Weld-ASSIST: Weldability Assessment for In-Space Conditions using a Digital Twin

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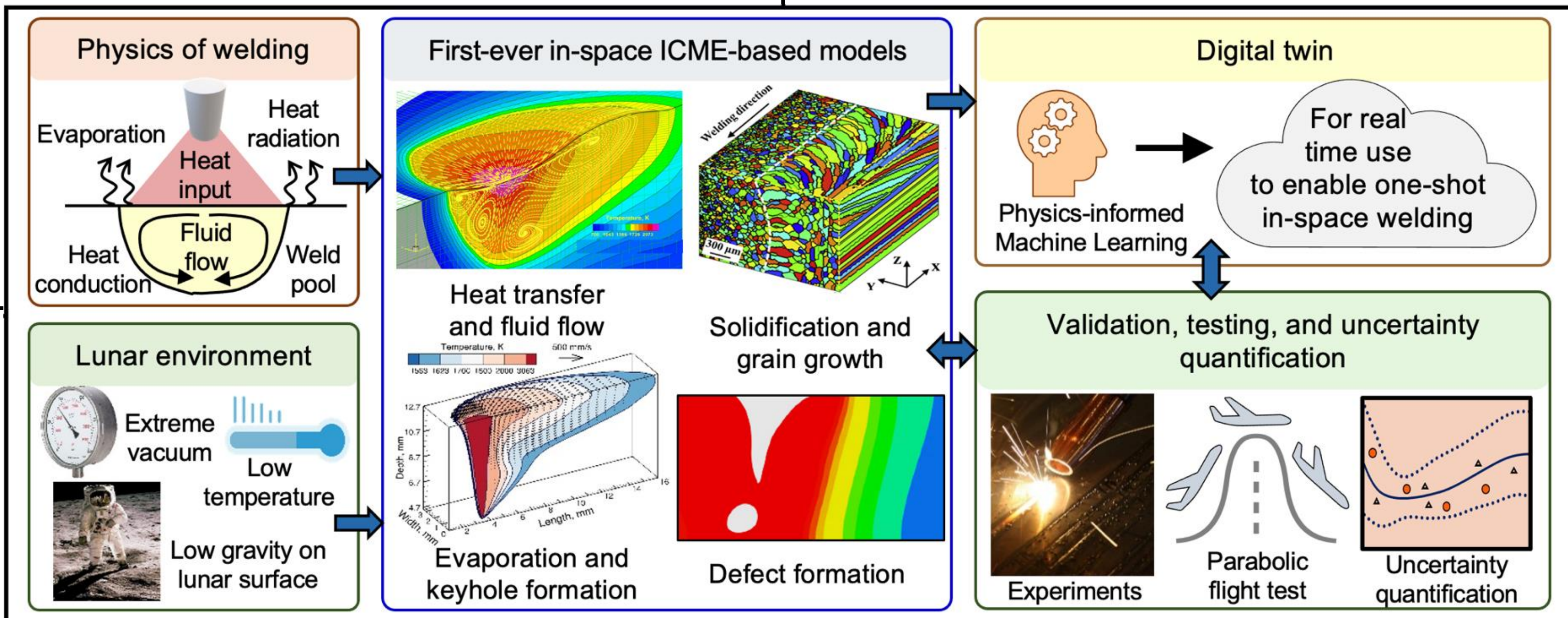
Research Objectives and Innovations:

- Fundamental understanding of the effect of extreme space/lunar conditions on thermal fields, evaporation, melt pool dynamics, microstructural growth and porosity (No existing model simultaneously captures these effects)
- **First-ever** ICME-based welding framework, capturing lunar and extreme space conditions
- Fast and efficient physics-informed machine learning emulator that can enhance itself using limited data and physics, and is robust to uncertainties
- **Starting TRL 2**: No existing holistic in-space welding framework
- **Ending TRL 3**: First effort to establish and validate an ICME-based digital twin for welding in space



Approach

- Combined computational, data-driven, and experimental efforts to formulate and validate the models
- Multi-physics modeling of heat transfer, fluid flow, evaporation and alloy composition change, grain growth, melt pool flow and porosity formation
- Integration with physics-informed machine learning as an emulator to enhance efficiency and accuracy
- Validation and uncertainty quantification using earth-based experiments, parabolic flight tests, and publicly available results from different agencies worldwide

Potential Impact

- Enabling the in-space assembly, joining and repair
- Minimizing the logistical burdens and supply from Earth
- Enhancing fundamental understanding and predictability of the in-space welding, and minimizing expensive trial-and-error efforts in space
- Enabling high-quality one-shot welds in space, and reducing the need for reworks
- Reducing mission costs and time
- Facilitating extendibility to support in-situ resource utilization, including construction and repair using locally sourced materials like regolith