Levitation Experiments on ISS: Science and Applications

Michael P. SanSoucie (NASA MSFC)
Paul Craven (NASA MSFC)
Robert Hyers (University of Massachusetts)
Kenneth Kelton (Washington University in St. Louis)
Douglas Matson (Tufts University)
Ranga Narayanan (University of Florida)
Richard Weber (Materials Development, Inc.)
Jan R. Rogers (NASA MSFC)

Levitation experiments on the International Space Station (ISS) are ongoing. The European Space Agency (ESA) Materials Science Laboratory Electromagnetic Levitator (MSL-EML) has been in operation since 2015. US investigators are on several of the European Topical Teams and have been heavily involved with the experiments since 2009. The experiments include magneto-hydrodynamic (MHD) modeling of macro-convection, the effects of convection on microstructure, investigation of metallic glass formation, and much more.

Recently NASA selected four proposals to the MaterialsLab NASA Research Announcement (NRA) for experiments on the Japan Aerospace eXploration Agency (JAXA) Electrostatic Levitation Furnace (ELF), which was launched to the ISS in 2015. It is estimated that the four US investigators will have flight experiments on ELF within the next few years. The experiments range from a novel method to measure interfacial tension to investigations of thermophysical properties of metals, metal oxides, and non-linear optical materials.

Using the MSL-EML and ELF, US investigators are studying a wide range of NASA exploration-relevant materials. Levitation experiments enable exploration in many ways. For example, high quality thermophysical properties of high-temperature materials are critical to develop accurate models of casting, welding, and metal additive manufacturing, which could lead to more efficient and more reliable production of metallic parts for exploration, commercial, and industrial applications. High-quality thermophysical properties could also lead to the development of functional oxide glass and optical materials. In many cases, the accuracy of available property data is the limiting factor in the predictive capabilities of the models.

Many thermophysical properties can be measured in a levitator on Earth, but with convective contamination. This contamination plays a significant role in the formation of the intermediate phases. In particular, nucleation and viscosity measurements demand quiescent conditions that can only be attained in microgravity-based levitation systems.

A brief overview of the ongoing and planned levitation experiments on the ISS will be presented, followed by the exploration-relevance.