LOW ALBEDO SURFACES OF LAVA WORLDS

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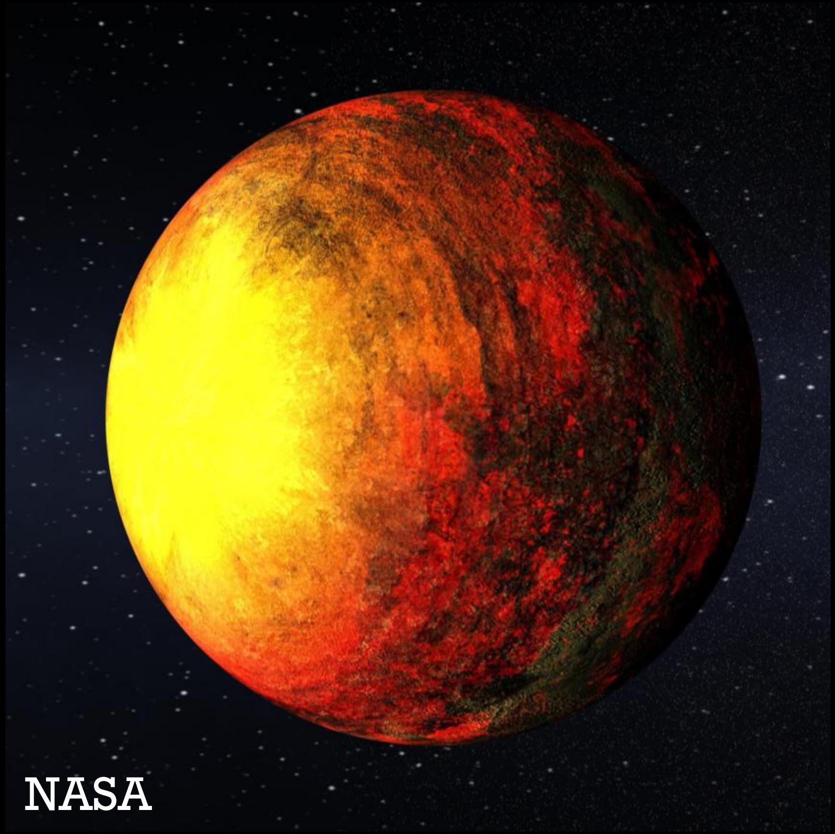
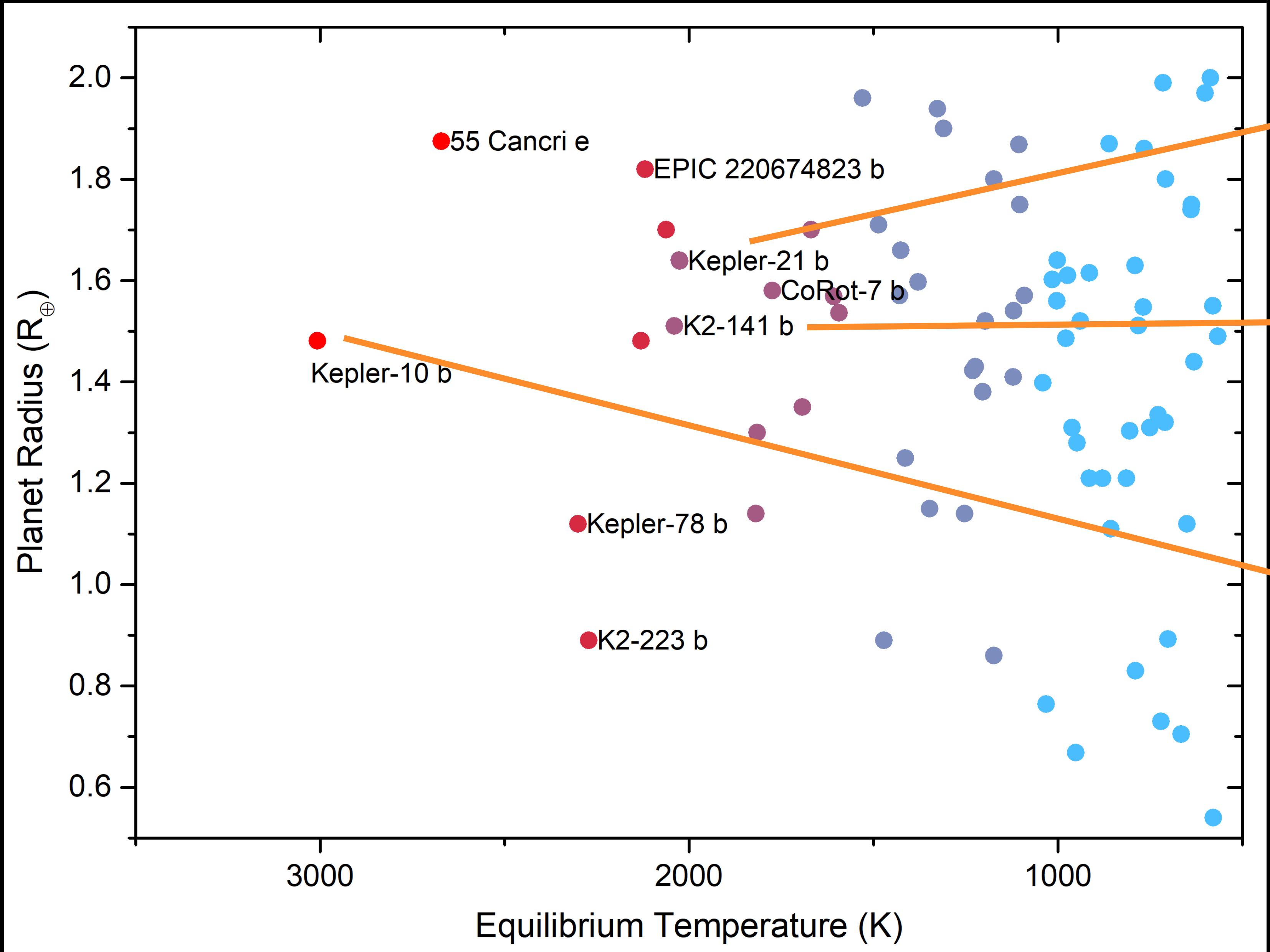
HOT SUPER EARTHS
LAVA-OCEAN EXOPLANETS

What causes the high geometric albedos on some hot super Earths?



