Tufts University | School of Engineering

Material Science Research: Thermophysical property measurement using levitation techniques in Microgravity

Jannatun Nawer
Douglas Matson (PI)
Tufts University, USA

May 19th , 2021

UNOOSA Hyper gravity/Microgravity Webinar Series

SPACE4SDGS

About me

B.Sc. in Aeronautical Engineering 2015 (MIST, Bangladesh)

M.S in Mechanical Engineering 2018 (Tufts University, USA)

PhD in Mechanical Engineering 2021 (Tufts University, USA)

- Pure Metals
- Industrial alloys

Started space work in 2017 NASA grant NNX17AH41G

Ground based testing in 2018 at NASA MSFC ESL lab

Parabolic flight testing in 2019 with ESA TEMPUS EML

Space testing in 2020 collaboration with JAXA ELF

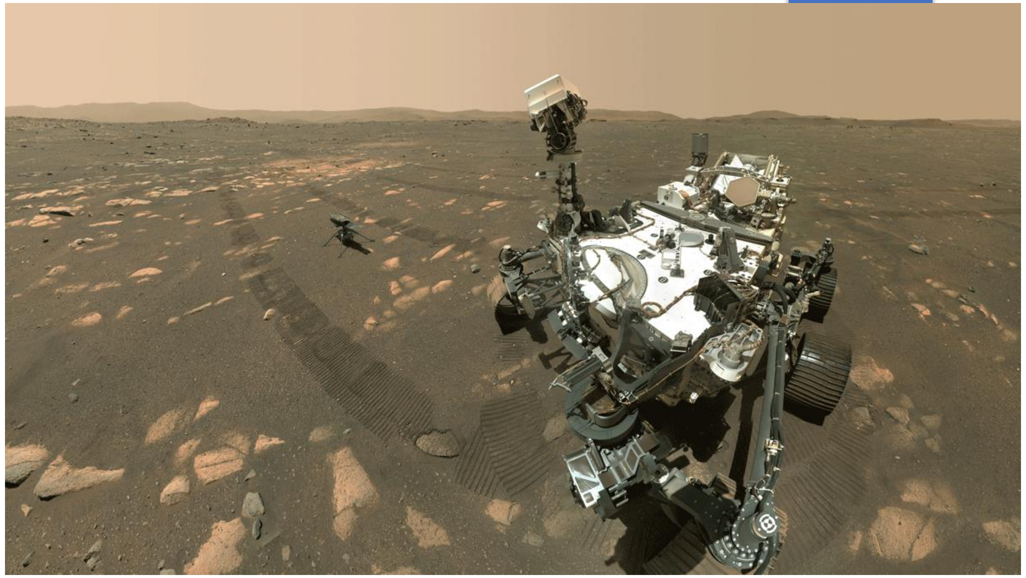
Scientific goals and motivation

Support material development for space exploration, commercial, and industrial applications

Provide high quality thermophysical properties for accurate modelling with predictive capability for

- Casting
- Welding
- Additive manufacturing

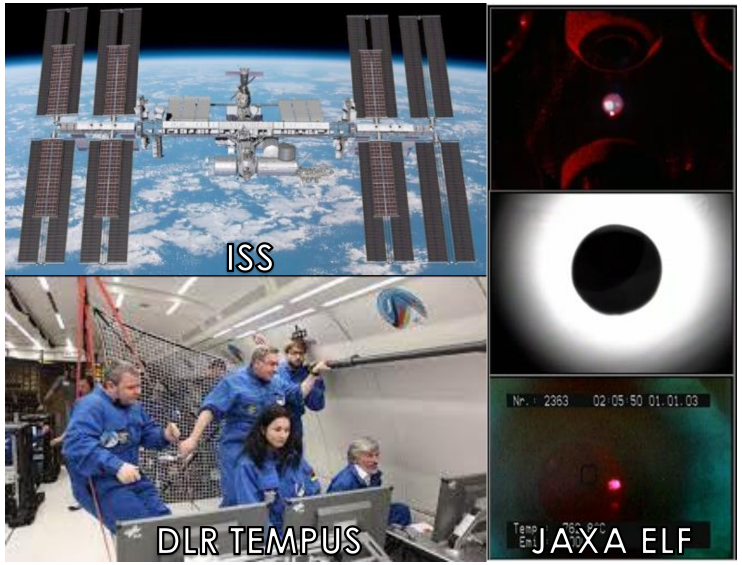
Improve manufacturing leading to better performance, sustainability and higher reliability



https://mars.nasa.gov/news/8912/say-cheese-on-mars-perseverances-selfie-with-ingenuity/

