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SPINSAT: A NOVEL VARIABLE-GRAVITY-AND-RADIATION-EXPOSURE PLATFORM FOR DEEP-SPACE SCIENCE

Abstract

Measuring the effects on biological and physical systems of the deep-space-radiation and reduced-gravity environments relevant to the Moon, Mars, and interplanetary space travel is challenging and, particularly for living biological systems, has scarcely been attempted. Resultant knowledge gaps pose risks to life support, human health and performance, and many operations critical to space and planetary exploration. By providing low-cost, reliable, frequent access to beyond-low-Earth-orbit space environments, the SpinSat platform will bridge such gaps. A disk-shaped rotating small spacecraft, the platform provides simultaneous artificial gravity, with radiation exposure to tailored to simulate lunar or Martian radiation environments for each individual payload. SpinSat will accommodate up to 64U of CubeSat form-factor payloads, ranging from 1U to 16U; this substantially improves affordability over single-payload spacecraft. By providing payloads with all necessary infrastructure (power, data handling, and communications) investigators can focus solely on their experiment rather than the spacecraft. It is orbit-agnostic, enabling frequent access to a variety of radiation environments (LEO, Van Allen belts, deep space, cis-lunar); Spinsat payload experiment durations can run for up to 18 months, allowing first-ever long duration low-dose studies. SpinSat prioritizes late loading for biological payloads, suiting it to host everything from human tissues and organoids to microorganisms, plants, chemical reactions, physics experiments, materials processing, and engineering components and subsystems.

After summarizing the platform, we will offer exemplary experiment concepts suitable for SpinSat, and discuss how various aspects of experimental designs may interact with, and be accommodated by, the platform. The range of diverse applications envisioned to be implemented as CubeSat form-factor payloads includes fundamental radiation biology such as DNA damage and repair; cancer biology and countermeasure development; space agriculture; bioproduction of nutrients and pharmaceuticals; biology-based life-support and waste-management systems; understanding regolith-transfer dynamics in low gravity; multigenerational microbial evolution; prebiotic chemistry and panspermia. We will further highlight ideas for SpinSat-compatible experimental hardware, existing and in development, and experiment-relevant details on SpinSat capabilities including artificial gravity, customized radiation environments, data, and power. We aim to inspire the design and development of novel experiments for SpinSat, many of which might exist or be planned as current or future CubeSat payloads. We also seek community input to help guide the evolving design of this platform and the payloads it will accommodate.