- $R_{planet} < 1.6\ R_{earth}$
- Tidally locked
- Low pressure atmospheres (< 0.1 bar)
- Substellar temperature > 850 K
- Surface lava oceans due to intense stellar irradiation

LAVA-OCEAN EXOPLANET CANDIDATES



$0.4 < A_g < 0.5$

$0.2 < A_g < 0.4$

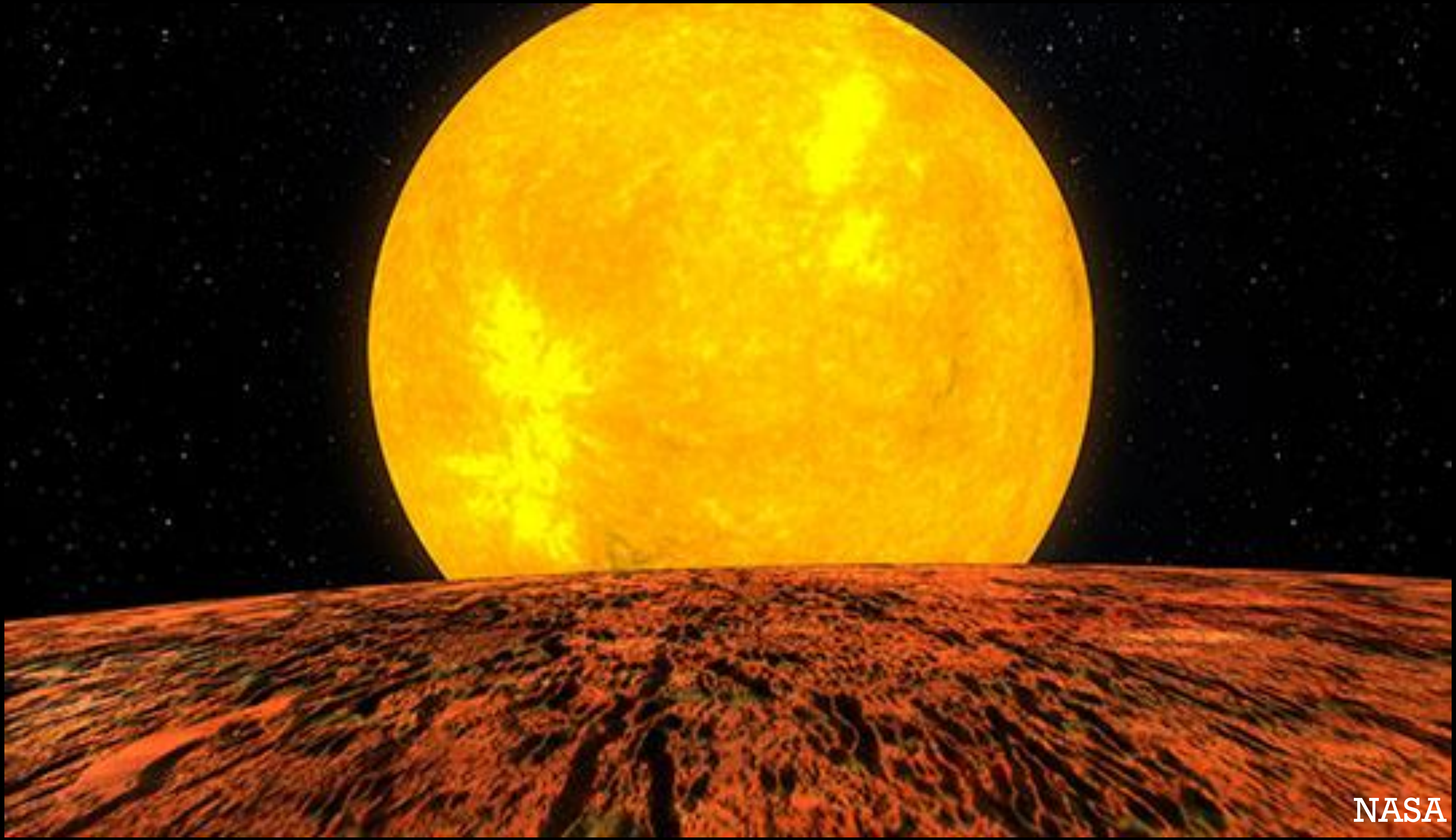
$0.4 < A_g < 0.5$

Demory (2014)

