

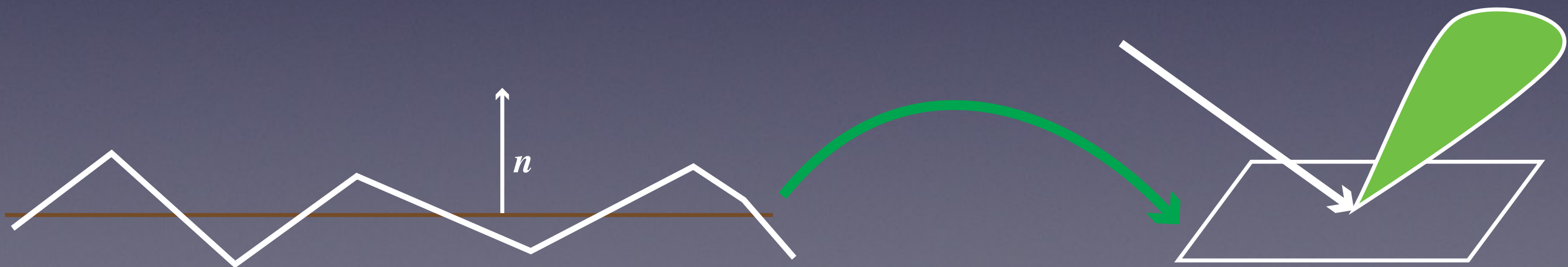
Identifying diffraction effects in measured BRDFs

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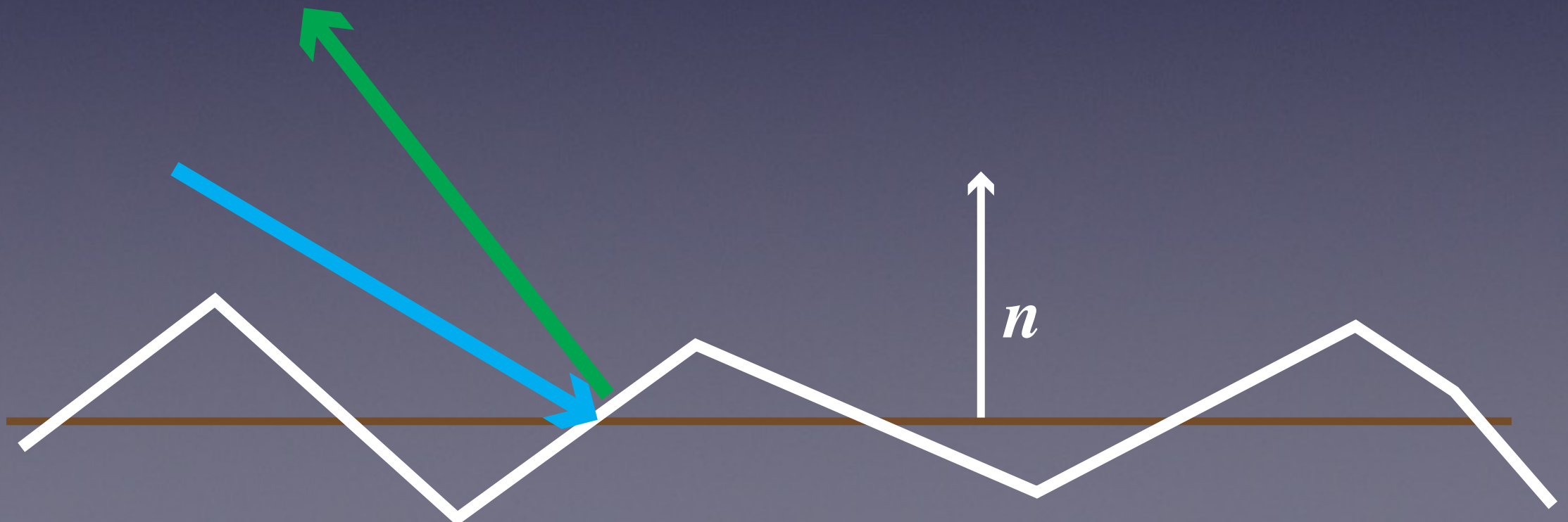
Micro-geometry and reflectance

- BRDF related to surface geometry at micro-scale
- 2 main models: Cook-Torrance and Diffraction

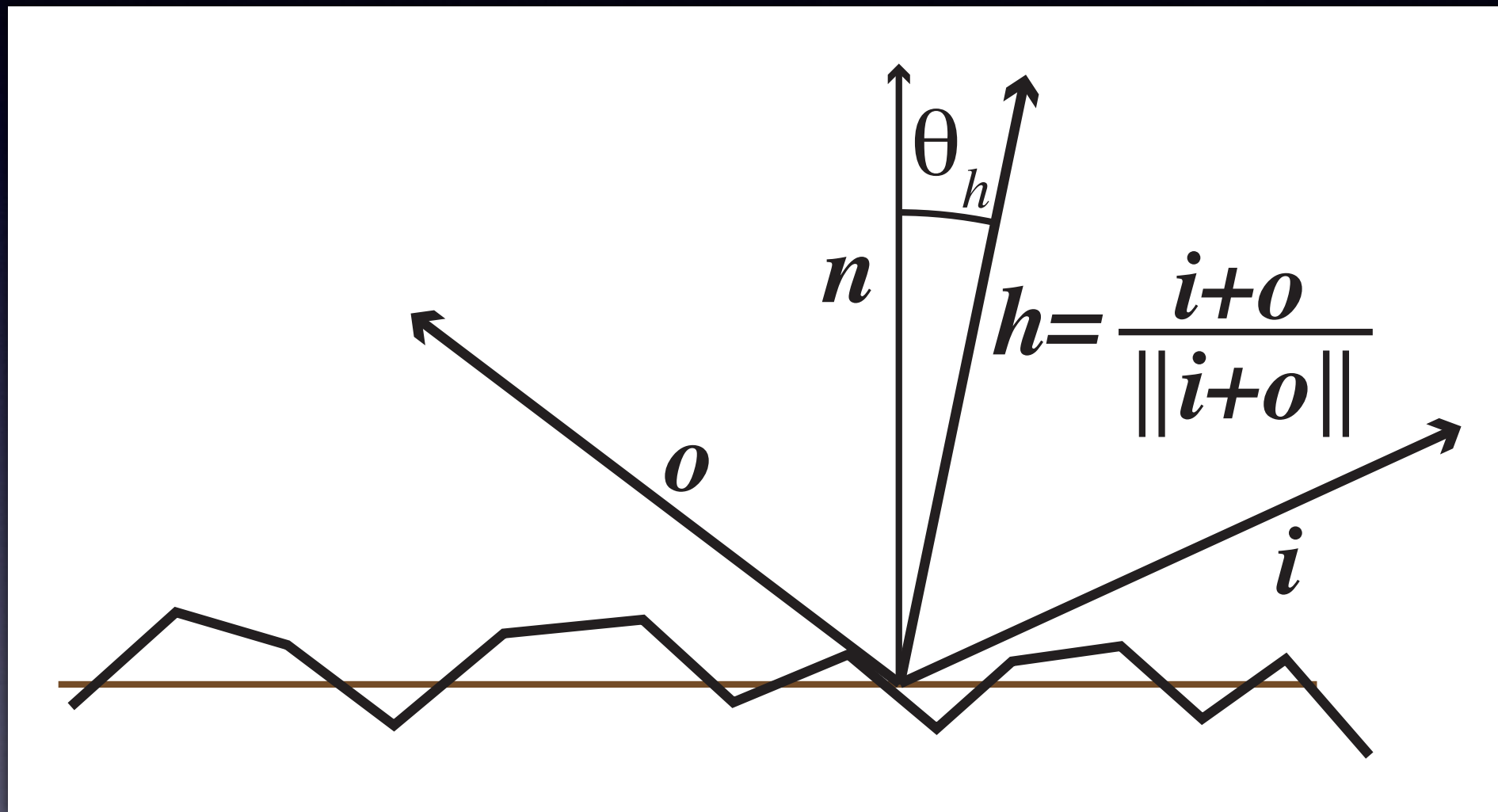


Cook-Torrance

- Specular *reflection* on micro-facets
- Main parameter: distribution of micro-facets
- Fresnel term, shadowing/masking



