Efficient Microgravity Heat and Mass Transfer with no Moving Parts

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In our work with NASA EPSCOR, we propose to demonstrate an efficient, noncontact method of transporting heat via fluids in microgravity. This method does not use any moving parts and only requires a modest power supply which drives 3 mutually orthogonal, low impedance Helmholtz coils. This differs from current methods of heat transfer in microgravity which traditionally require mechanical mechanisms, such as a pump, to drive artificial convection. Extensive testing of artificially created convection currents with this method has been carried out on Earth and there is evidence that using such a technology could result in a more efficient heat transfer process in microgravity. This will be tested through the implementation of an orbital payload using an infrared camera for visualization and quantification of flow as driven by Helmholtz coils in the previously described configuration acting on magnetic nanoparticles inside of a fluid capsule. The demonstration of efficient heat transfer via this method allows for the development of low power heat transfer systems for potential use in microgravity environments where traditional mechanical systems have potential for failure.

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Pill Bug-Inspired Robot for Lunar Exploration

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Through the Artemis Program, NASA intends to conduct prolonged scientific research and exploration of the lunar surface with the eventual goal of establishing a long-term human presence on the moon. Specific interests have been placed on lunar lava tubes, caves, and craters as potential sites for habitation. As a result, NASA is pursuing possibilities utilizing advancements in autonomous navigation and swarm robotics to explore the lunar surface in the near future.

The need for robust and versatile robotics systems is necessary to traverse the foreign lunar environment efficiently and conduct scientific operations. Proposing the Fengaribot, a robot capable of ascending steep, rocky terrain while having the ability to transform its shape to roll down inclines for a controlled, energy-efficient descent. Biologically inspired by the pillbug, the Fengaribot‚Äôs frame is based upon a segmented shell-like approach with a twelve-legged locomotion system. Where a heavy-bodied rover may have been blocked, the Fengaribot‚Äôs low center of gravity allows the robot to climb unleveled terrain without flipping. Furthermore, the transformation into a rolling state allows for the controlled descent of a sloped surface while protecting sensitive components and preventing a scenario in which the robot topples into an irrecoverable state. The robot‚Äôs electronics are mounted separately in the shell segments with the capability of storing various scientific instruments depending on the task.

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Effect of Processing Route on Properties of NbMoTaWVTix Refractory High Entropy Alloys

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The four core effects of high entropy alloys (HEAs) intrigued the researchers towards the exploration of HEAs, in particular, HEAs made from refractory elements, as high temperature materials. Of all the refractory high entropy alloys (RHEAs) studied, NbMoTaWVTix RHEAs have showed good strength retention and excellent thermal stability. However, while these RHEAs have the potential to achieve desirable performance targets, manufacturing of these alloys is challenging as casting produces segregations due to difference in the elemental melting temperatures. Powder metallurgy approach eliminates these effects but suffers from porosity and impurities. We have studied different PM routes like pressure-less sintering, Hot isostatic pressing and Spark plasma sintering with variable parameters for manufacturing of dense RHEAs. The effect of processing route on properties of RHEAs is presented.

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Predictive Analysis of Genetic Radiation Resistance Mechanisms

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Extremophilic bacteria and archaea are able to tolerate traditionally uninhabitable environments. Understanding the cellular mechanisms necessary for this survival has implications ranging from medicine to bioremediation to astrobiology. One such extreme is survival to high levels of ionizing radiation. These highly resistant species are candidates for model organisms in fields where radiation resistance has a large influence. Over the last couple of decades, a large body of work has focused on molecular mechanisms for radiation resistance. While a wide variety of mechanisms contributing to radiation resistance have been identified, how they specifically result in radiati on resistance is largely unknown. However, metagenomic and transcriptomic studies have uncovered a multitude of genetic trends related to radiation resistance. My PhD work centers on the creation of a machine-learning model-based computational tool which, using these trends, will:

- Identify which known genomes a naïve genome is most similar to based on suspected genetic markers for radiation resistance.
- Determine the impact of previously identified genetic trends on prediction of radiation resistance.
- Determine the degree of radiation resistance of a microorganism based on its genomic composition.
- Identify new genetic trends associated with radiation resistance

This work required the creation of a specialized database focused on molecular radiation resistance mechanisms, the development of a tool featuring machine learning models designed for both classification and regression-based analysis, and the validation of the tool using both new and established data sets.

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