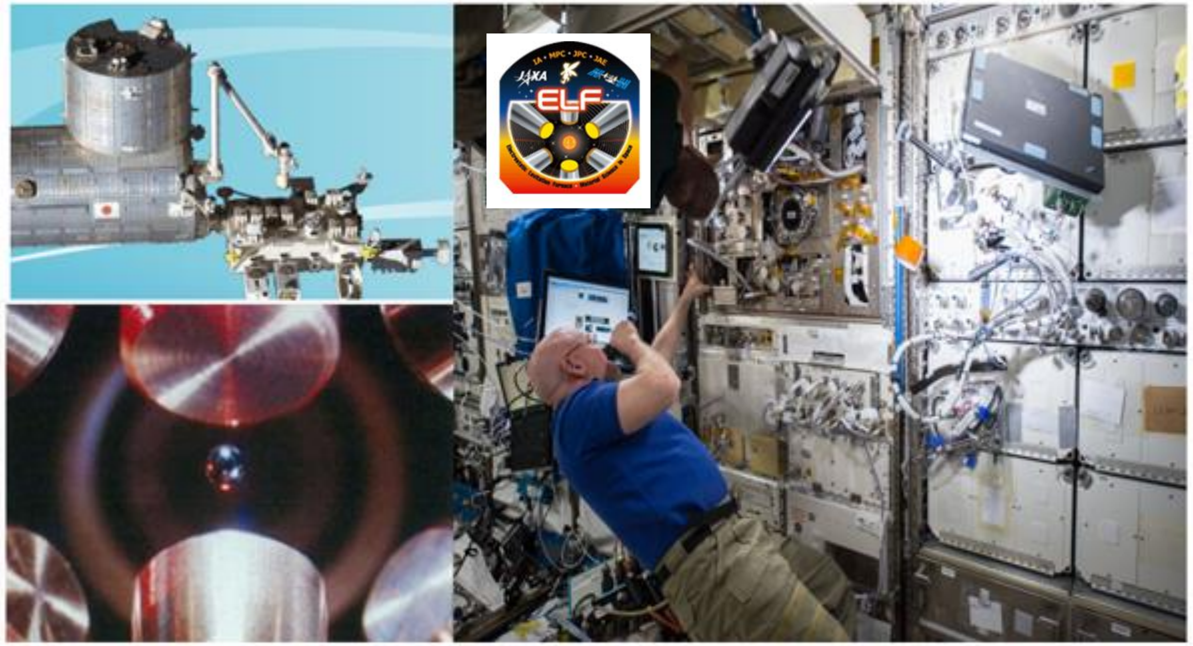
Why levitation in microgravity?

- Reduce contamination at high temperature
  - limits nucleation sites during solidification
  - free-surface ensures precise property evaluation
- Limit effects of buoyancy and sedimentation
- Provides extended duration of microgravity to complete experiment
- Better control of convection in space

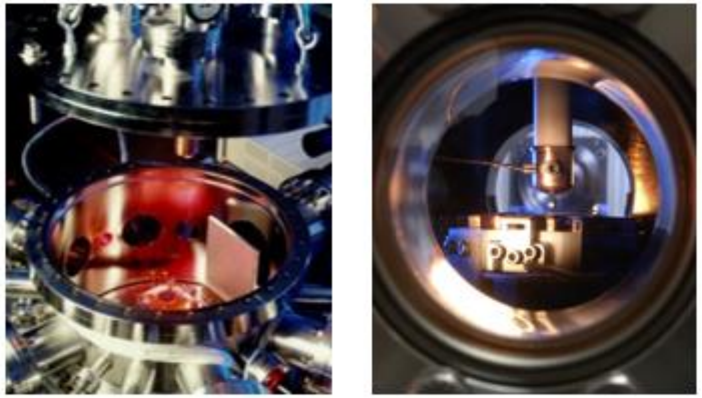


Levitation Techniques

Containerless levitation techniques:
- Electrostatic levitation (ESL)
- Electromagnetic levitation (EML)

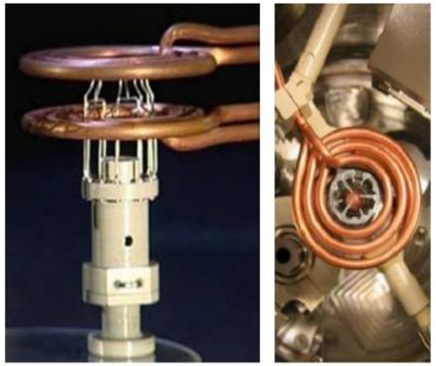


JAXA ELF



NASA MSFC ESL

DLR/ESA TEMPUS



ESA ISS-EML

Investigated Materials and Properties

Pure metals
- Gold (Au)
- Platinum(Pt)
- Zirconium (Zr)