Notations (Cook-Torrance)



$$\cos(\theta_d) = i \cdot h$$

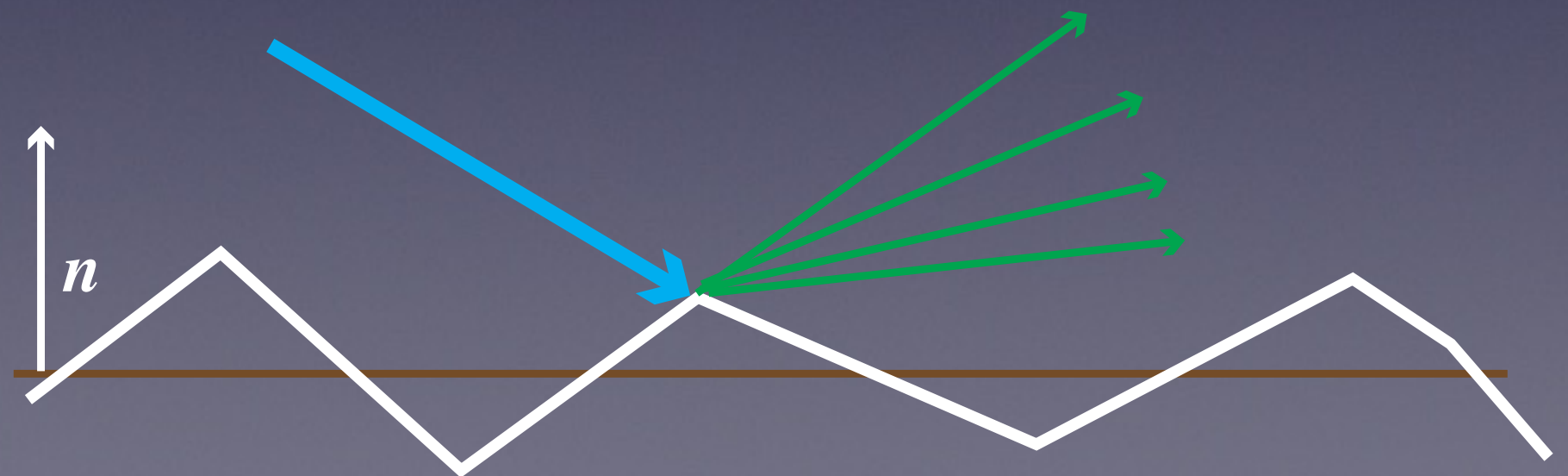
Cook-Torrance

$$p(\mathbf{i}, \mathbf{o}) = \rho_s \frac{D(\theta_h) F(\theta_d) G(\mathbf{i}, \mathbf{o})}{\pi \cos \theta_i \cos \theta_o}$$

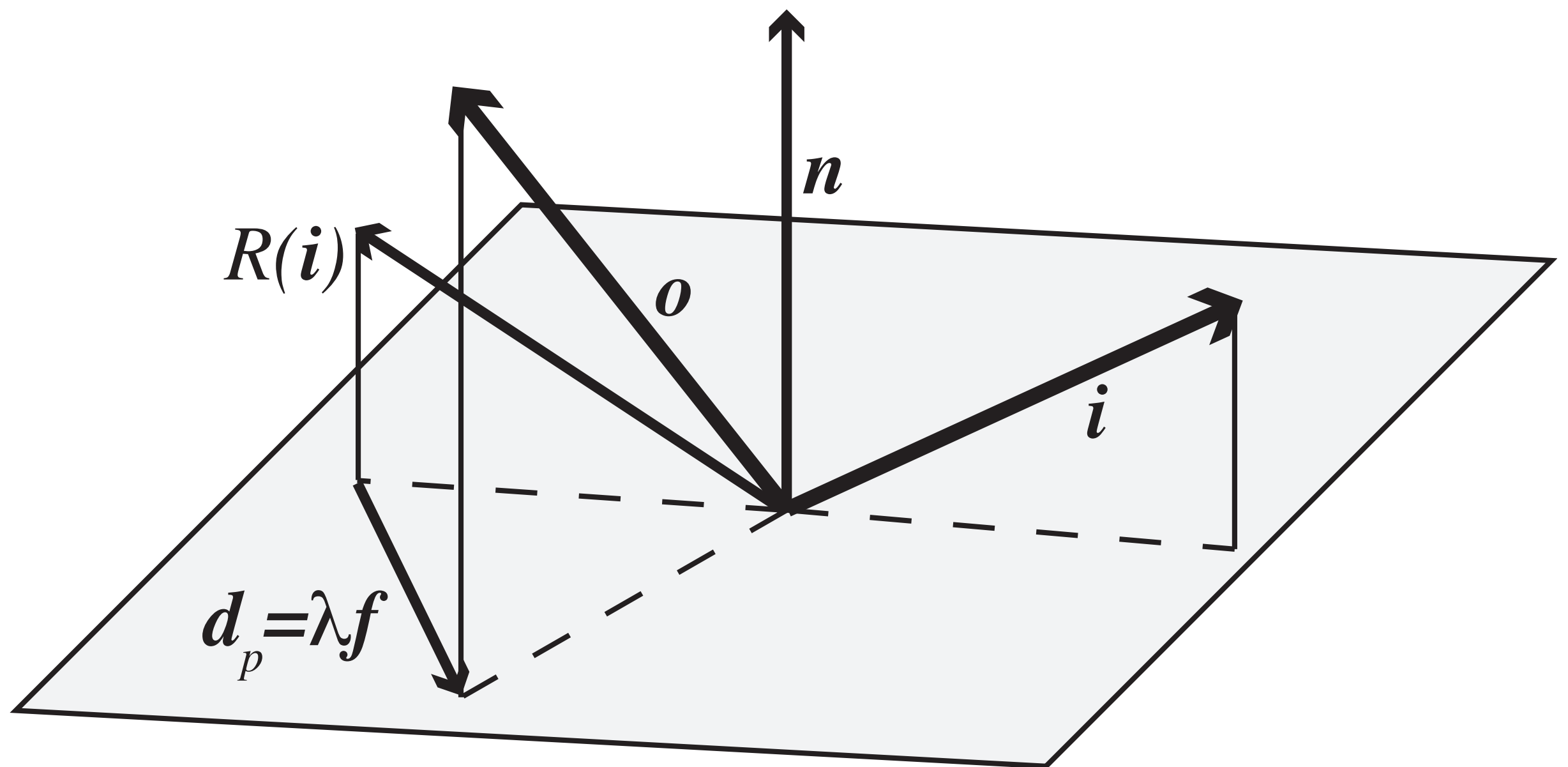
- D = probability distribution of micro-facet normals
- Fitting to measured reflectance:
 - TR/GGX (Walter et al. 2007)
 - SGD (Bagher et al., 2012) (heuristic model)
Good fit for measured BRDFs in MERL database

Diffraction

- Light is *diffracted* by micro-geometry
- Widely used in optical engineering
- Main parameter: PSD of surface height



Notations (diffraction)



Diffraction

$$p_w(\mathbf{i}, \mathbf{o}) = \frac{\rho_w}{\lambda^4} F(\mathbf{i}, \mathbf{h}) S_z(f)$$

- S_z = Power Spectral Distribution of surface height
- S_z = ABC (heuristic model)
- Löw et al. 2012: good fit for measured BRDFs in MERL database.