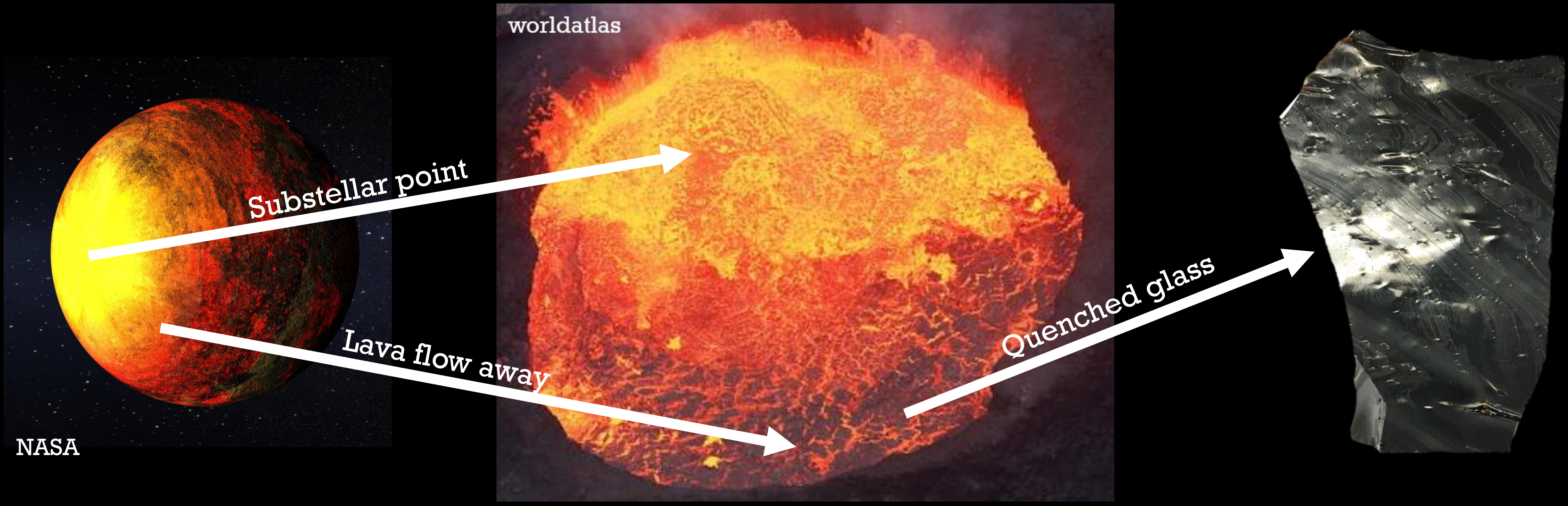
Malavolta et al. (2018)

