Computing the Bidirectional Scattering of a Microstructure Using Scalar Diffraction Theory and Path Tracing

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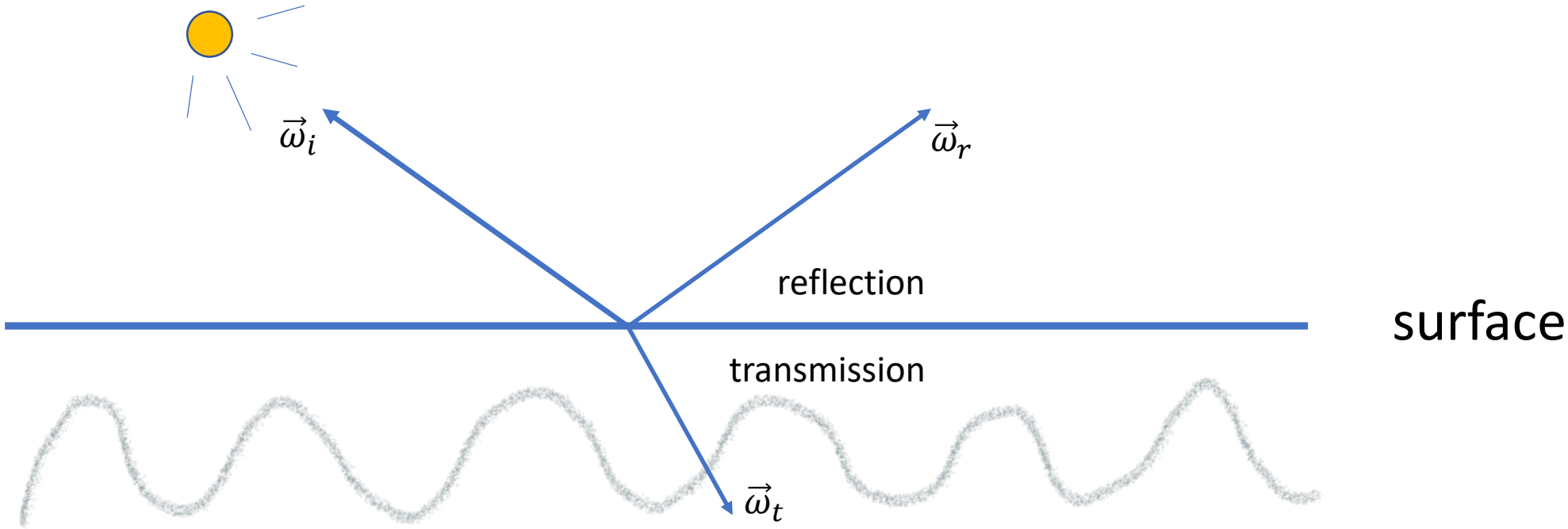
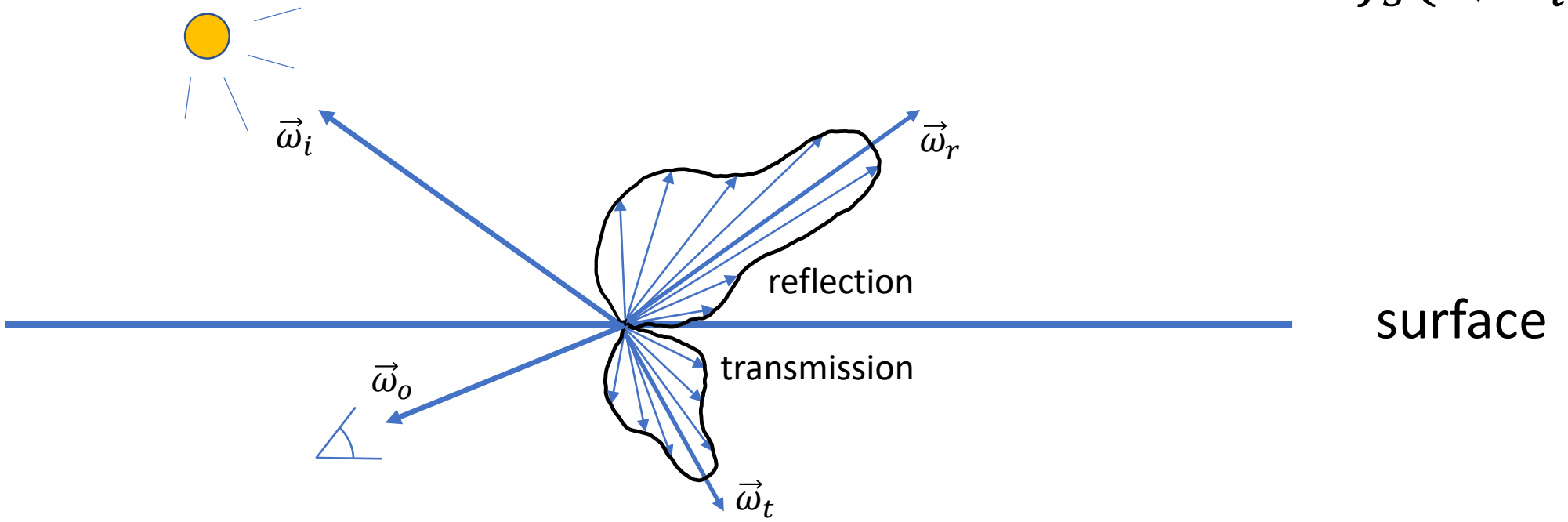
Bidirectional Insurface Scattering Function