Diffraction

- f = parameter for PSD
- Contains dependency on wavelength λ
- Material response is different for RGB channels

$$f = \frac{\|(\mathbf{i} + \mathbf{o}) \times \mathbf{n}\|}{\lambda}$$

$$f = \left(\frac{2}{\lambda}\right) \sin(\theta_h) \cos(\theta_d)$$

Diffraction/Reflection

- *Both* models provide a good fit for measured BRDFs
- They can't be both right!
- Both models have issues too:
 - SGD has different distribution for RGB
 - [Löw 2012] removed λ dependency

What if?

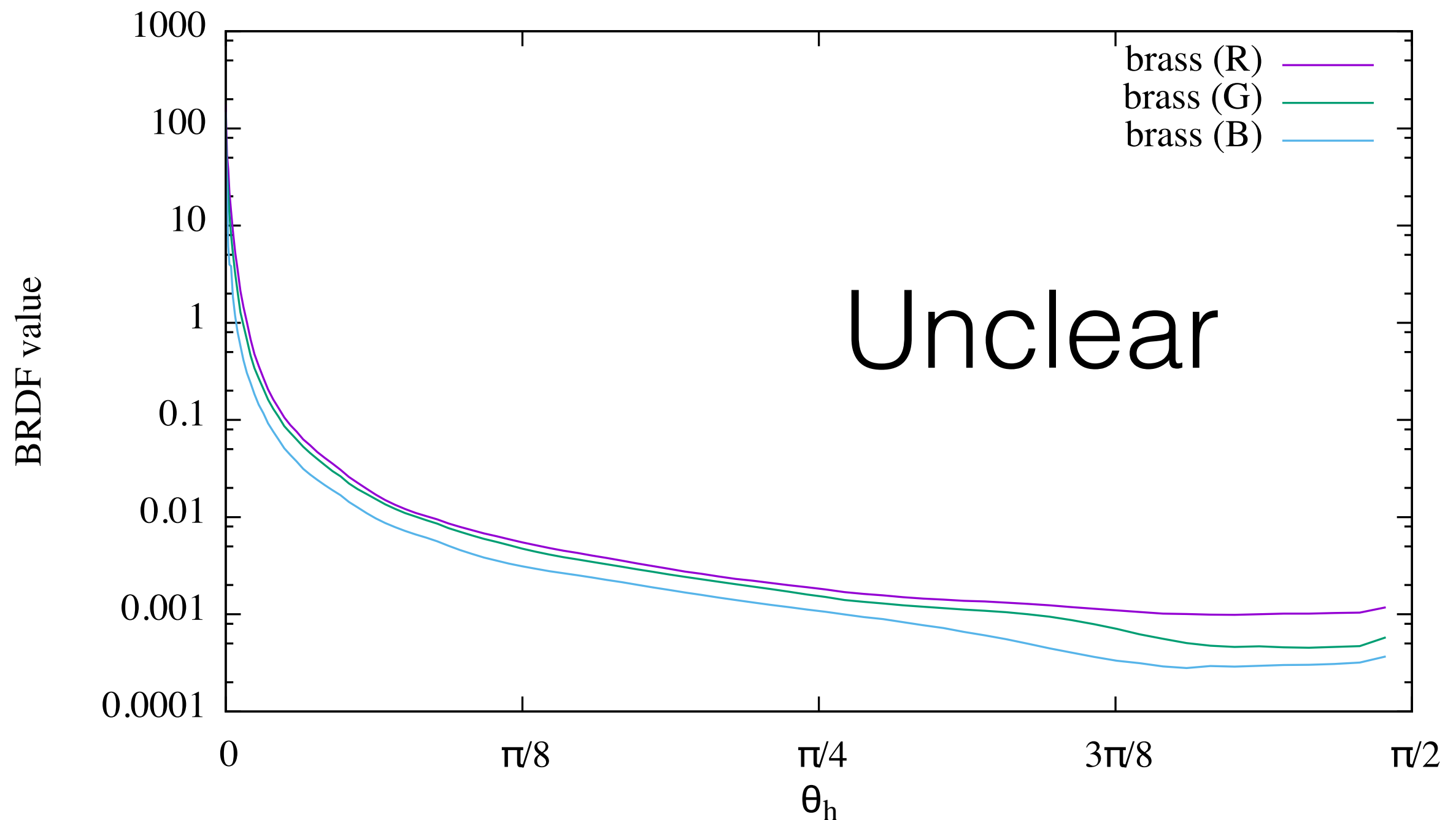
- What if they are *both* right?

What if?

- What if they are *both* right?

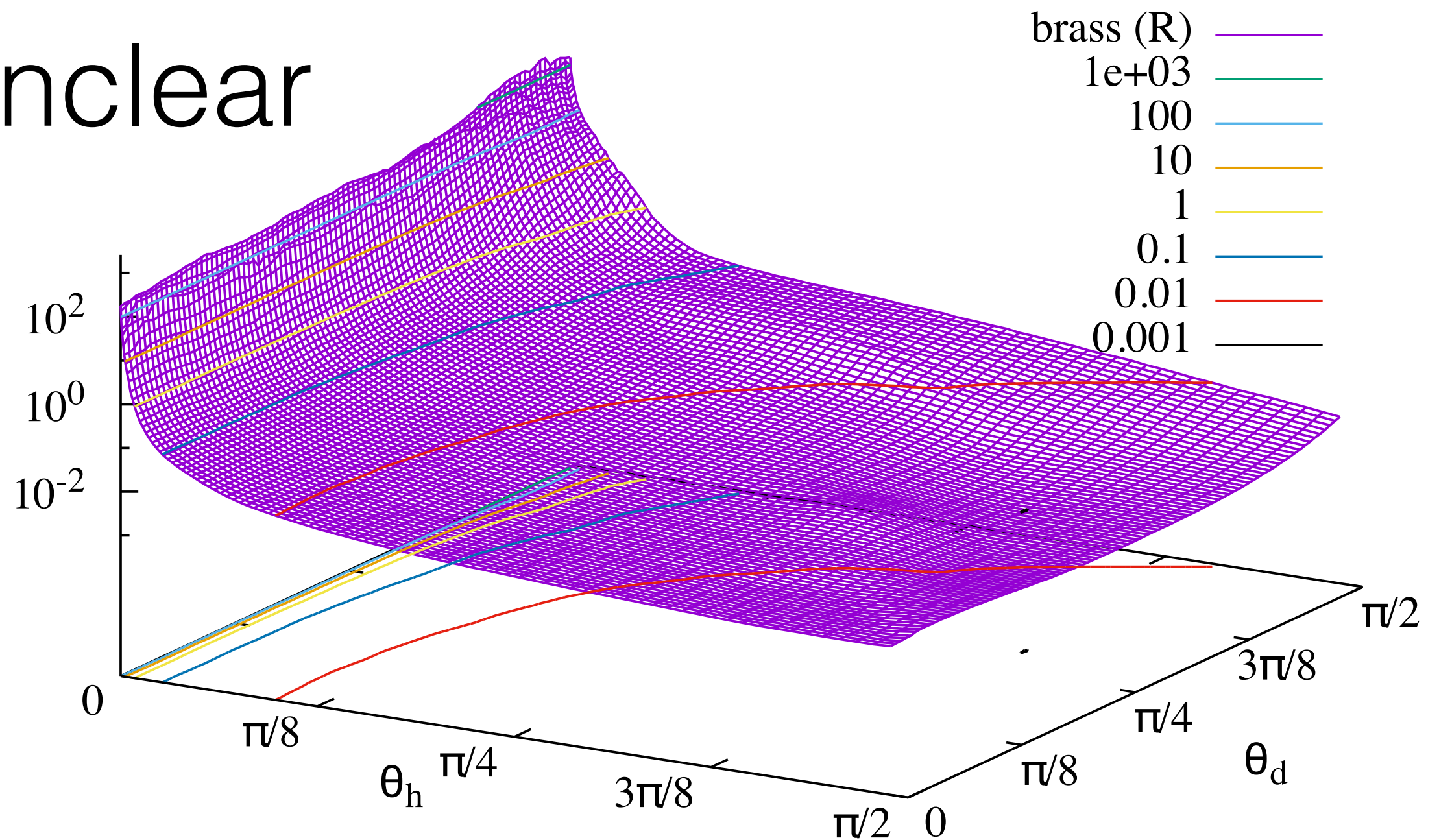
How can we test that hypothesis?