A_g = *Geometric Albedo*

SURFACES AS A SOURCE OF HIGH ALBEDOS



A (SIMPLE) THEORETICAL SURFACE OF A LAVA WORLD



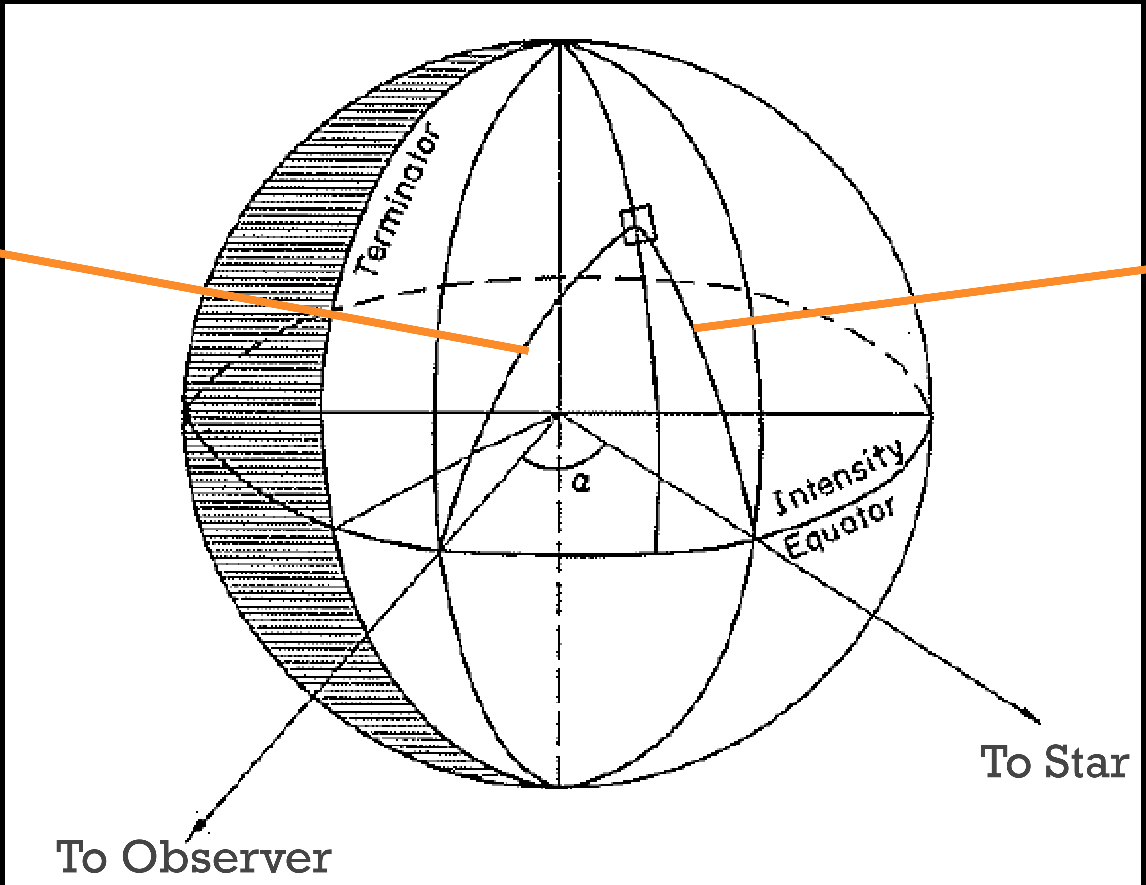
GEOMETRIC ALBEDO OF A PLANET

Reflected angle: η

$\cos(latitude)\cos(longitude)$

Incidence angle ζ

$\cos(latitude)\cos(longitude - \alpha)$



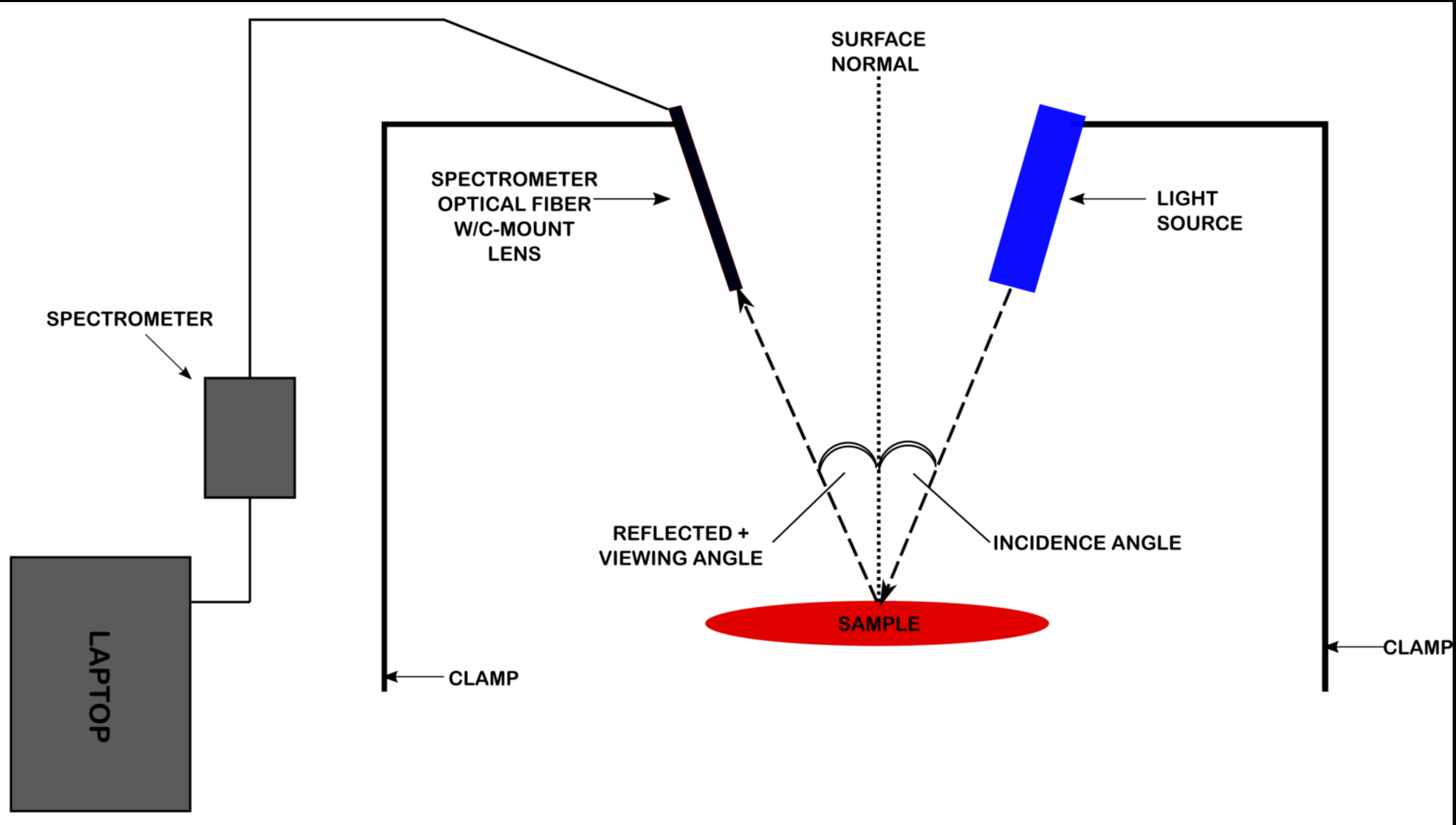
Reflection coefficient

$$\varrho(\eta, \zeta, \varphi)$$

$$A_g = 2\int_0^1 \varrho(\eta, \eta, \pi)\eta^2 d\eta$$

Sobolev (1975)

MEASURING REFLECTION FROM QUENCHED GLASSES

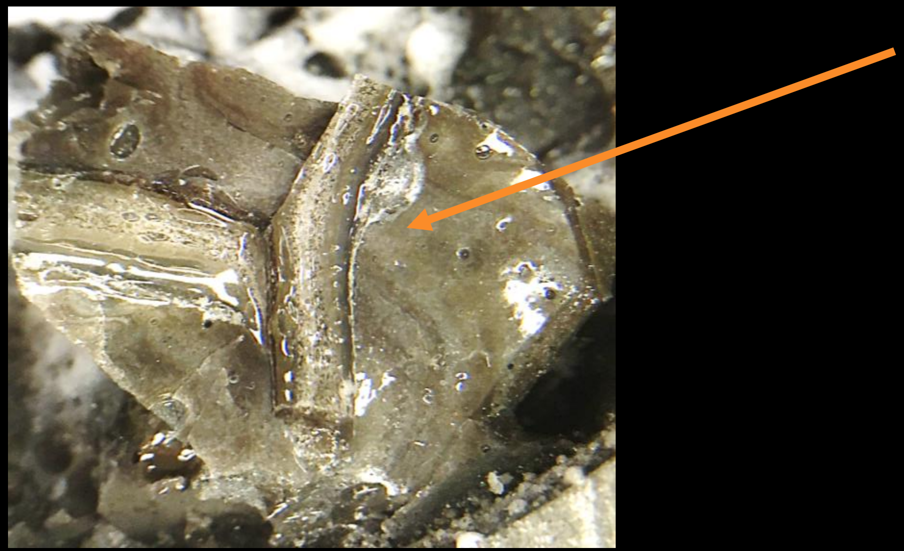


Essack et al. (in review)

