampere = 1 coulomb/second and energy = charge * voltage.

A large number of qubits would be needed to deliver this amount of power.

3 Success Criteria/Risks

Isolation from any sort of disturbance that could cause decoherence such as sources of radiation and particles that could interfere with the delicate quantum states.

Large number of qubits.

Funding/Resource Needs

- What is the expected cost of executing this experiment?
- What resources are needed to execute (resources external to the space chemistry roadmap)
- Funding opportunities already identified?

Prepared by Dr. Keeper L. Sharkey, ODE, L3C, July 2023

PoC 3: Quantum Computing (QC) in LEO

Overview

Current QCs are noisy intermediate-scale quantum (NISQ) devices, limited in the number and complexity of the quantum operations which can perform due to noise and error.

However, researchers are actively working on developing and implementing error correction techniques to overcome these limitations and perhaps if quantum computing was moved to low earth orbit some of the engineering efforts can be overcome due to microgravity effects.

Current experiments are conducted with trapped-ions at NASA's cold atom lab (CAL) with preparation for launch to the ISS.

Goal Alignment

Low earth orbit quantum computing could lead to the achievement of having fault-tolerant quantum computers, where the engineering process could be optimized for Commercial In-Space Manufacturing.

Further, the Fundamental Research of quantum computing use case applications would accelerate.

Next Steps

Knowledge partnerships with current trapped-ion manufacturing to create workshops and a robust knowledge base of LEO quantum computing is critical for success of obtaining universal quantum computers.

Experimental Plan Overview

1 Hypothesis

Atomic quantum sensors for quantum computing are much more precise under zero gravity conditions than on Earth, which also makes them interesting for basic research in physics.

2 Capabilities Needed

Large scale, low-error, universal QCs called fault-tolerant QC.

Large number of qubits.

3 Success Criteria/Risks

Funding/Resource Needs

- What is the expected cost of executing this experiment?
- What resources are needed to execute (resources external to the space chemistry roadmap)
- Funding opportunities already identified?

Prepared by Dr. Keeper L. Sharkey, ODE, L3C, July 2023