Testing with data over θ_h ?



Testing with data over (θ_h, θ_d) ?

Unclear



Testing with derivatives?

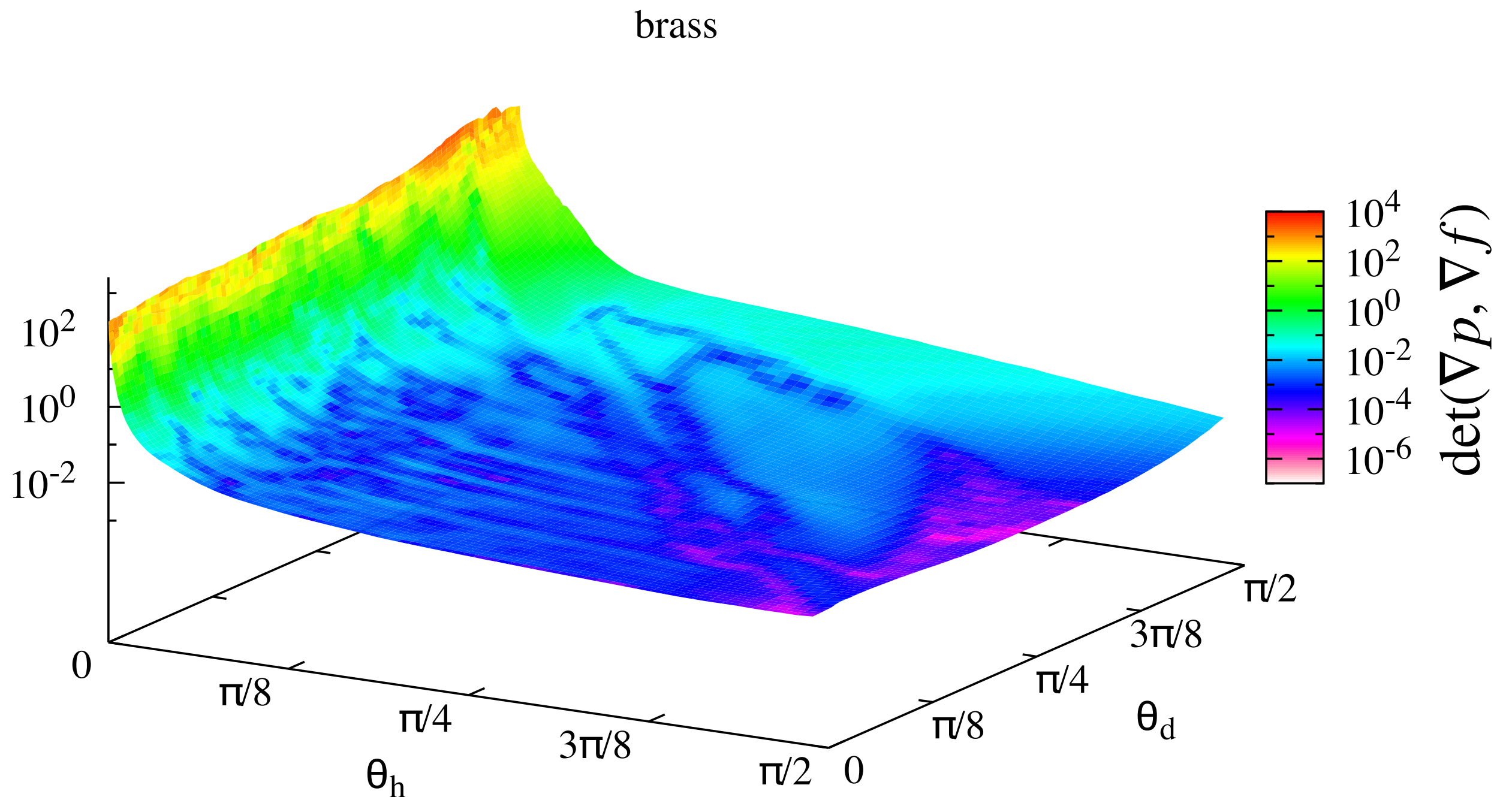
- If diffraction effects are predominant:

$$p(\mathbf{i}, \mathbf{o}) \approx \frac{\rho_d}{\pi} + \frac{\rho_w}{\lambda^4} S_z(f)$$