medium (index of refraction: $n = n' + i\,n''$)

Bidirectional Insurface Scattering Function

BSDF: $f_s(\boldsymbol{x}, \vec{\omega}_i, \vec{\omega}_o)$



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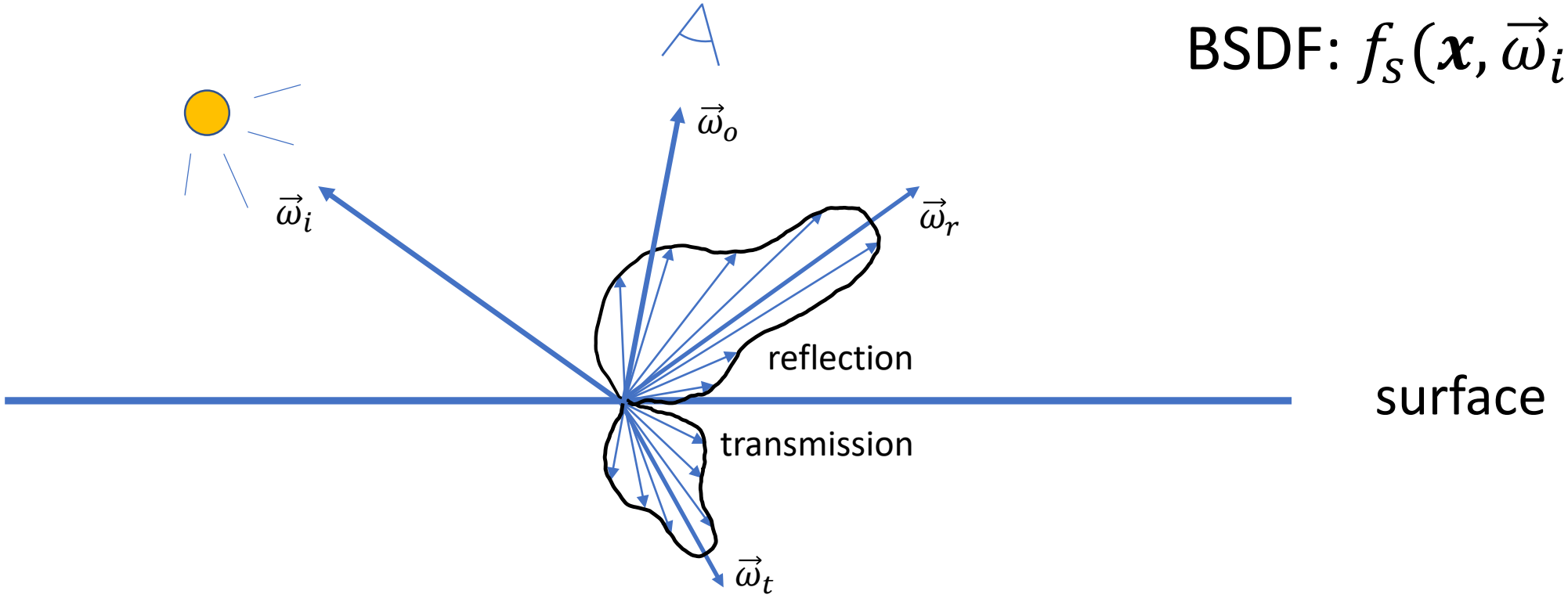