Industrial superalloys
- Inconel 718
- Inconel 625
- CMSX-10
- CMSX-4 Plus

Thermophysical properties of the melt:
Density, Thermal expansion, Surface tension, **Viscosity**,
Electrical resistivity, Thermal conductivity, Specific heat capacity

Methods

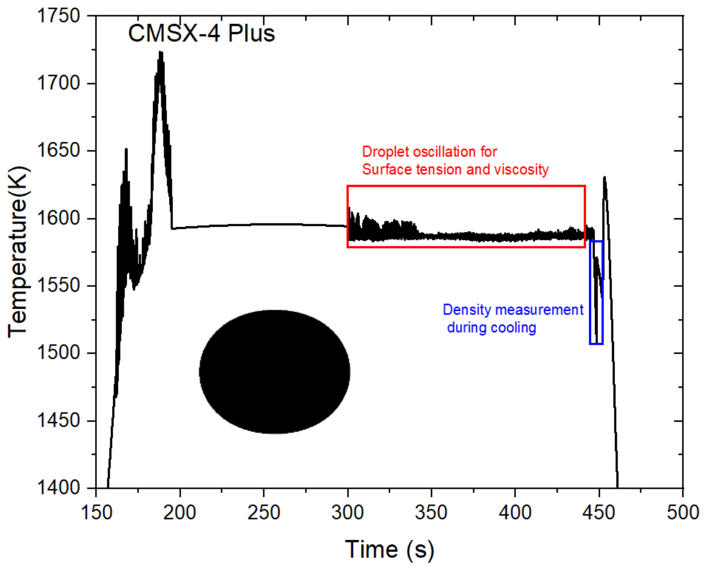
- Density
  - Volume is measured from the projected backlit image using high-speed camera
  - Dynamic mass is tracked throughout the process

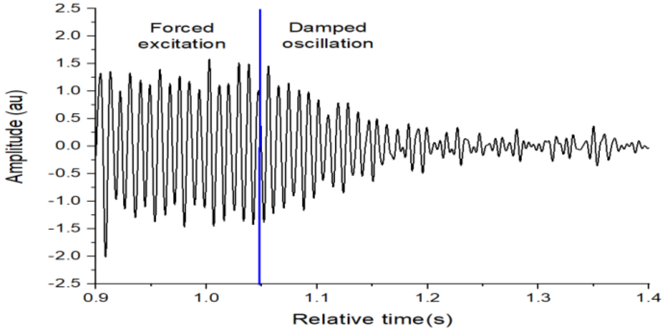
$$\rho = \frac{m}{V}$$

- Droplet oscillation
  - Sample oscillates within a varying induced electric field in ESL and pulse excitation in EML
  - Sample resonant frequency is used for surface tension measurement
  - Time constant for decaying signal is used for viscosity measurements

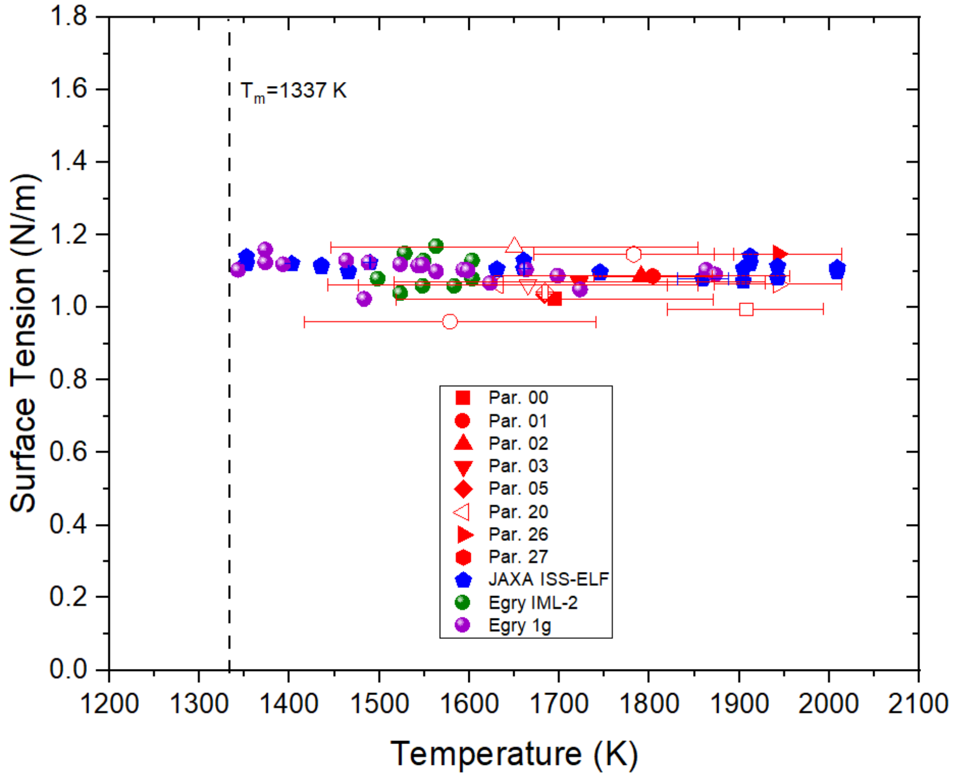
$$\sigma = \frac{3\pi m f^2}{l(l-1)(l+2)}$$

