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Characterization of Thermal Radiative Properties of Space Materials at Cryogenic Temperatures

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Introduction

Thermal radiative properties for cryogenics and space applications

We can measure **total hemispherical emissivity or absorptivity 0.1 % - 100 %**

- Temperature of the radiator: **10 K - 320 K** (controlled)
- Temperature of the absorber: **5 K ~ 130 K** (sample depended)
- Sample dimensions: diameter **40 mm**
  thickness max. **5 mm**
- Materials: solids, sheets, foils, coatings, thin films on one side of the sample

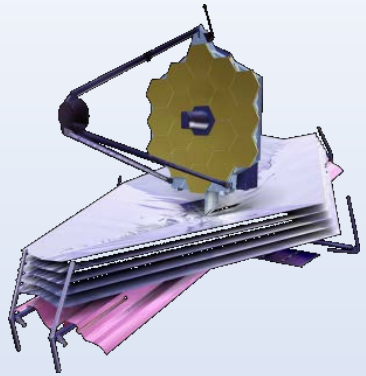
History

- First absorptivity measurements 2001-2002 for cryogenic applications
- Measurements for space applications since 2008

Collaboration

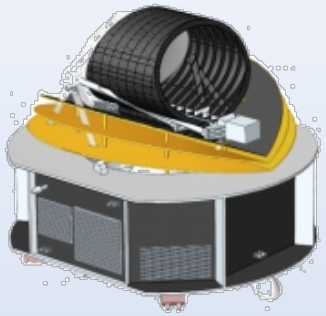
- Mostly contractual research
- Joint publication
- Consortium

