The potential OBPR Free Flyer Platform and Fundamental Physics

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AGENDA

- *Overview of the Free Flyer augmentation request*
- *Importance from a fundamental physics perspective*
- *Summary*
- *Group Discussion*

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OBPR FF Objectives versus NASA Goals

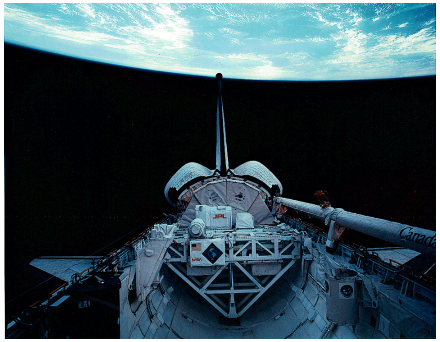
"Diversifying Research Platforms… While the Space Station will be the focus of biological and physical research, alternative space platforms are needed to fill gaps in research the Station cannot do."

OMB FY2003 President's Budget Request

FF Objectives		NASA Goals
■ Enable innovative Earth-based technologies through research discoveries beyond LEO with our partners	→	3. Create a secure world and improve the quality of life by investing in new technologies and collaborating with other agencies, industry, and academia
■ Enable important space research beyond what can be done on ISS	→	4. Explore fundamental principles of physics, chemistry, and biology
■ Understand life's response to increasing distances and durations beyond Earth.	→	9. Extend the duration & boundaries of human space flight
■ Increase access to space for broader science and technical community involvement and education.	→	6. Inspire and motivate students to pursue careers in science, technology, and mathematics
■ Inspire tomorrow's explorers to share in our journey of discovery	→	7. Engage the public in shaping and sharing the experience of exploration and discovery.

Expanding OBPR's research capabilities

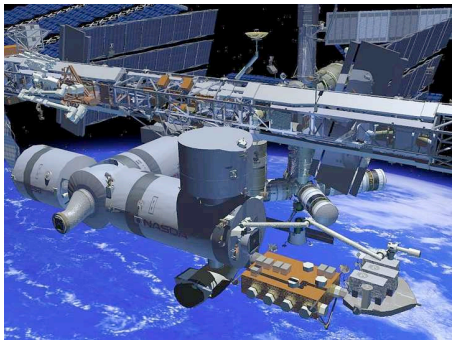
Space Shuttle
1985 - 2015



Key Capabilities

- Short Duration micro-gravity environment
- Crew tended
- Circular orbit
- 28 – 57 degree inclination
- 300 km altitude
- Return Capability

Space Station
2003 - 2015



Expanded Capabilities

- Long Duration micro-gravity environment

Free Flyer
2008 - 2025

Expanded Capabilities

- Long Duration sub-micro-gravity environment
- Radiation environment beyond the Van Allen belts
- Use of very hazardous materials and techniques
- Expanded orbit selection
- Multiple spacecraft capability

1985 2025

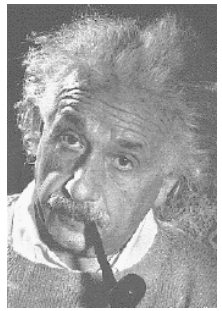
Research Activities enabled by FF

Human Exploration

- Determine combined microgravity/radiation risks for human exploration.
- Validate radiation protection strategies using in situ hardware.
- Develop countermeasures for human exploration impediments beyond Low Earth Orbit.

Fundamental Research

- Understand combined microgravity/radiation effects in cells, living tissue, and animals.
- Determine if cell radiation damage and repair are similar in space and on the ground.
- Determine the validity of Einstein's theory of gravitation with many orders of magnitude better precision than possible on crew-tended vehicles.
- Explore the nature of the quantum world with many orders of magnitude better precision than possible on crew-tended vehicles.



Technology and Research Partnerships

- Demonstrate potentially hazardous technologies and techniques before exposing them to crew.
- Provide access to space for activities incompatible with crewed vehicles.

FF Implementation

- **Will be submitted as an Augmentation this year to be considered for a *FY05* new start.**
  - Outcome of the augmentation request will be known when the FY04 budget is approved.
- **Ames Research Center would be the lead center for the Free Flyer activity**
- **GSFC would support ARC with Spacecraft systems, launch vehicles, and Mission management**
- **JPL would be the lead for development of fundamental physics payloads.**
  - JPL will submit an approximate budget requirement to develop and fly one FP free flyer mission in mid-2010 and follow-on flights every 2 years thereafter.
- **JPL may also lead development of sample return hardware and drag-free technology hardware.**
- **Three classes of autonomous space craft envisioned**
  - Heavy class, sample return capability (500 – 2000 kg payload)
  - Medium class, one-way (100 – 500 kg payload)
  - Small class, one-way payload of opportunity (up to 100 kg payload)
- **A variety of Earth-orbits envisioned**
- **Payload solicitation mechanism not yet finalized (NRA versus AO)**