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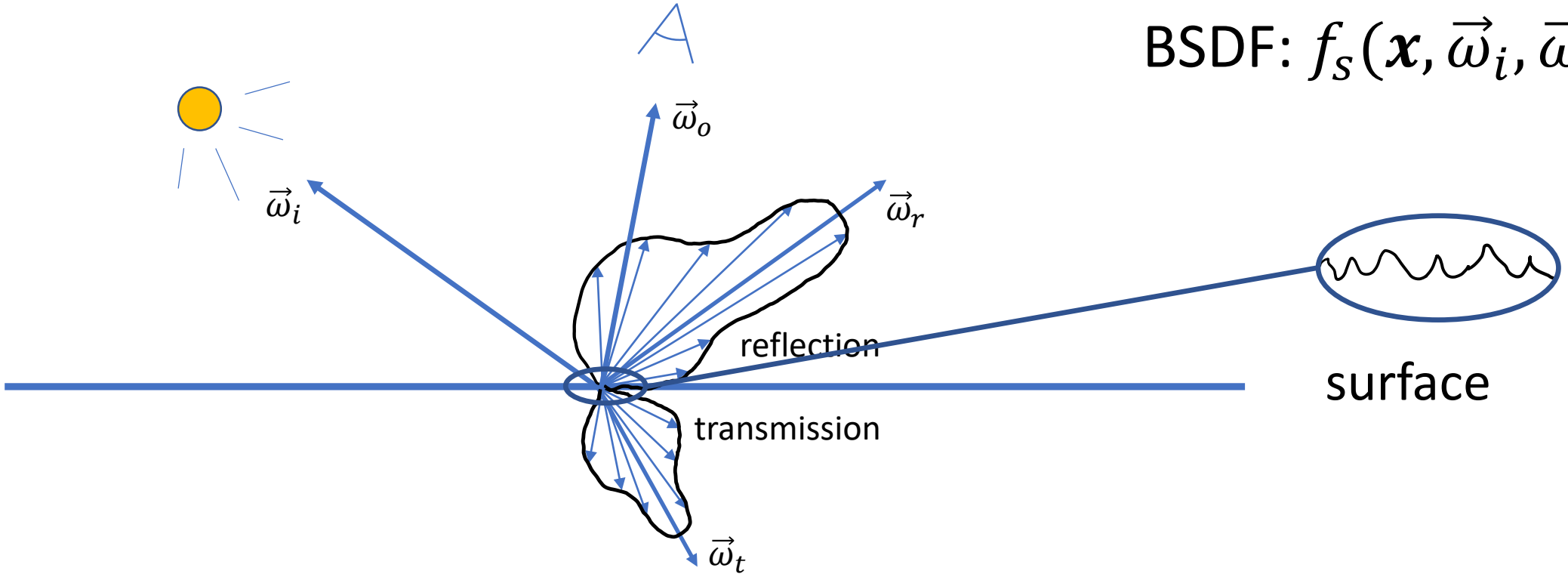
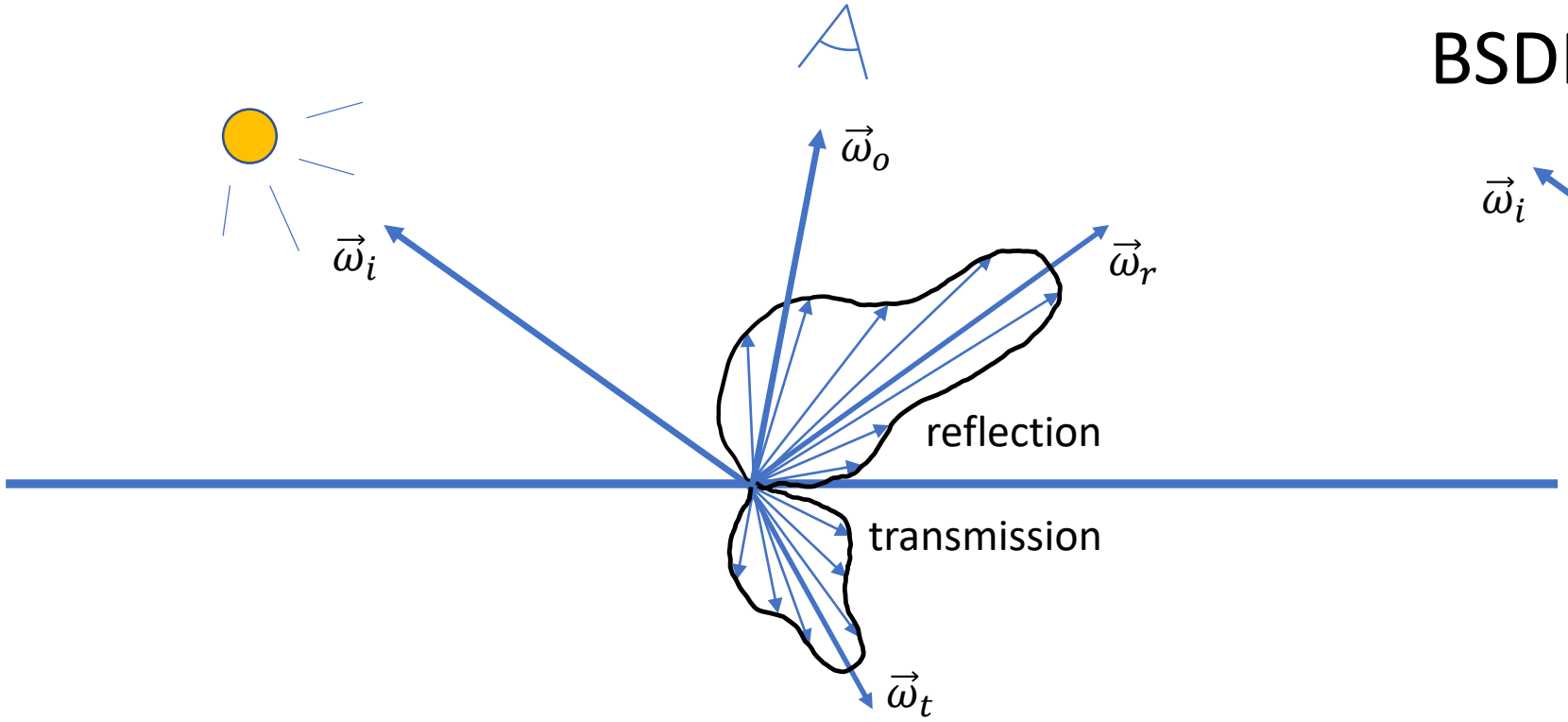
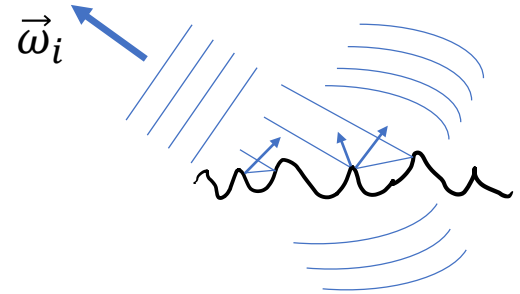