BASALT AND FELDSPAR QUENCHED GLASSES

Basalt

Feldspar



Essack et al. (in review)

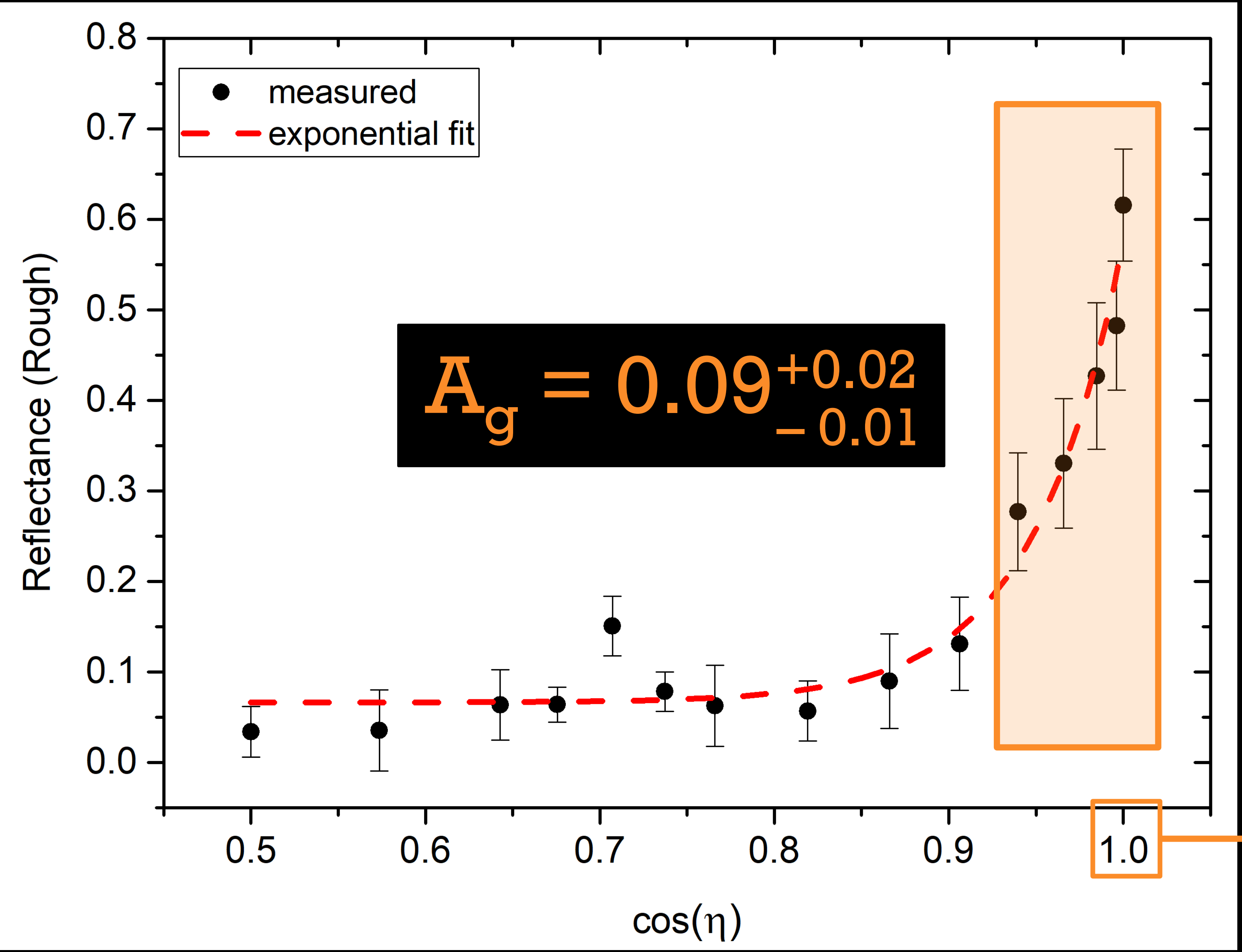
BASALT: REFLECTANCE VS. η (ROUGH GLASS)

Essack et al. (in review)

Lab measurements of reflection from quenched glass

Fit data from lab measurements to get **reflection coefficient function: $\varrho(\eta, \eta, \pi)$**

Integrate reflection coefficient function over all latitudes and longitudes on the planet dayside hemisphere to get **albedo: A_g**