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Why does Fundamental Physics need a Free flyer

- **Physics is standing at the threshold of major discovery.**
  - Two of our foundational descriptions nature, quantum mechanics and general relativity, are in conflict with each other.
  - When scientists resolve this conflict, a different view of reality may emerge.
- **Cosmological observations are providing additional clues that our understanding of reality is in need of modification.**
  - Most of the energy content of the Universe resides in unknown dark matter and dark energy that may permeate all of space-time.
- **Resolving the Quantum/gravitation conflict may also shed light on the cosmological unknowns.**
- **Today's availability of high-resolution technology and space access represents a unique opportunity for scientists to address these questions.**
- **Quiescent sub-microgravity freely flying research platforms would enhance the chances of major discovery substantially.**

Limitations of ISS Fundamental Physics Research

- **The Microgravity environment aboard the ISS limits the attainable precision in high-resolution physics experiments**
  - Sensitive gravitational physics experiments require a DC environment in the sub-micro-g range, or below. These experiments cannot be done on the ISS at all.
  - The DC environment limits how closely critical points can be approached.
  - The DC environment may limit studies of BE condensates.
  - The G-jitter environment heats low temperature samples and does not allow sensitive data to be collected.

- **The near circular orbit of the ISS does not allow variations in the gravitational potential as an experimental parameter**

- **ISS geometry complicates implementation of clock experiments requiring line of sight access between them**
  - A freely flying platform could accommodate multiple clocks linked together directly.

Example Free Flyer Mission - ISLES

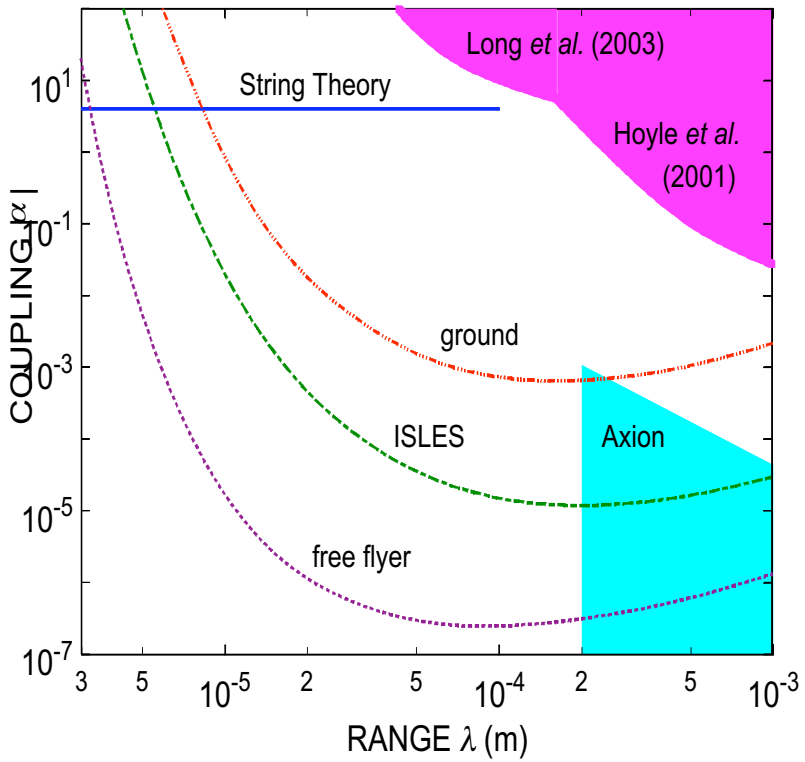
Experiment title: Inverse Square Law Experiment in Space (ISLES)

Principal Investigator: Ho-Jung Paik, University of Maryland

Experiment objective: To measure the 1/r^2 dependence of the force of gravity at 100 micro-meters a million times better than ground based experiments

Significance

- Newton's 1/r^2 law is a cornerstone of General Relativity
- Proposed extensions to the standard model of physics postulate the existence a lightweight axion particle.
- The axion is a candidate for the missing dark matter in the Universe.
- String theories aimed to unify the laws of physics predict a violation of the 1/r^2 dependence at short distances due to additional compacted dimensions.
- ISLES will verify or refute these fundamental fundamental predictions



Summary

- **The availability of the ISS is critical to developing and demonstrating a first generation of fundamental physics missions.**
- **A freely flying platform would enable the next generation of fundamental physics experiments with resolution not attainable on ISS**
  - Planned FP research on the ISS just beyond core complete can be used as pathfinder experiments
- **In many cases it may prove beneficial to design and operate experiments first on the ISS to prove out concepts and gain operational experience before committing to a free flyer development.**
- **A free flyer capability would enable candidate experiments that may shed light on some of the most vexing problems in physics today.**

Acknowledgement

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