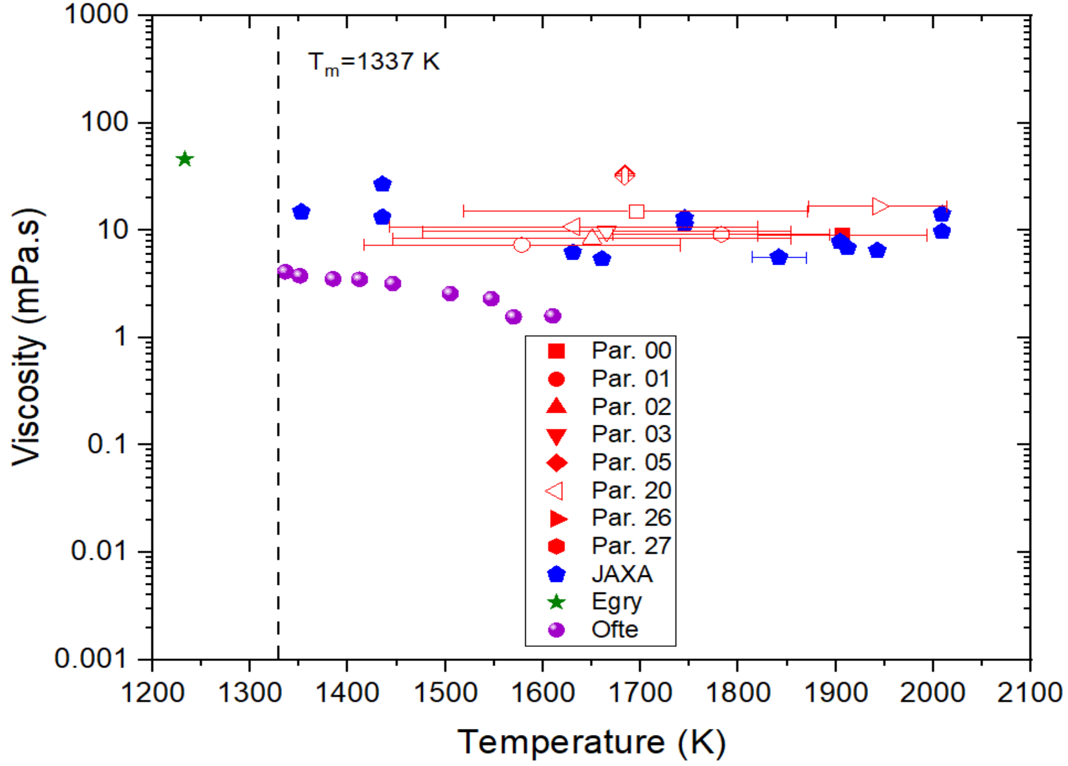
$$\mu = \frac{\rho r^2}{(l-1)(2l+1)\tau}$$





Results





Space results are comparable to published literature values

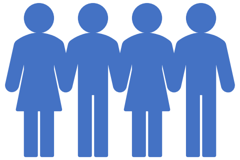
Summary

- Space research utilizing levitation is a powerful tool for space exploration
- Levitation research takes advantage of the unique microgravity environment for accurate property measurement
- Space results shows good agreement with ground-based testing

Future goals

Inspire people to pursue Space-related research through my journey

Finish my Ph.D. and work in STEM
- Start my own research projects towards academia
- Preferably in space related application



Help young researchers

Advice for those interested in Space Research

Space is accessible to everyone
- It's not just for scientists and engineers

Always look for opportunities to learn and apply

Be prepare to face unknown challenges when it comes to microgravity research

Thank you!

Any questions?