Incidence Angle = Reflected Angle η

Substellar point

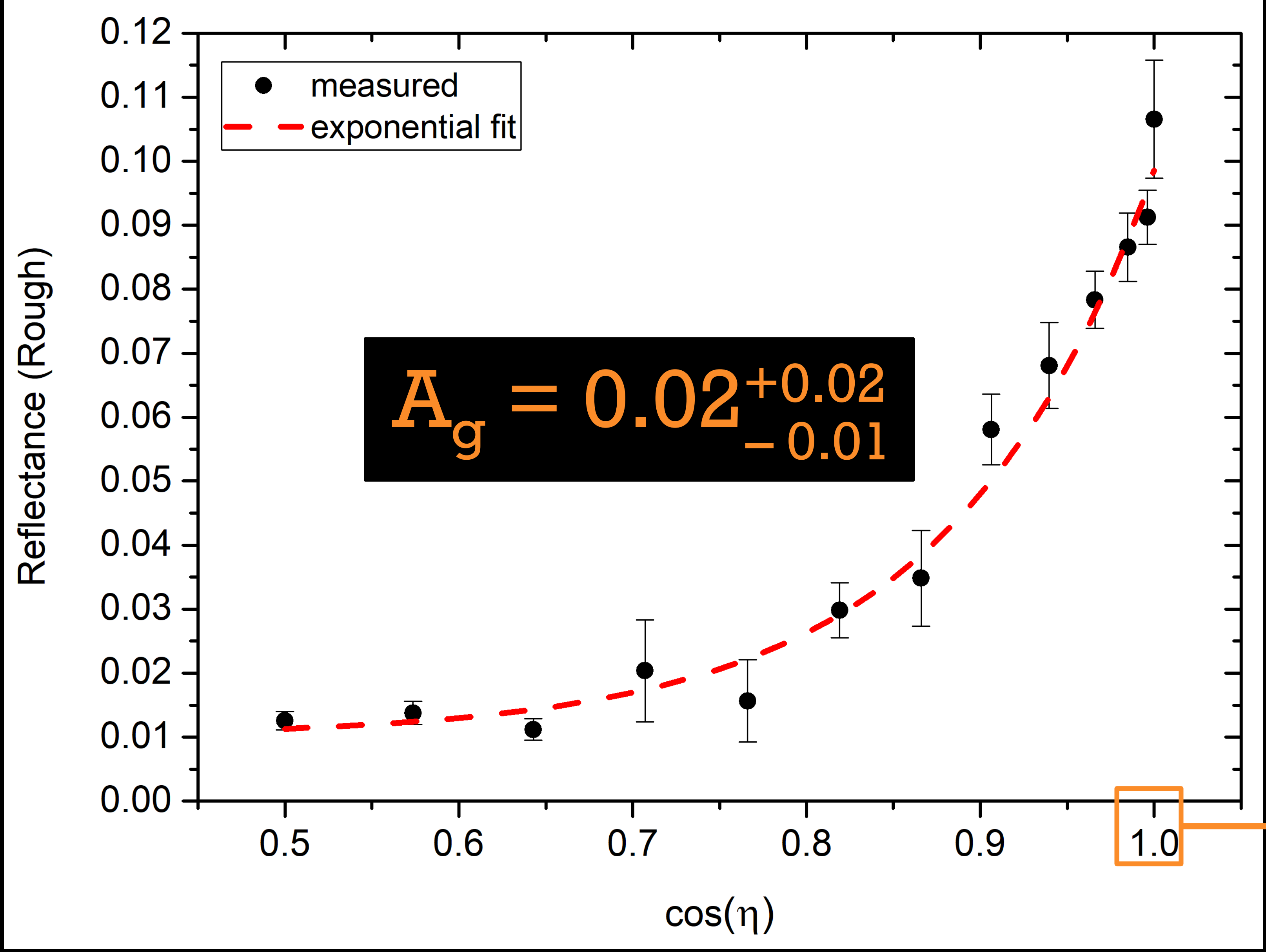
FELDSPAR: REFLECTANCE VS. η (ROUGH GLASS)

Essack et al. (in review)

Lab measurements of reflection from quenched glass

Fit data from lab measurements to get **reflection coefficient function: $\rho(\eta, \eta, \pi)$**

Integrate reflection coefficient function over all latitudes and longitudes on the planet dayside hemisphere to get **albedo: A_g**