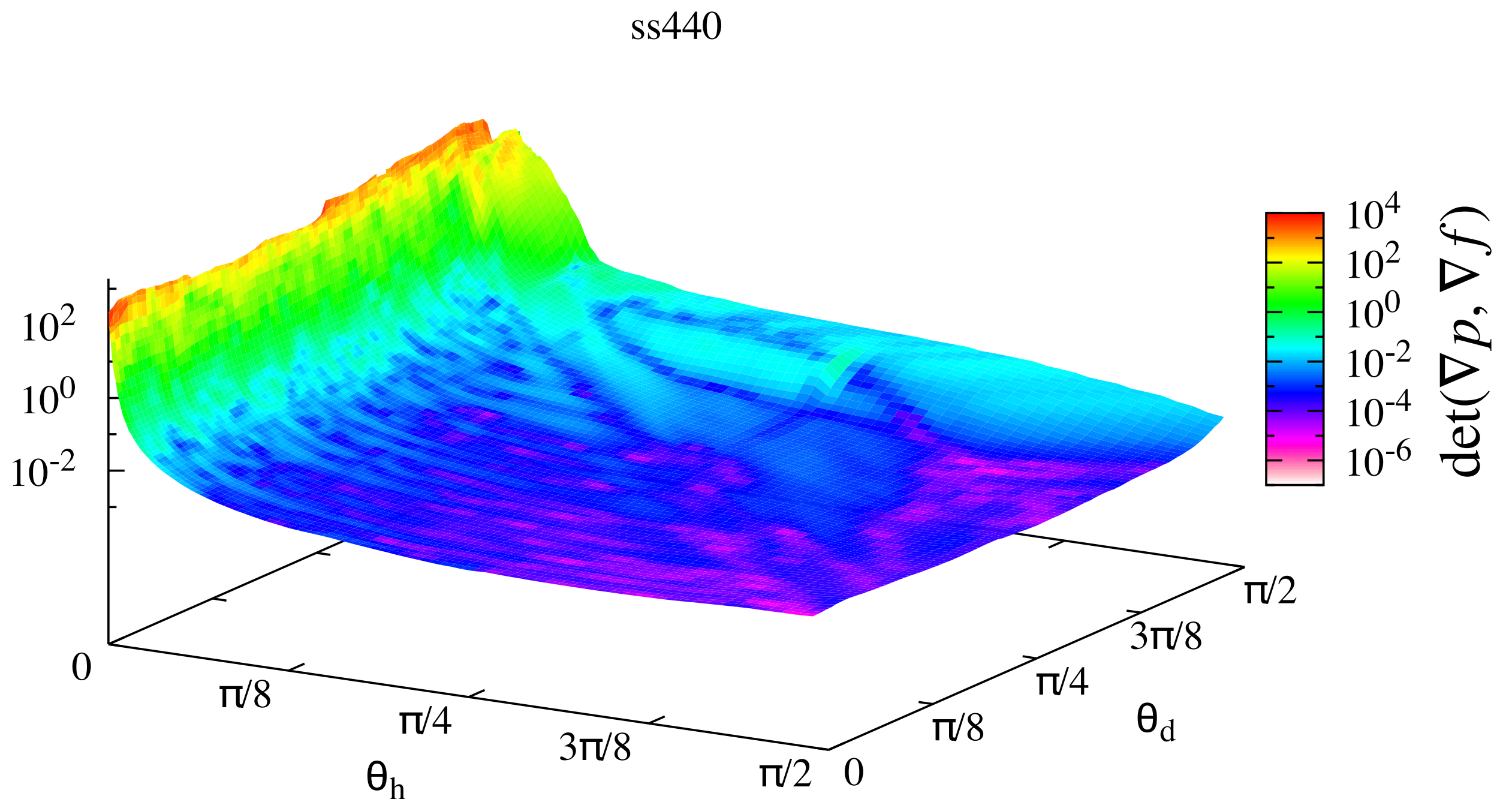
- Looking at derivatives:

