Spacecraft for Exploring Extreme Environments in the Solar System

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From the hottest deserts to the deepest oceans, life on Earth has evolved to thrive in many harsh environments. Given these capabilities, some scientists are exploring the possibility for life to emerge in extreme environments found throughout the solar system.

Scientists have recently discovered evidence of voids existing beneath the Martian and Lunar surfaces.

These spaces are shielded from micro-meteorites, damaging radiation, and extreme temperature changes. Therefore, they could have provided refuge for extraterrestrial life, and could even someday be used as habitable bases in future crewed missions.

So far, these underground voids have remained inaccessible to planetary rovers. Recently, however, rapid advances in electronics, sensors, actuators and power sources are leading to ever-smaller devices and instruments.

Jekan Thanga at the University of Arizona designs spacecraft that are capable of searching for life in these inhospitable places.

His team proposes the use of small robots that can travel over rough terrains, and be deployed from larger rovers. These devices could allow scientists to access subsurface voids on both Mars and the Moon.

In 2014, Thanga and his colleagues first introduced SphereX – a spherical robot that uses hopping and rolling motions to move across rugged terrains in low gravity. Weighing just a few kilograms, the robot can be inexpensively manufactured using commercially available components.

With a wide range of advanced features, SphereX is not limited to exploring subsurface voids. Thanga's team also investigated how they could be adapted to explore other features, including cliffs and crater rims on asteroids.

Before sending SphereX robots into space, their performance must be tested in the same conditions they will likely experience during their missions. Asteroids, for example, have a surface gravity of one-thousandth that of Earth's.

To recreate this microgravity, Thanga and his colleagues have developed a centrifuge named AOSAT+. The device is no larger than two cornflake boxes, and completes a full rotation every minute. The resulting centrifugal force gently pushes any material inside – mimicking the gravity of an asteroid.

Using AOSAT+, the researchers will study the behaviour of regolith: the loose rock that covers the surfaces of asteroids, moons and rocky planets. By studying this material, they will gain insights into how these environments can be explored by SphereX robots.

Over the next 35 years, space organisations around the world hope to send both human and robot explorers to every corner of the solar system. By designing SphereX and AOSAT+, Thanga and his colleagues are paving the way for spacecraft that can explore new environments on distant worlds, potentially allowing us to find evidence for extraterrestrial life.

Summary of **'Mobility, Power and Thermal Control of Spherex for Planetary Exploration'**, in AAS Guidance and Control Conference 2020, and 'A cubesat centrifuge for long duration milligravity research', in npj Microgravity.