Bidirectional Insurface Scattering Function



BSDF: $f_s(\boldsymbol{x}, \vec{\omega}_i, \vec{\omega}_o)$



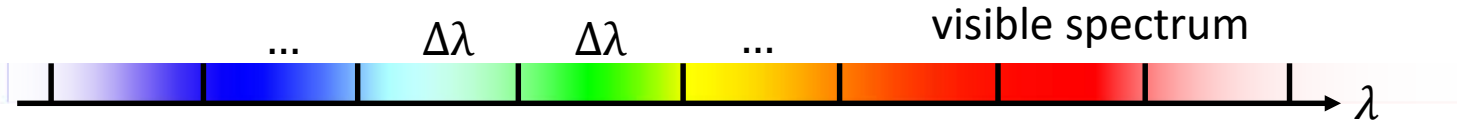
surface

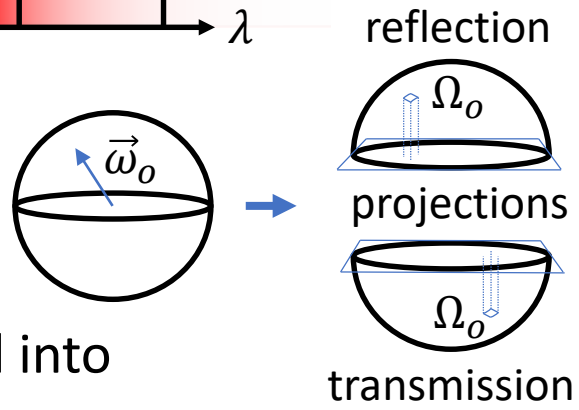
wave effects

multiple scattering

Simulation based on microgeometry to compute the bidirectional scattering distribution function (BSDF) of a surface.