JWST

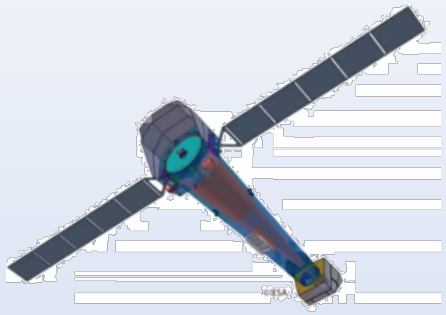


MTG

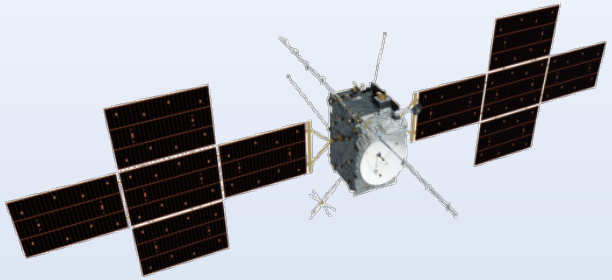
Ariel



Athena



JUICE



Our experimental setup for thermal-radiative properties

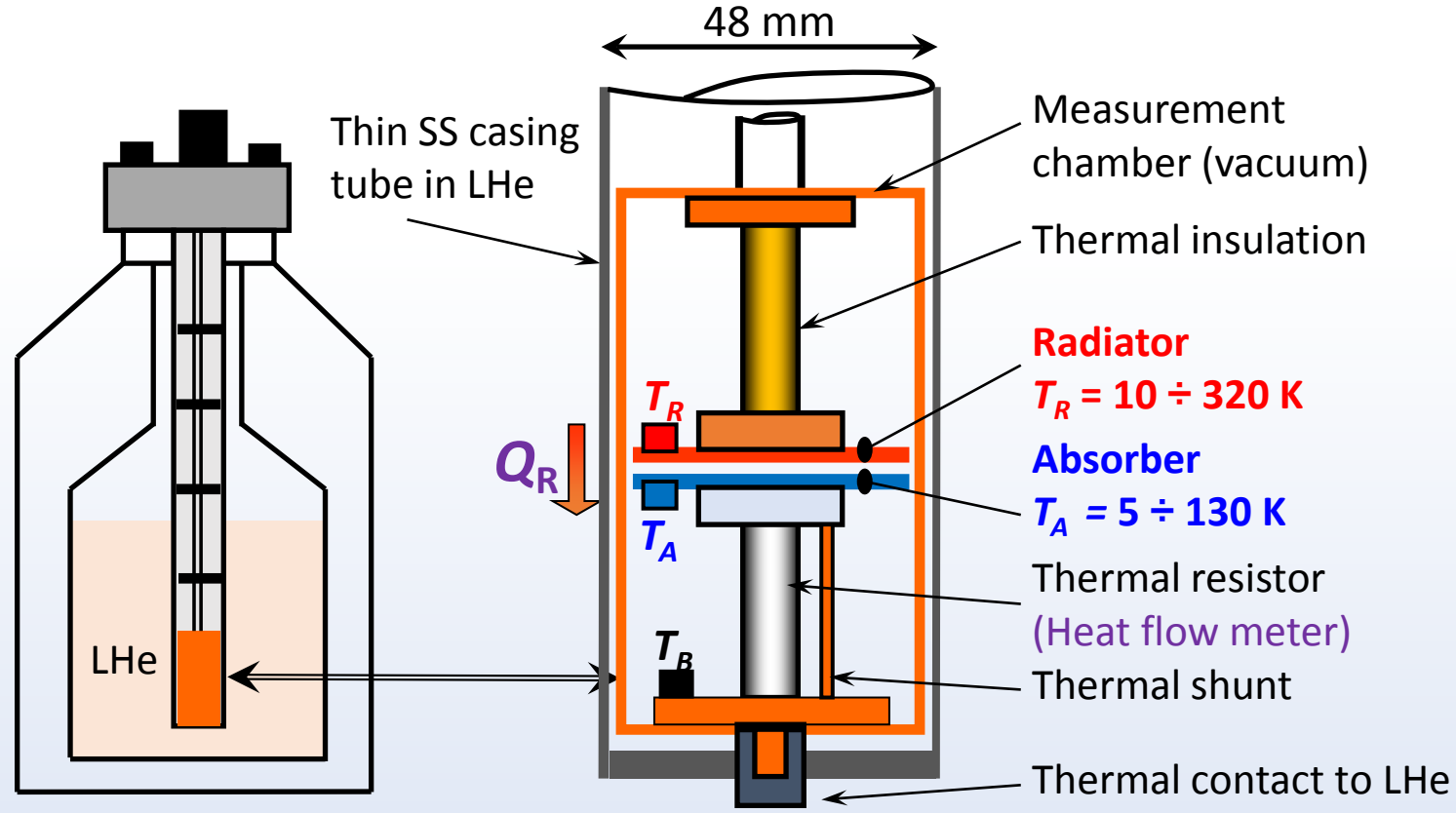
We measure radiative heat exchange ($T_R \leftrightarrow T_A$) between two surfaces (Ø 40 mm disks)

Mutual emissivity $\varepsilon_{RA} = \dfrac{Q_R}{A\sigma(T_R^4 - T_A^4)}$ ← Measured / ← Black body radiation

Q_R - radiative heat flow [W]

A - area of the sample [m²]

σ - Stefan-Boltzmann constant [W·m⁻²·K⁻⁴]



Apparatus in a Dewar vessel *Scheme of the measurement chamber*

Sample as radiator

Emissivity $\dfrac{1}{\varepsilon_R} = \dfrac{1}{\varepsilon_{RA}} - \dfrac{1}{\alpha_{REF}} + 1$

Sample as absorber

Absorptivity $\dfrac{1}{\alpha_A} = \dfrac{1}{\varepsilon_{RA}} - \dfrac{1}{\varepsilon_{REF}} + 1$