$$\nabla p \approx \frac{\rho_w}{\lambda^4} \frac{dS_z}{df} \nabla f$$

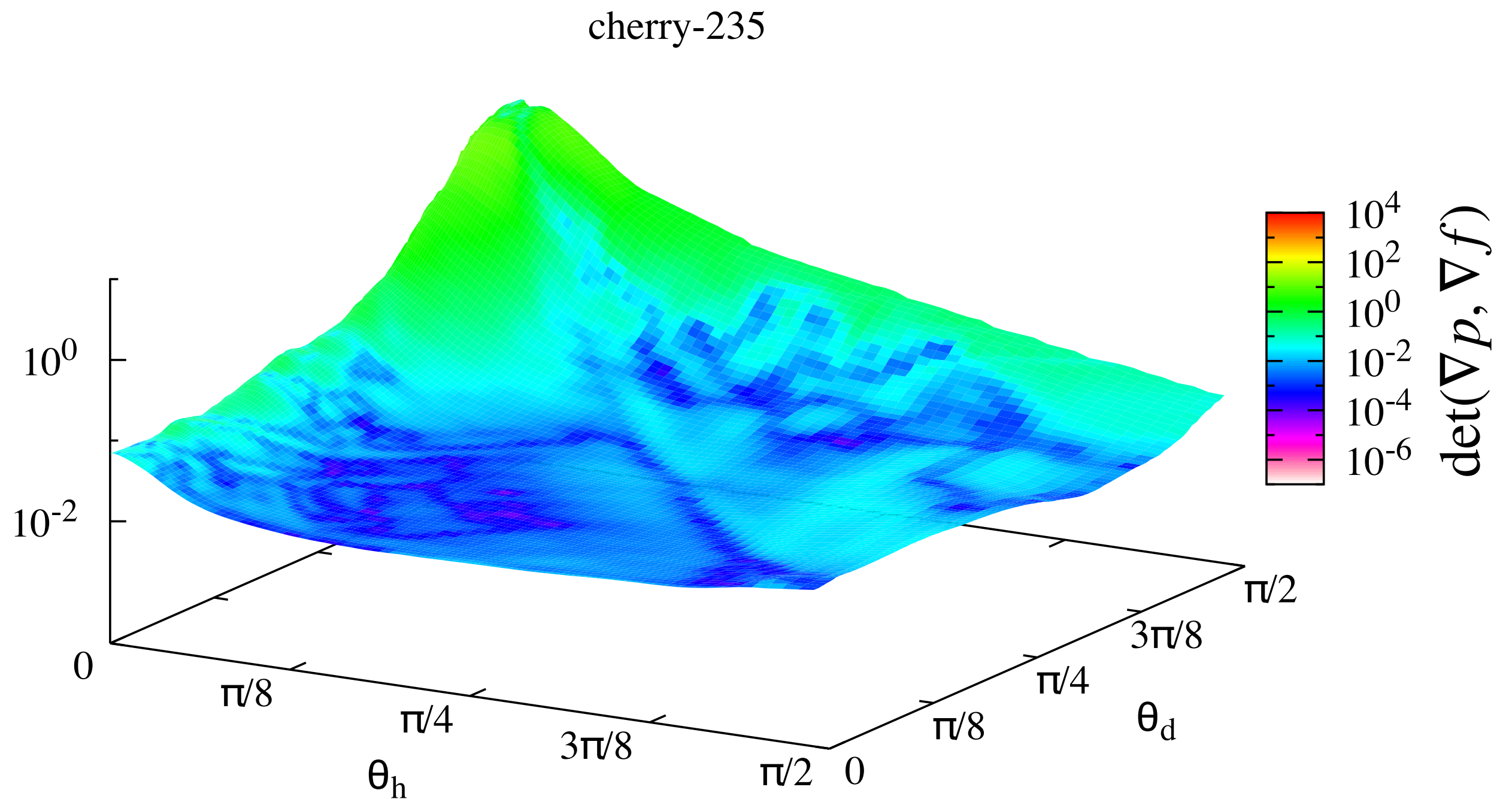
Testing with derivatives



Another metal

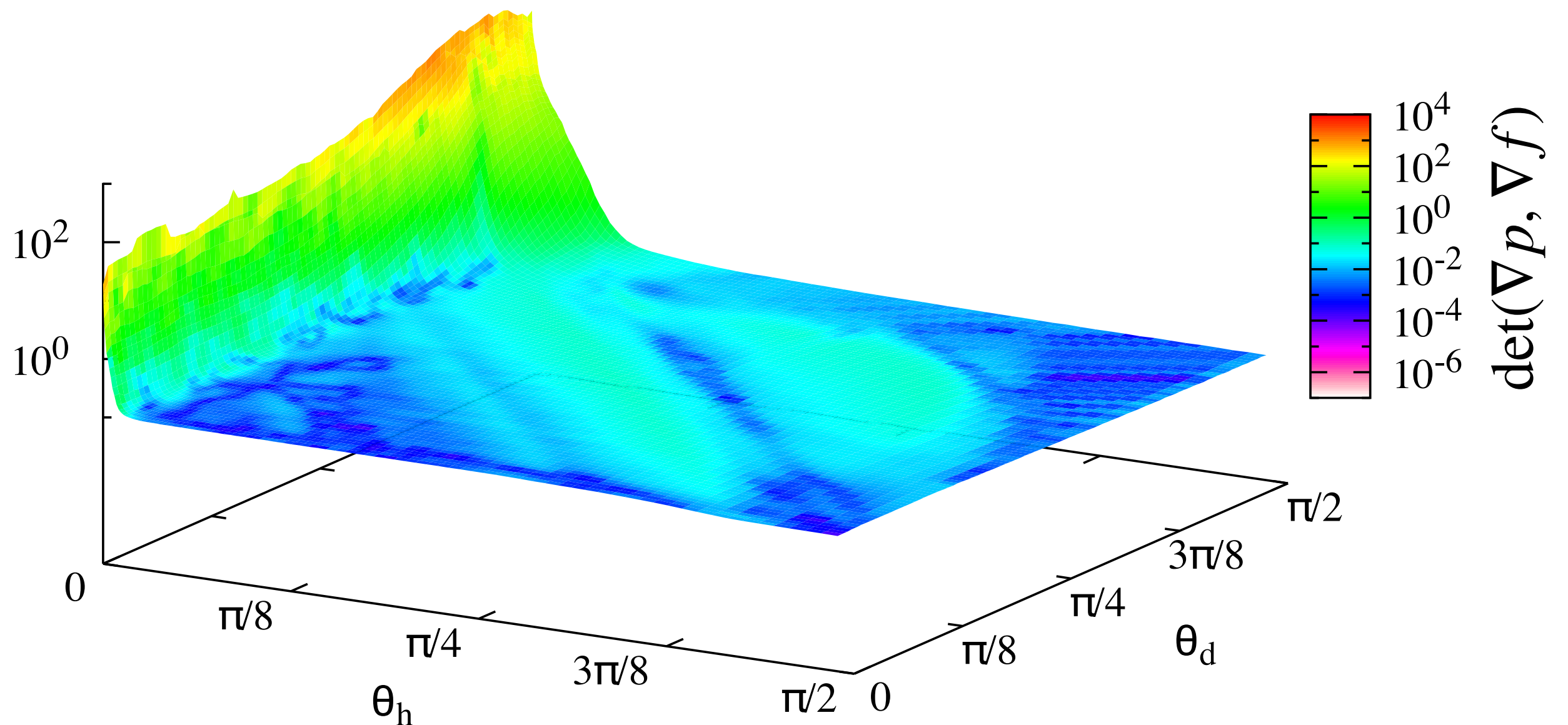


Wood



Smooth plastics

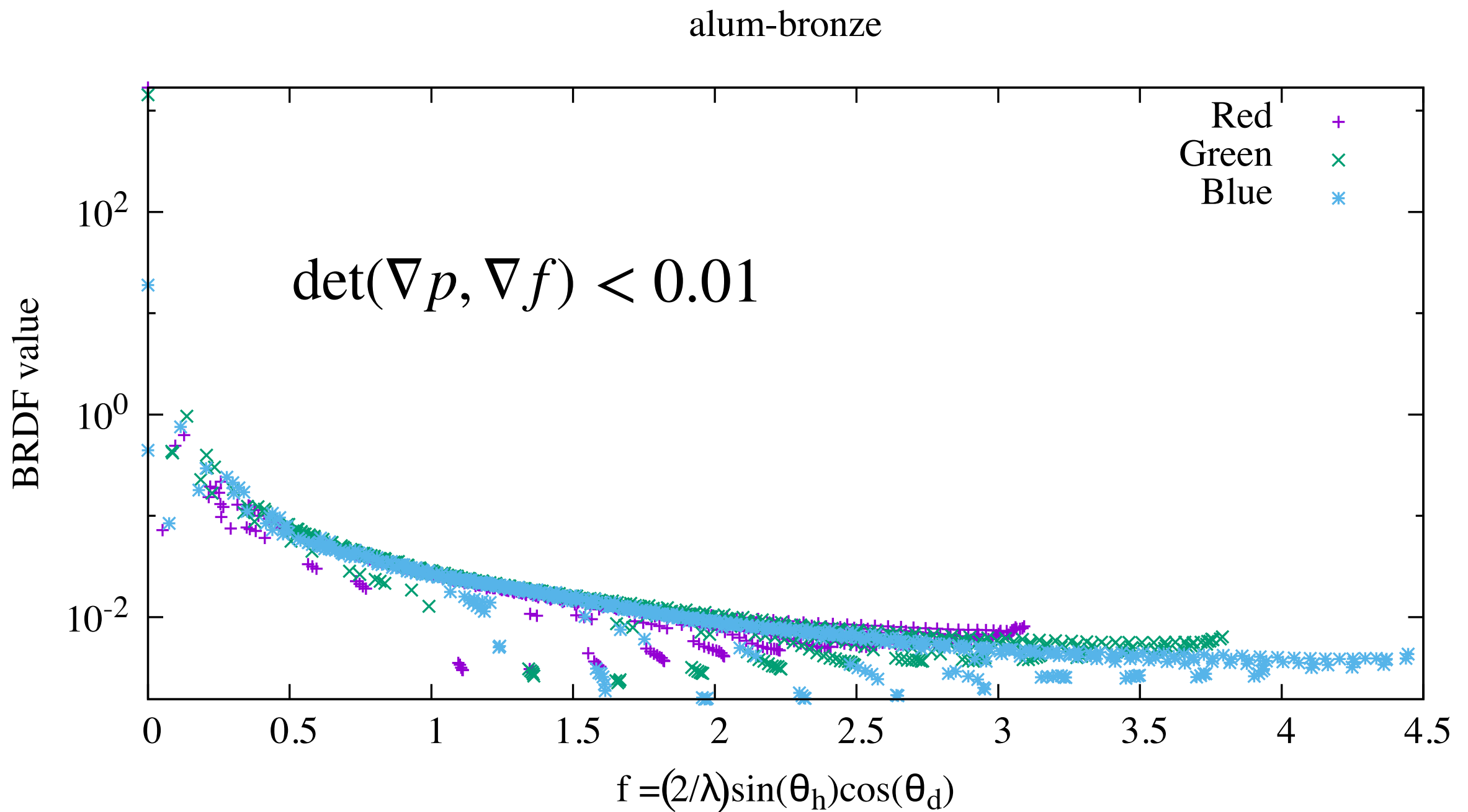
specular-red-phenolic



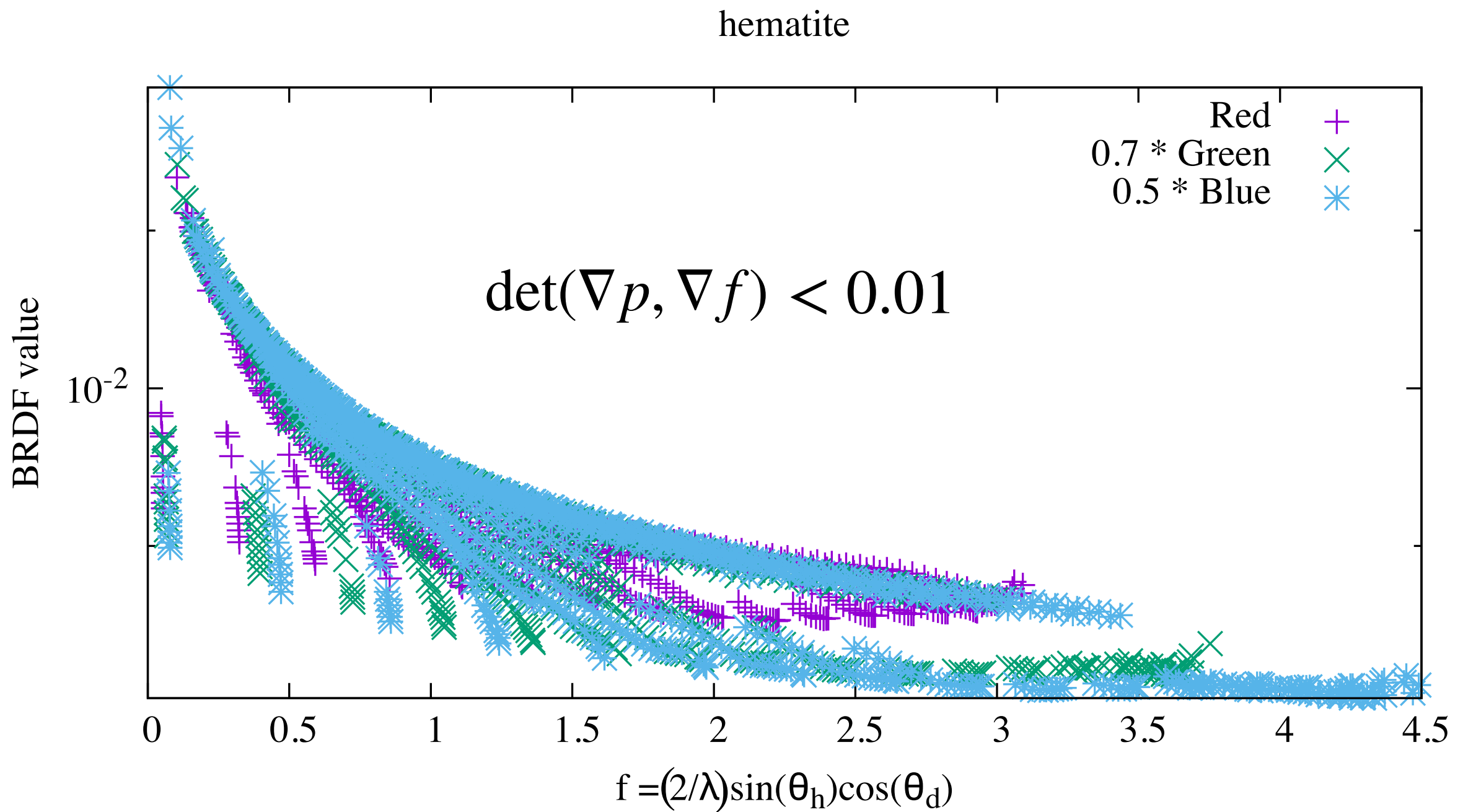
Analysis

- Diffraction dominant for wide-angle scattering