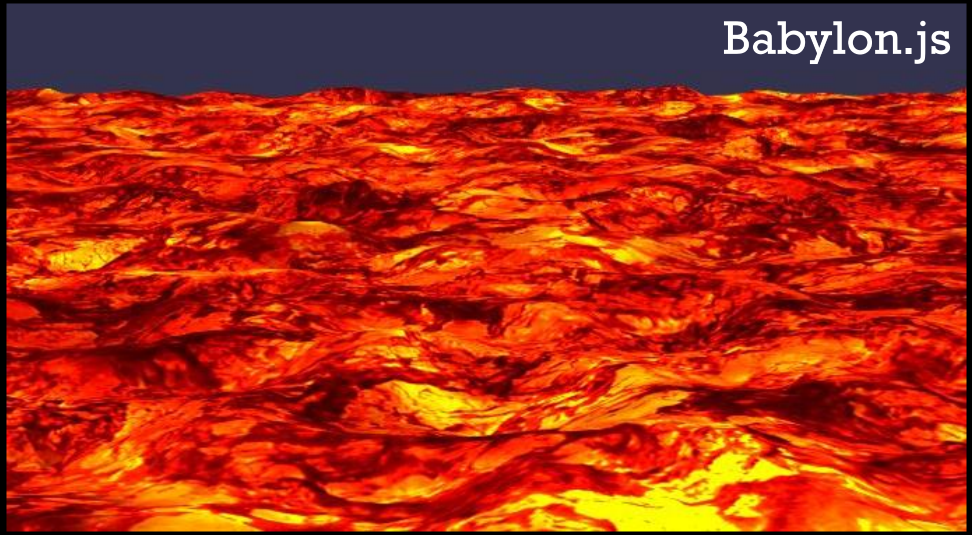


$$A_g = 0.02^{+0.02}_{-0.01}$$

Incidence Angle = Reflected Angle η

Substellar point

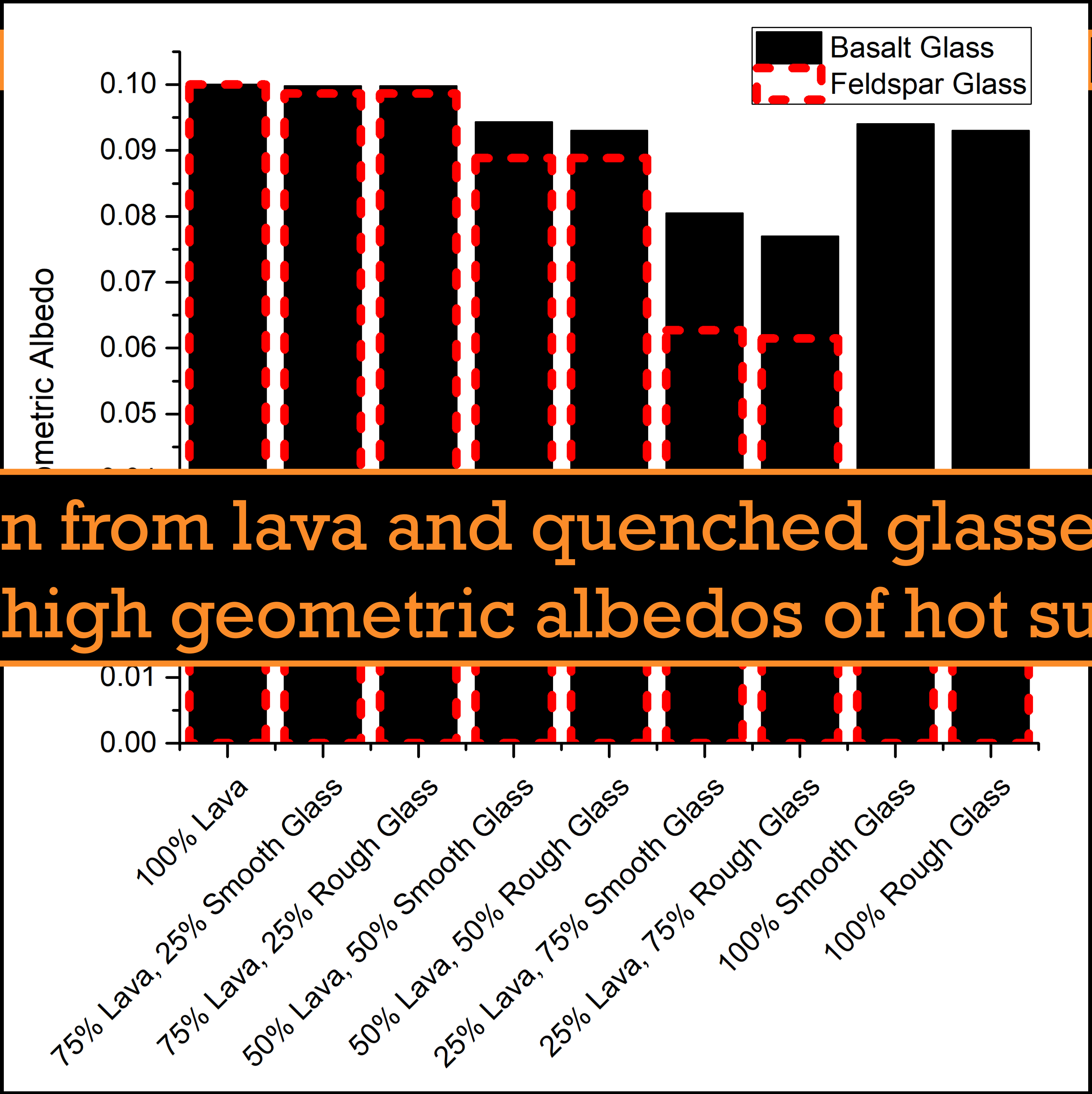
GEOMETRIC ALBEDO OF A COMBINATION LAVA-GLASS PLANET



Lava: Specular reflection value from non-crystalline solids **literature.**

Quenched Glass: Reflection values measured **experimentally.**

GEOMET … INATION



Reflection from lava and quenched glasses <u>cannot</u> explain the high geometric albedos of hot super Earths.

Essack et al. (in review)