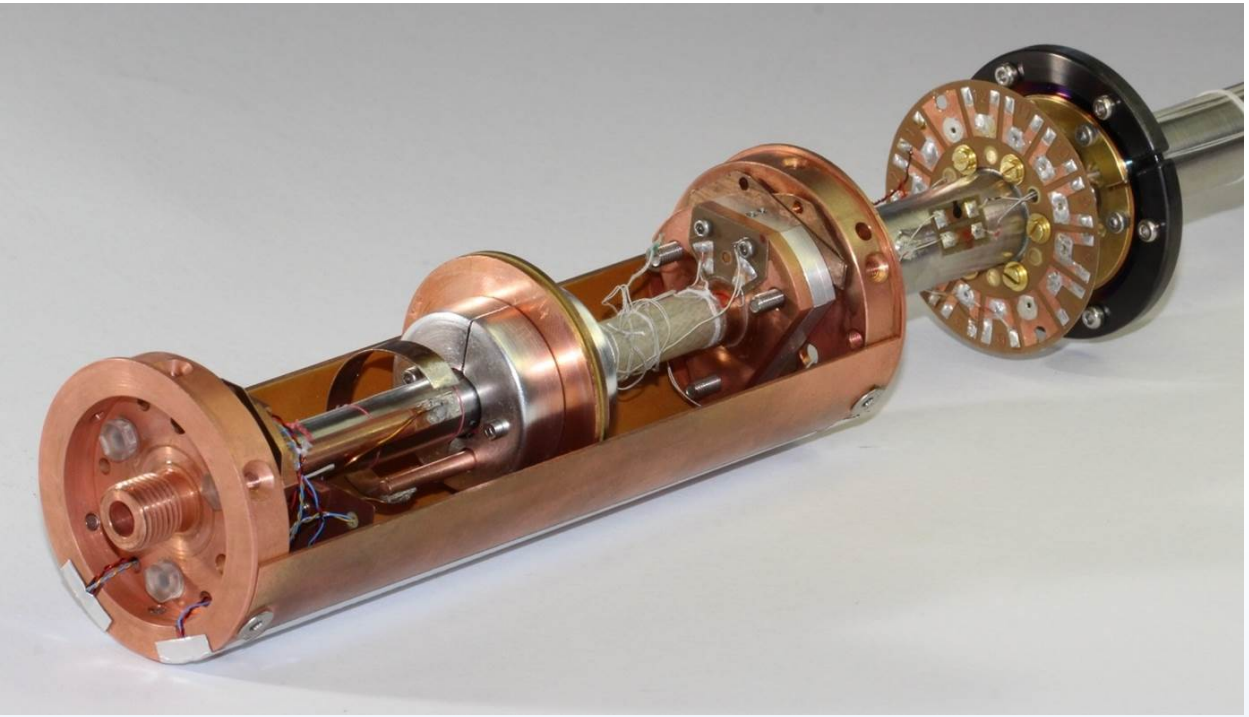
Sample in opposite position

Black reference sample ε_{REF} , α_{REF} **≈ 95%**

Our cryogenic apparatus and the method in detail: Králík T, et al. 2016. Metrologia. 53(2), 743-753