Method

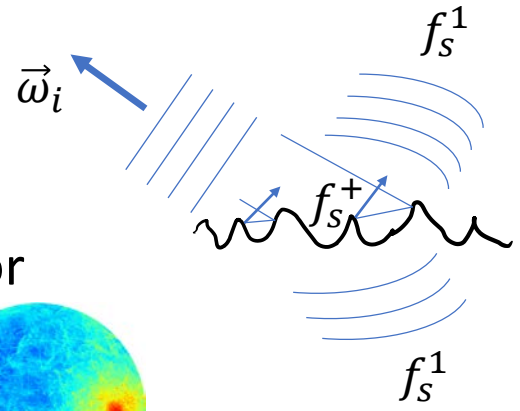


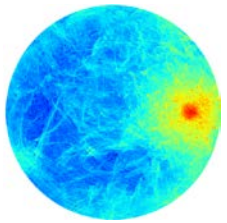


- Discretization of visible spectrum into wavelength intervals: $\Delta\lambda$.
- Discretization of direction hemispheres into solid angle bins: Ω_i, Ω_o.
- Measurement equation for the BSDF value of a given set of bins divided into single and multiple scattering terms:

$$f_s(\boldsymbol{x}, \Omega_i, \Omega_o) \approx f_s^1(A, \Omega_i, \Omega_o) + f_s^+(A, \Omega_i, \Omega_o).$$

- A is the microscopic patch of surface area representing the macroscopic surface location $\boldsymbol{x}$.
- f_s^1 is evaluated by Monte Carlo integration of the Kirchhoff integral augmented by shadowing and masking based on ray tracing.
- f_s^+ is evaluate by path tracing but excluding single scattering.
- We visualize our results using orthogonally projected slices of the BSDF for a given direction of incidence $\vec{\omega}_i$ and integrated across the spectrum.