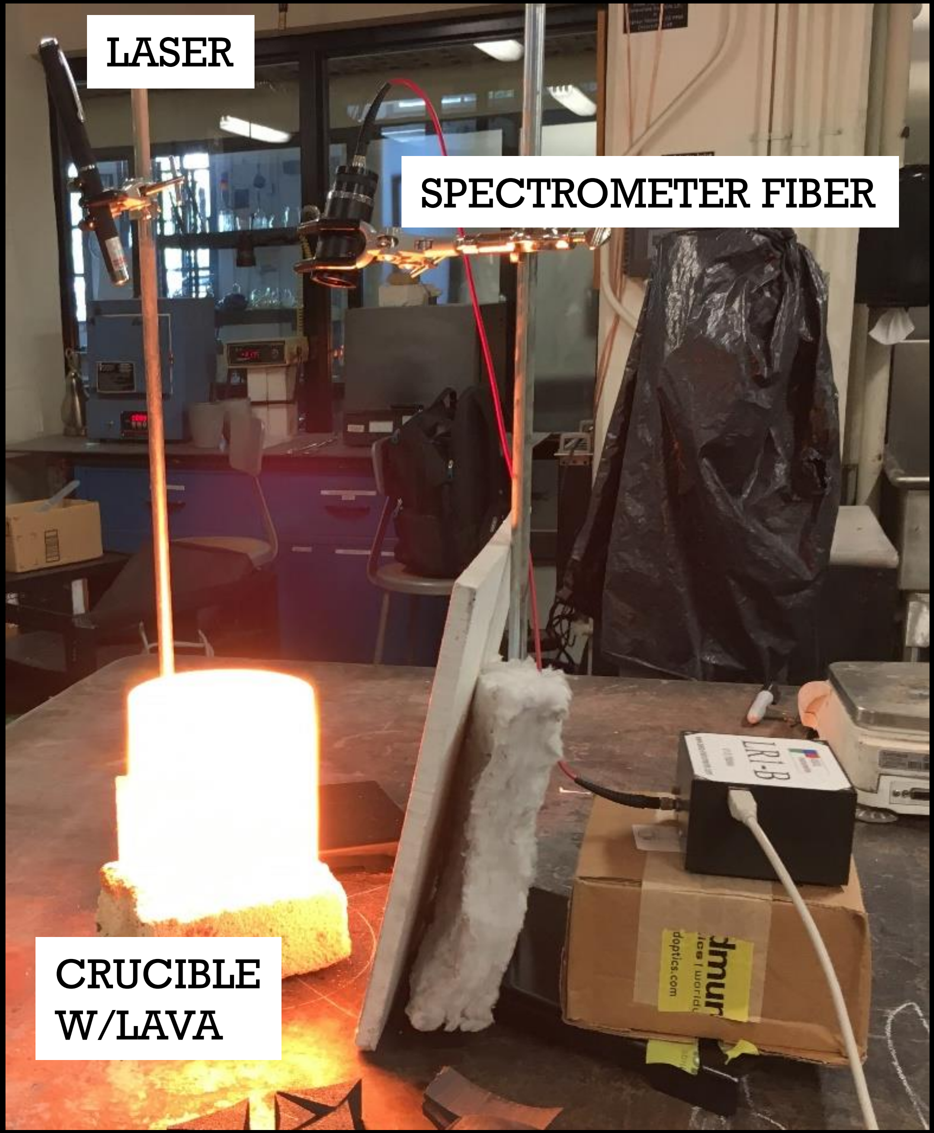
OTHER SOURCES OF REFLECTION

ATMOSPHERES

EVOLVED HIGH ALBEDO SURFACES

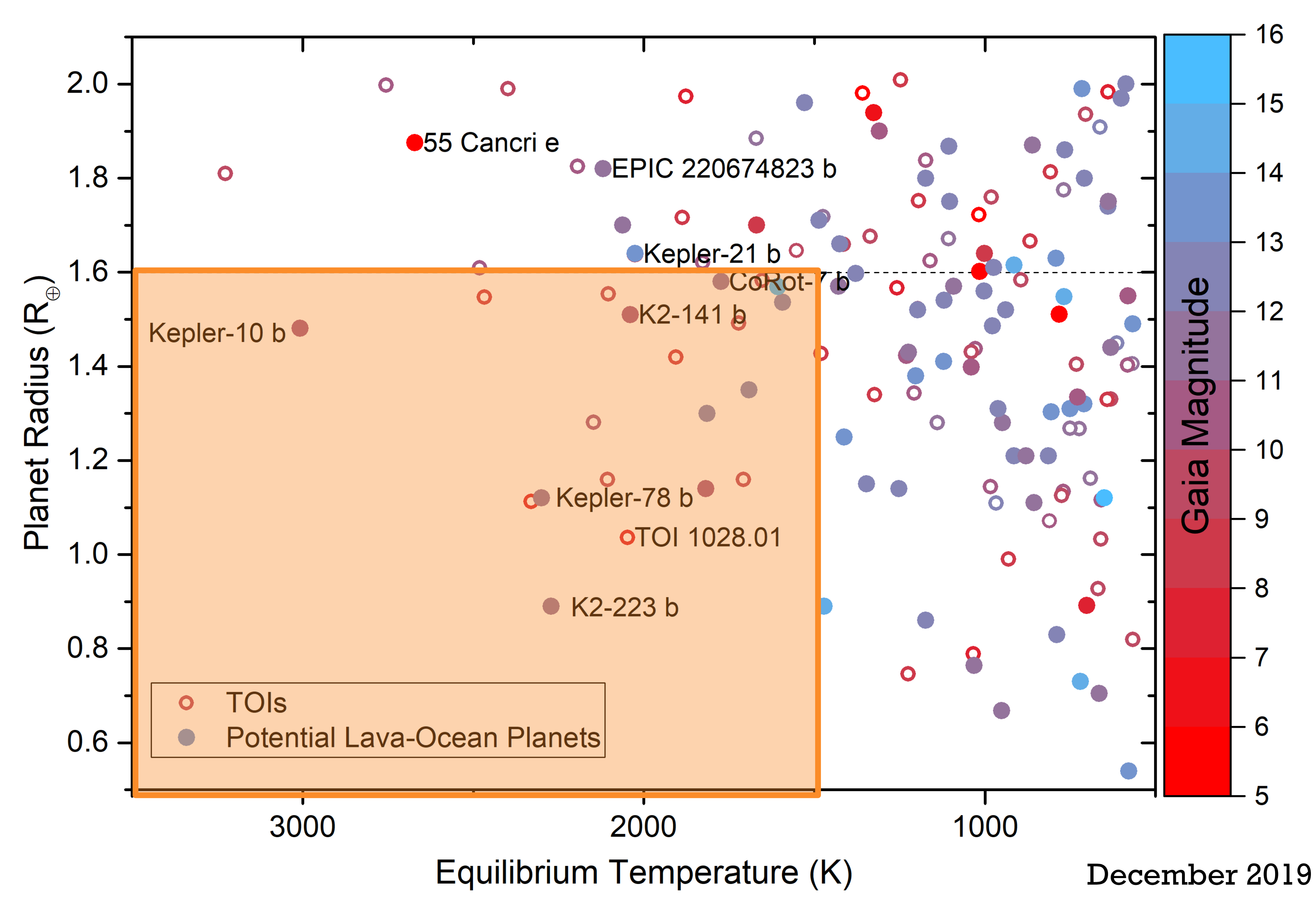
Combining results from Zebger et al. (2005); Hu et al. (2012); Kite et al. (2016).

FUTURE WORK: MEASURING THE ALBEDO OF LAVA



Sept. 2019
Z. Essack

FUTURE WORK: LAVA WORLDS FROM TESS



December 2019

Essack et al. (in review)

CONCLUSION

- Lava worlds with solid (quenched glass) or liquid (lava) surfaces have low albedos (< 0.1), and hence a negligible contribution to the high geometric albedos of some hot super Earths.
- The high geometric albedos of hot super Earths are likely explained by atmospheres with reflective clouds or evolved surfaces.
- Validating lava planet candidates from TESS and characterizing them with JWST will allow us to better understand their atmospheres, surfaces, and other properties.