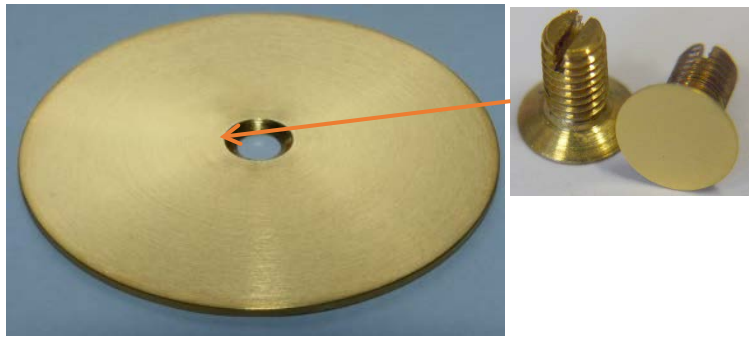
Apparatus and samples

Opened measurement chamber



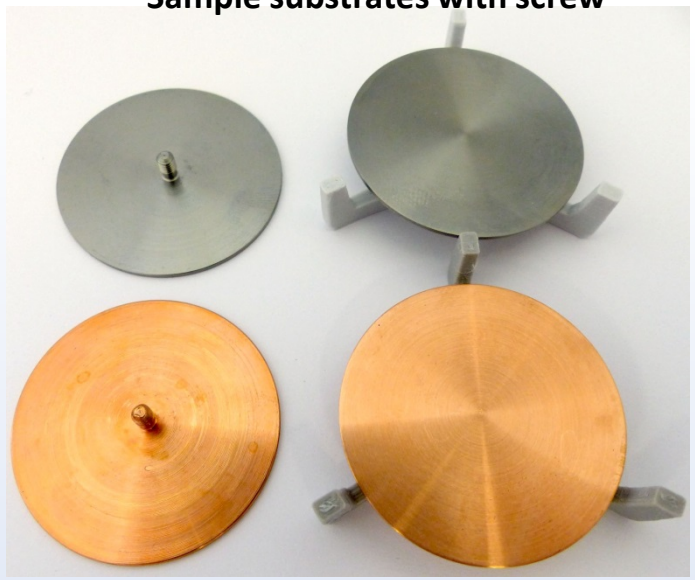
Samples

Flat sample substrates

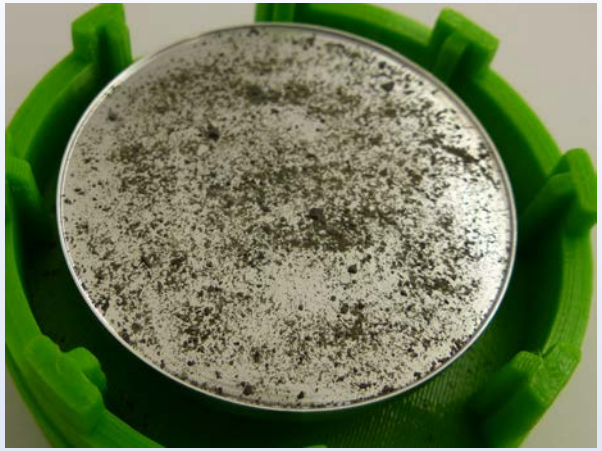


Solar white coating

Sample substrates with screw

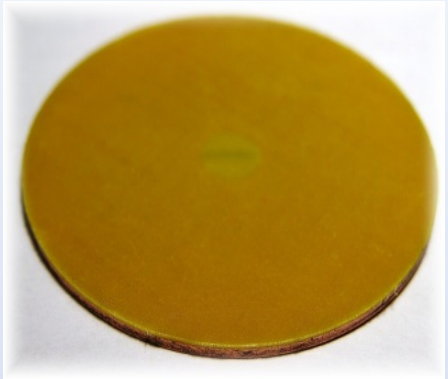


Lunar regolith simulant

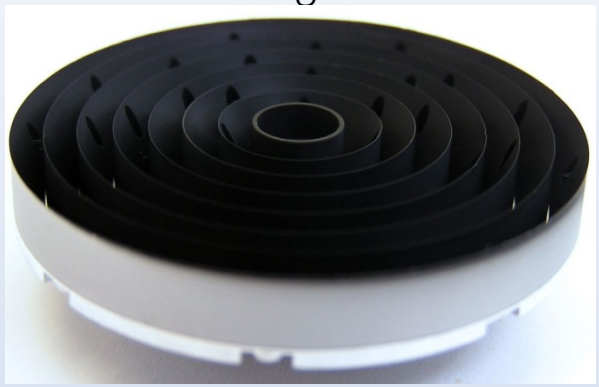


