LOW ALBEDO SURFACES OF LAVA WORLDS

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

- $R_{\text{planet}} < 1.6 \ R_{\text{earth}}$
- Tidally locked
- Low pressure atmospheres ($< 0.1 \text{ bar}$)
- Substellar temperature $> 850 \text{ K}$
- 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)

\( A_g = \text{Geometric Albedo} \)
SURFACES AS A SOURCE OF HIGH ALBEDOS

NASA
A (SIMPLE) THEORETICAL SURFACE OF A LAVA WORLD
GEOMETRIC ALBEDO OF A PLANET

Reflection coefficient
\[ \rho(\eta, \zeta, \varphi) \]

Sobolev (1975)

Reflected angle: \( \eta \)  
Incidence angle: \( \zeta \)  

\[ \cos(\text{latitude}) \cos(\text{longitude}) \]

\[ A_g = 2 \int_0^1 \rho(\eta, \eta, \pi) \eta^2 d\eta \]
MEASURING REFLECTION FROM QUENCHED GLASSES

Essack et al. (in review)
BASALT AND FELDSPAR QUENCHED GLASSES

Basalt

Reference Standard

Feldspar

Essack et al. (in review)
Lab measurements of reflection from quenched glass

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

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

Incidence Angle = Reflected Angle $\eta$

$A_g = 0.09^{+0.02}_{-0.01}$

Essack et al. (in review)
Lab measurements of reflection from quenched glass

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

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

Incidence Angle = Reflected Angle $\eta$

Substellar point

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

Essack et al. (in review)
GEOMETRIC ALBEDO OF A COMBINATION LAVA-GLASS PLANET

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

Quenched Glass: Reflection values measured experimentally.

Babylon.js

Andrew Cooper
Reflection from lava and quenched glasses cannot explain the high geometric albedos of hot super Earths.
Combining results from Zebger et al. (2005); Hu et al. (2012); Kite et al. (2016).
FUTURE WORK: MEASURING THE ALBEDO OF LAVA
FUTURE WORK: LAVA WORLDS FROM TESS

Malavolta et al., 2018

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.