- Not for specular peak
- Separation easier with smooth metals
- Less so for woods, fabrics
- Smooth plastics: (almost) no diffraction

Is that condition sufficient?



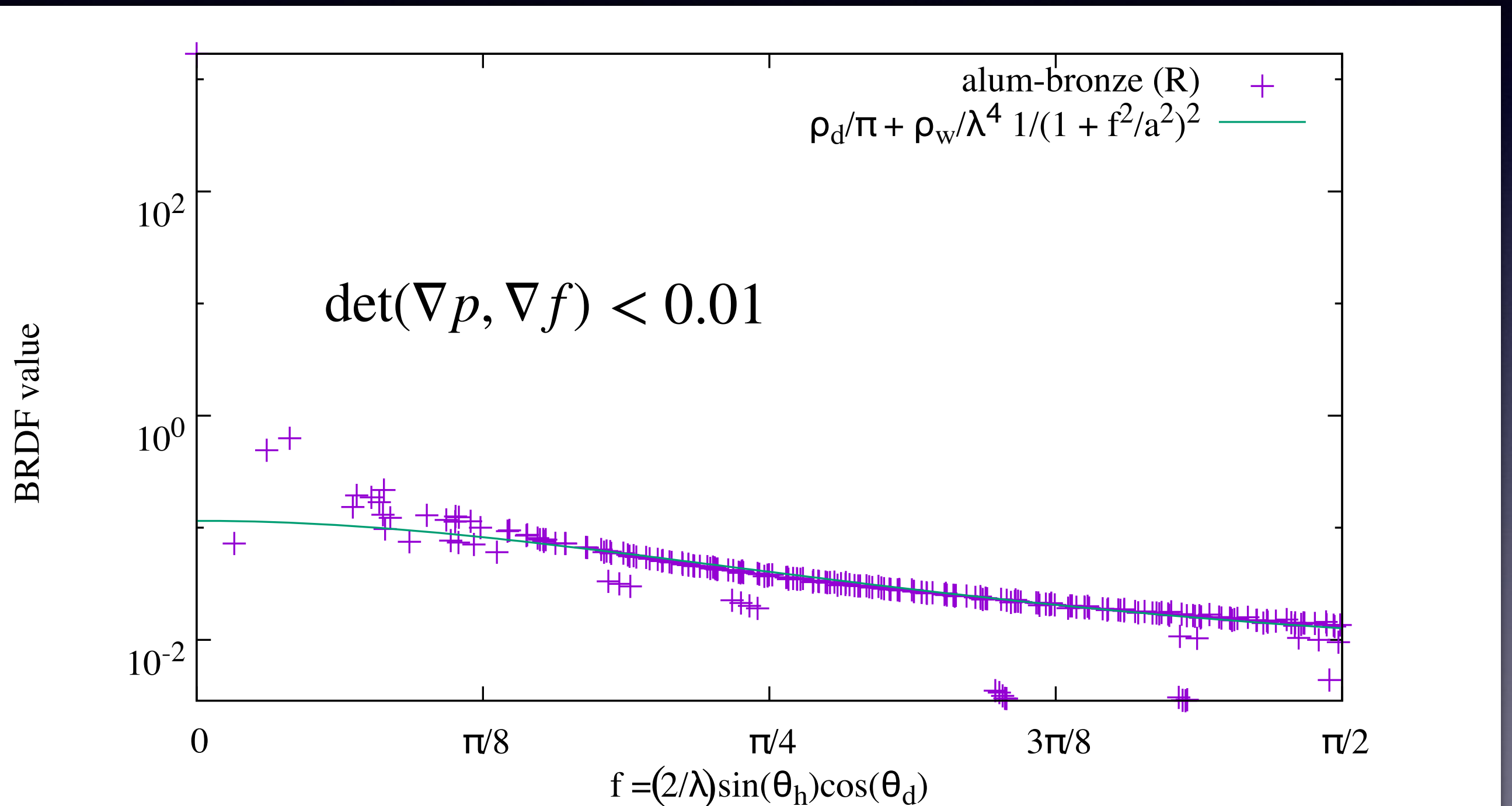
Is that condition enough?



Looking forward

- Diffraction model for wide angle scattering
- Cook-Torrance for specular peak
- Simple basis function for each