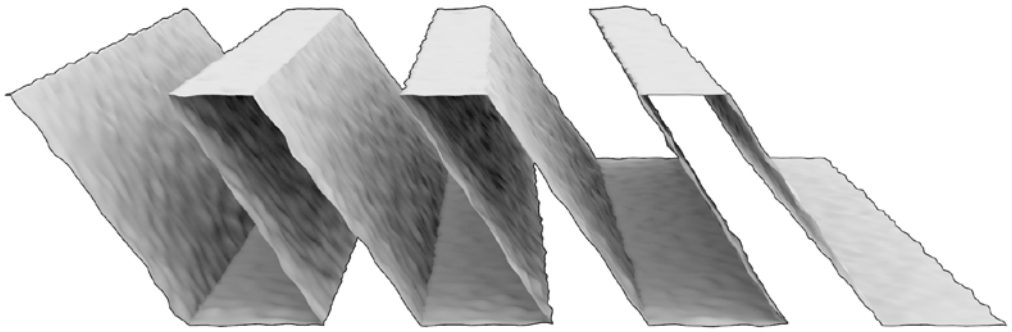




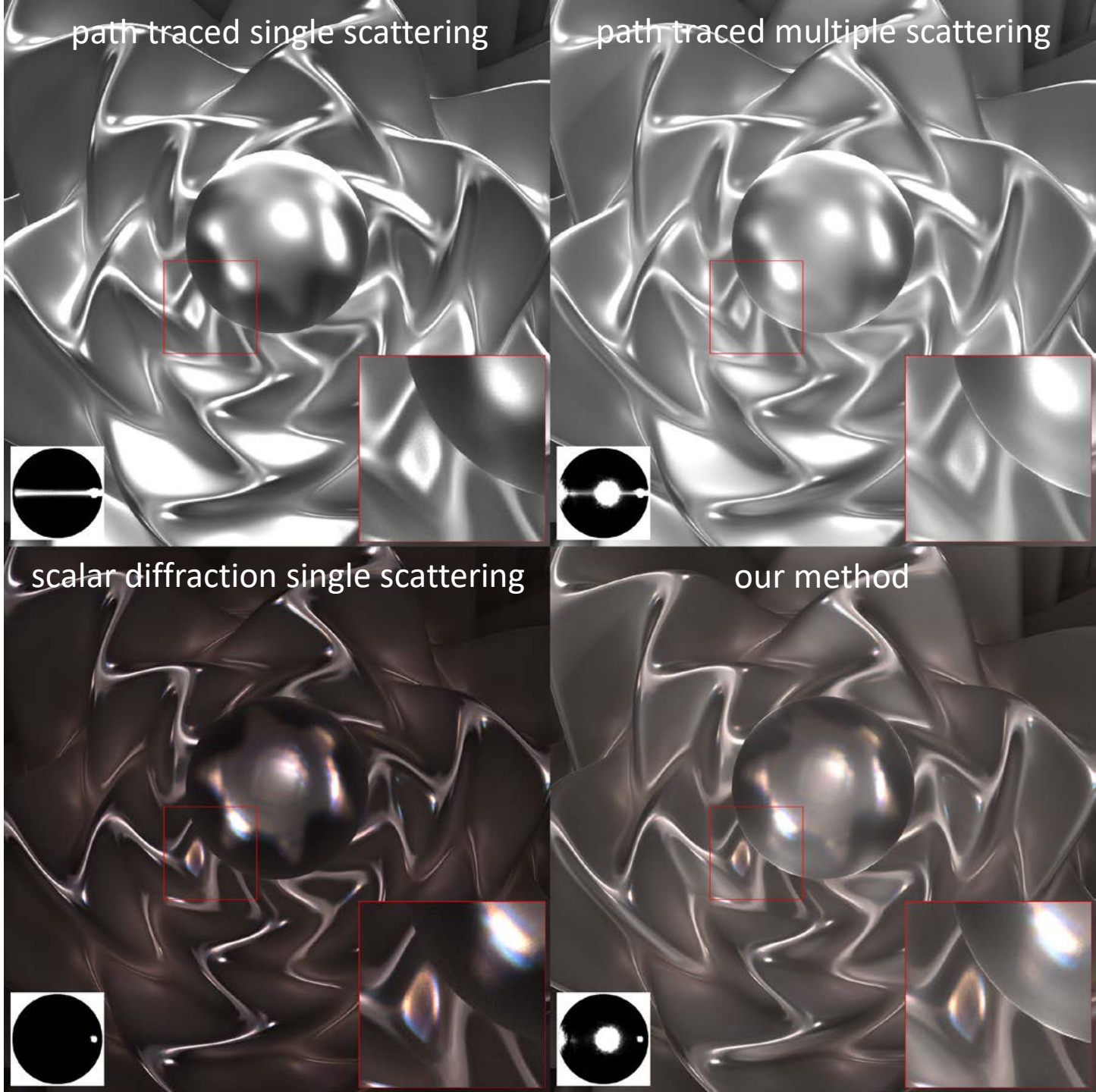
BSDF slice

Results

- Surface by Havran et al. [HTM16] for perceptual comparison of BRDFs.
- Mirror material.
- BRDF is normalized.
- Insets are BRDF slices in RGB and close-ups.
- Microgeometry (A):