Black reference surface

Epoxy coating on Cu

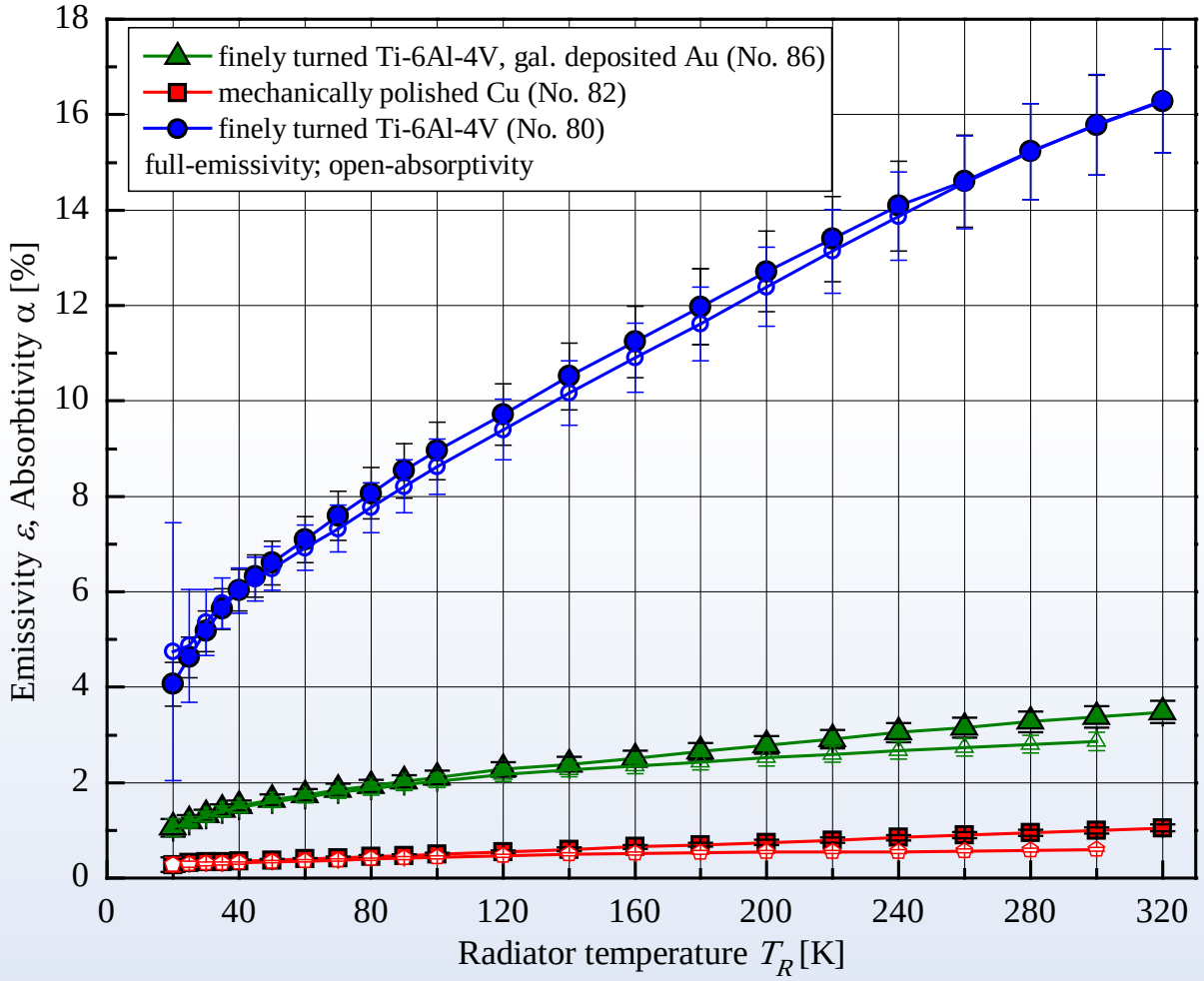


Circular V grooved structure

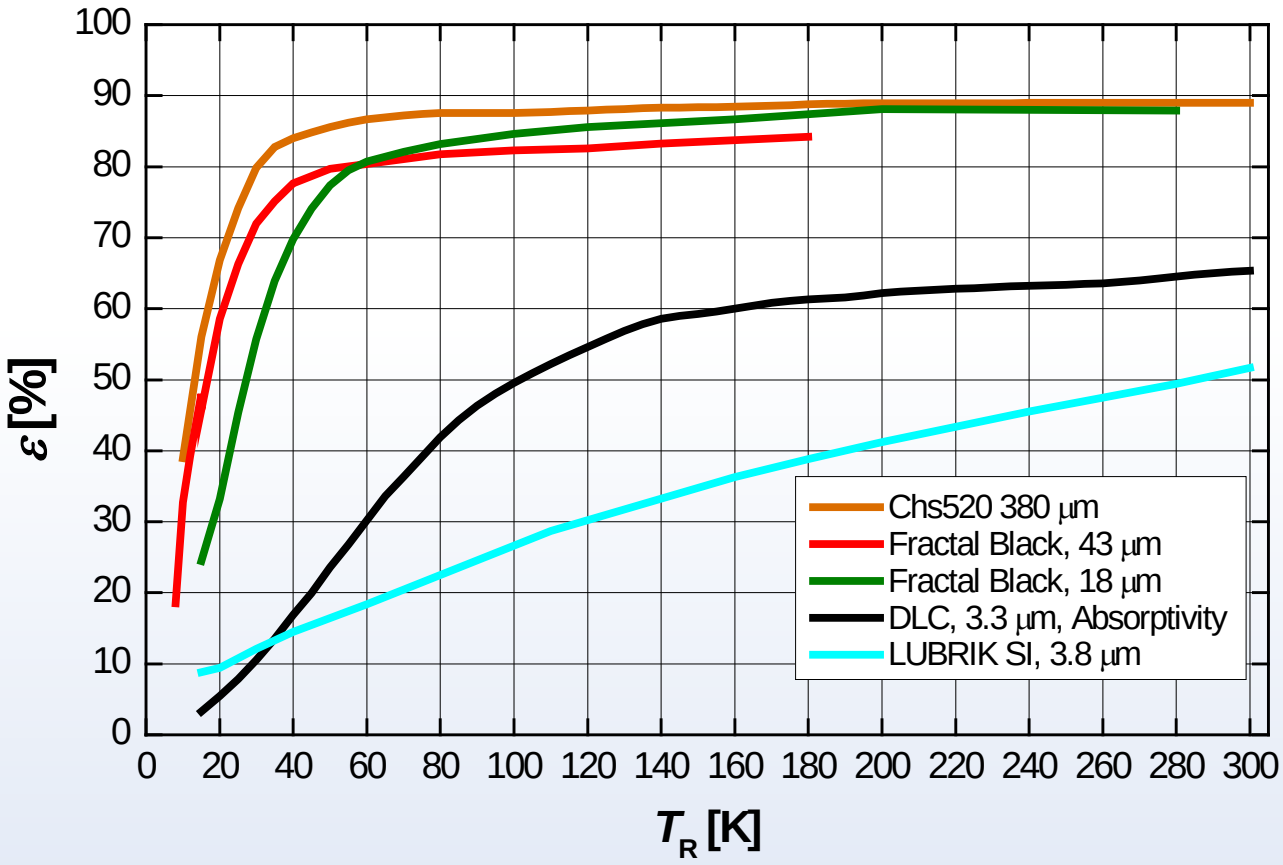


Examples of measurements

Emissivity and absorptivity of metals



Emissivity of “black” coatings



Temperature of the radiator [K]

Need more data? See our database or ask us.

Database of thermal radiative properties (ε, α) at cryogenic temperatures
Related paper: Frolec J., et al. 2019. Cryogenics. 97, 85-99
available at: https://data.mendeley.com/datasets/z8t423rwwd/4

- 69 measurements of about 50 individual samples
- temperature ranges 20 K-320 K; (plots & numeric data)
- mostly metallic materials with various surface finishes