Basis function for diffraction

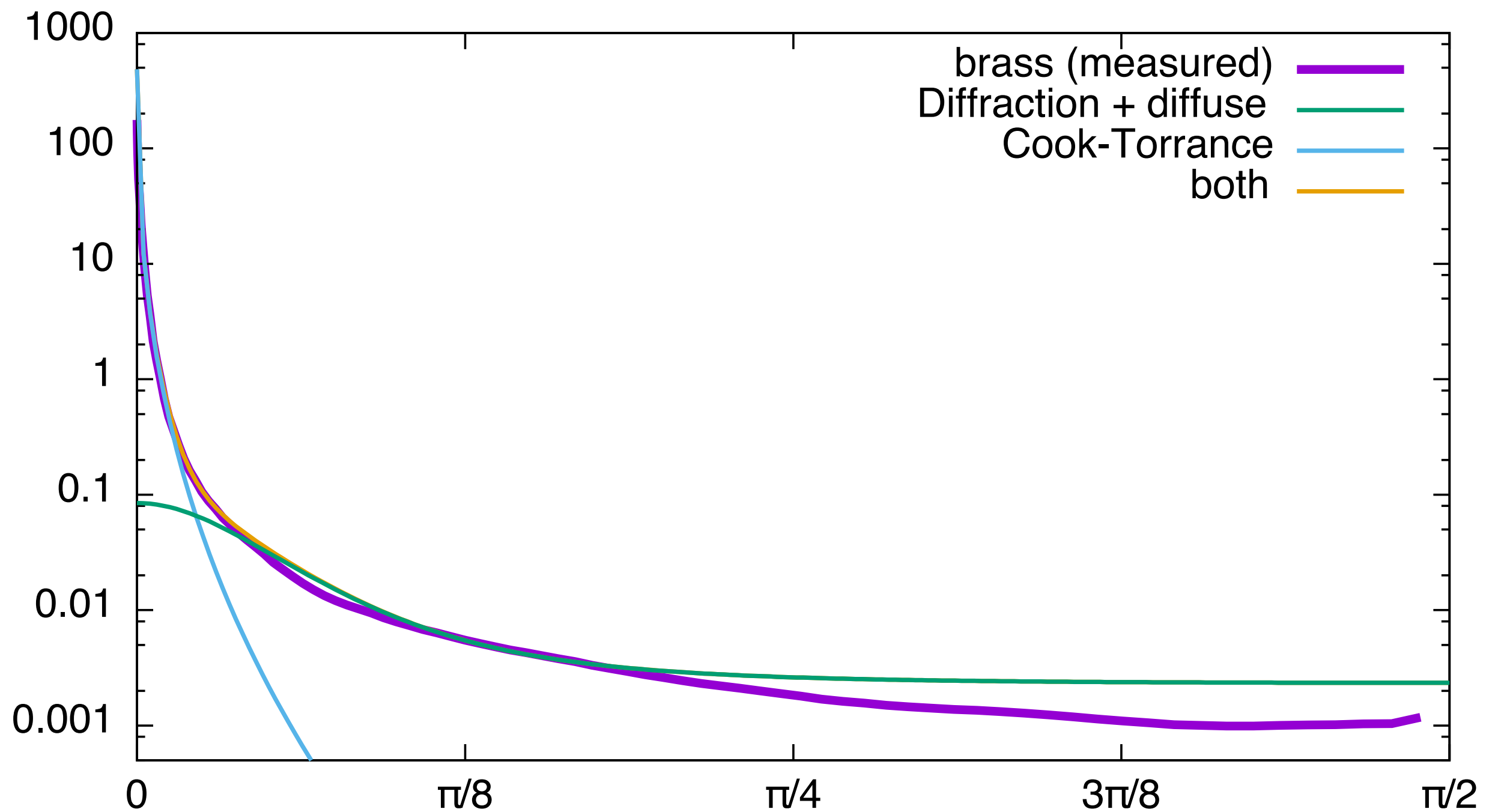


New term for diffraction

$$S_z(f) = \frac{1}{\left(1 + \frac{f^2}{a^2}\right)^2}$$

- Appears to be enough for all materials
- Fourier spectrum = square root of PSD
- Fourier spectrum of surface height $\approx 1/(1+\omega^2)$
- Consistent with continuous (C^0) surface, not C^1

Separate phenomena

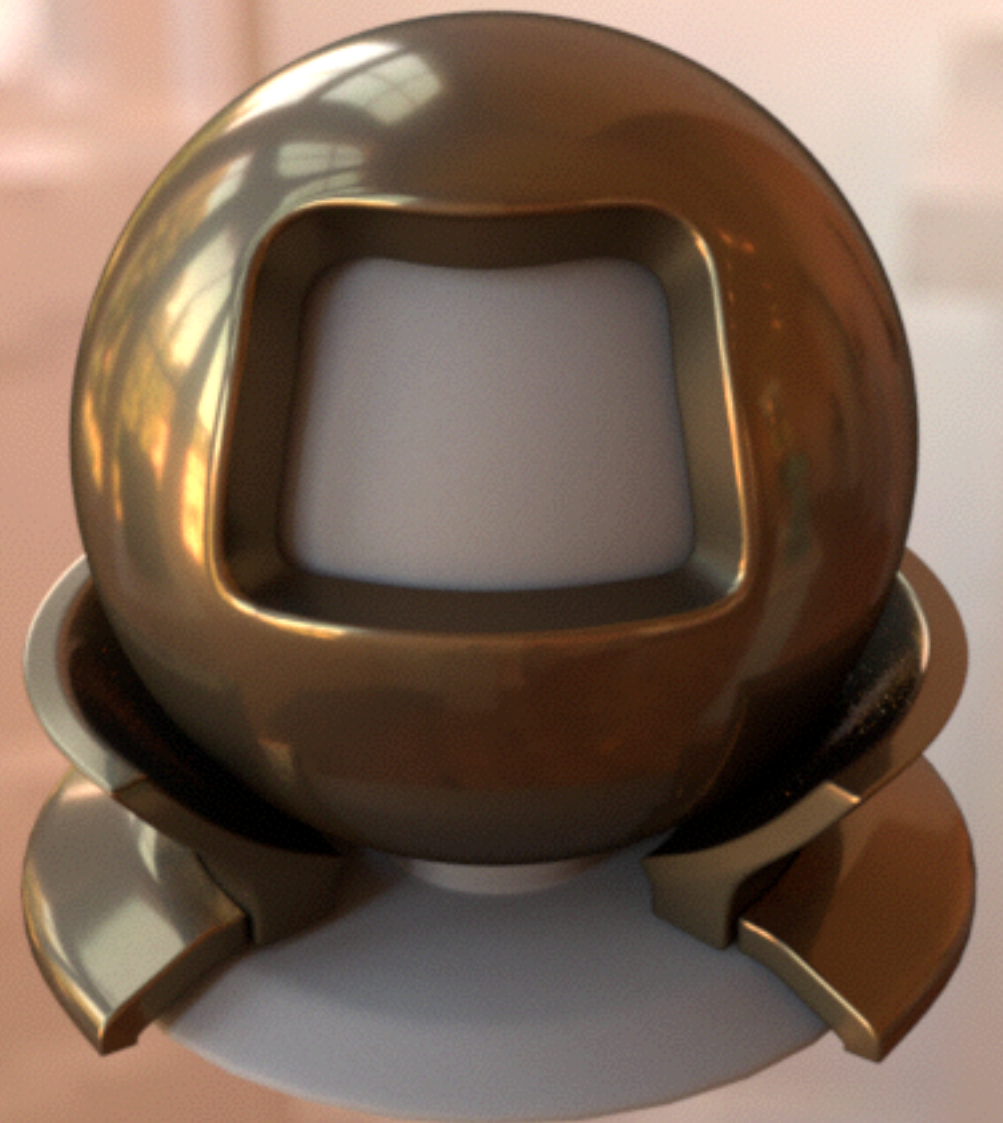


Conclusion

- Diffraction effects seem to be present in measured materials
 - More important in metals, smooth materials
 - Not responsible for specular lobe
- We can use this knowledge to fit a model to BRDFs
- 3 different lobes: diffuse, diffraction, Cook-Torrance
- Simple basis functions for each lobe

Looking even further

brass



Diffraction + Cook-Torrance

Measured

Separate components



+



=



Diffuse+
Diffraction

Cook-Torrance
brass

Full model

Future work

- Connection with surface micro-geometry
- Classify metals (diffraction) vs. plastics (none)
- Relations between diffuse, diffraction, CT colours

Extra slides



**IT'S NEVER A
GAUSSIAN**

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