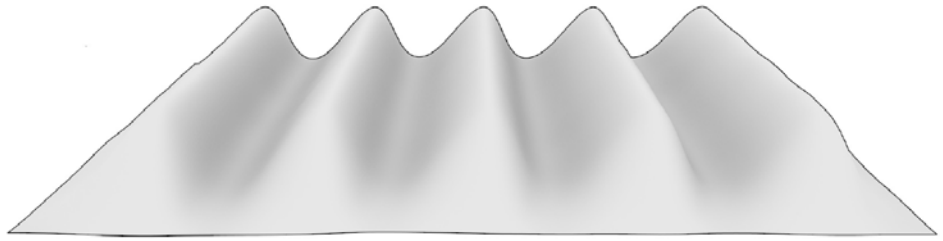


overhangs

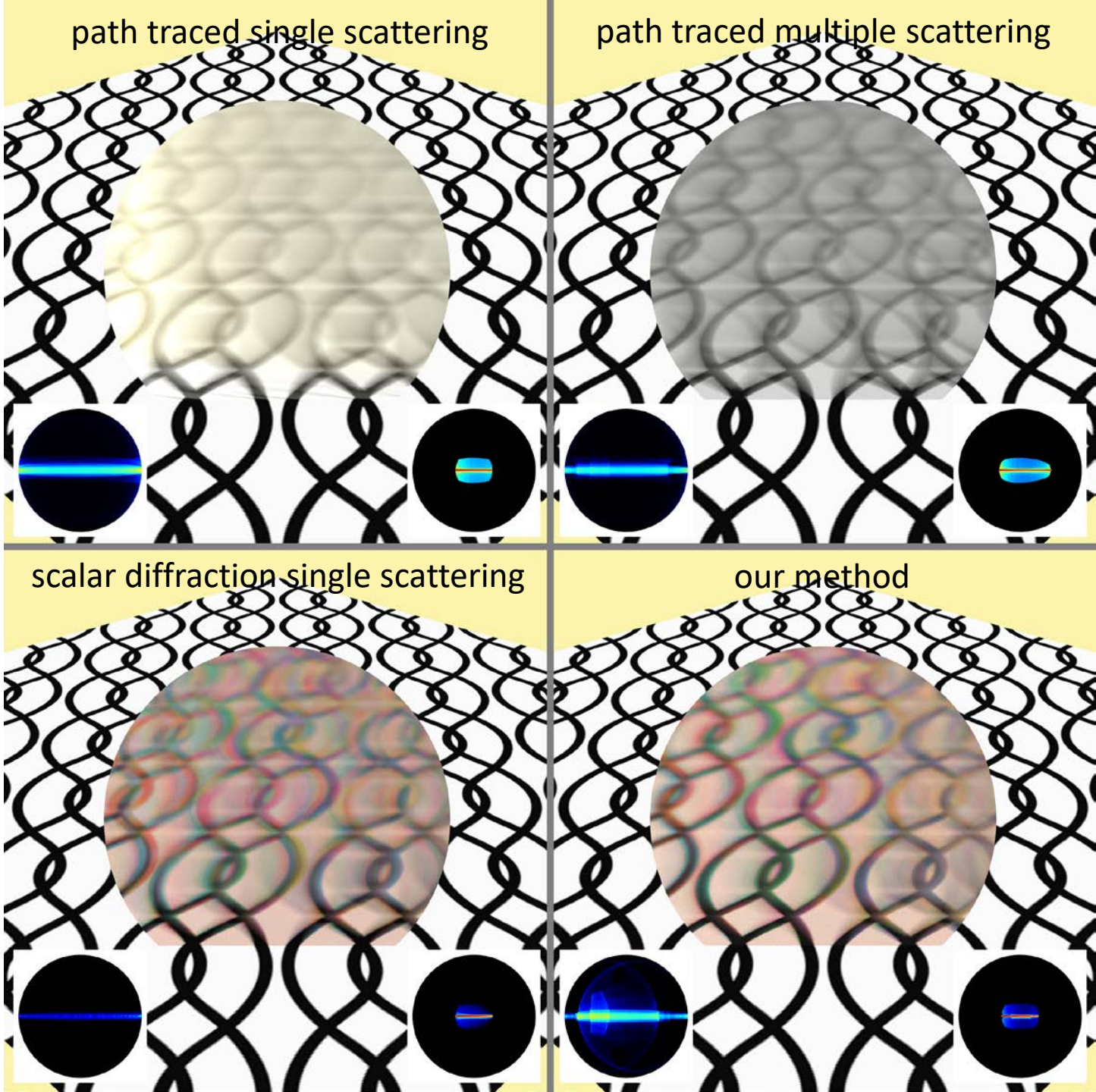


Results

- Disk standing on textured background for perceptual comparison of BSDF.
- Glass material.
- BSDF is normalized.
- Insets are BRDF and BTDF slices in false colors.
- Microgeometry (A):

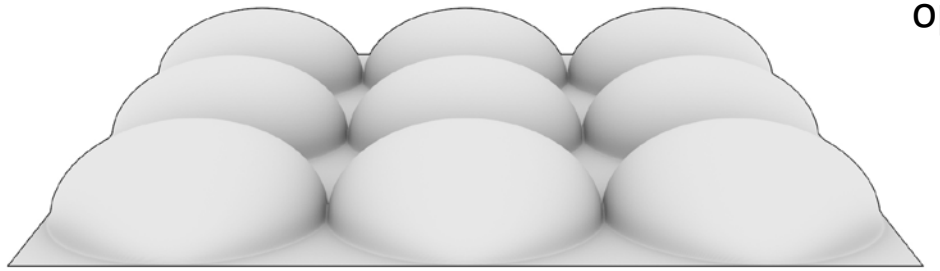


ridges

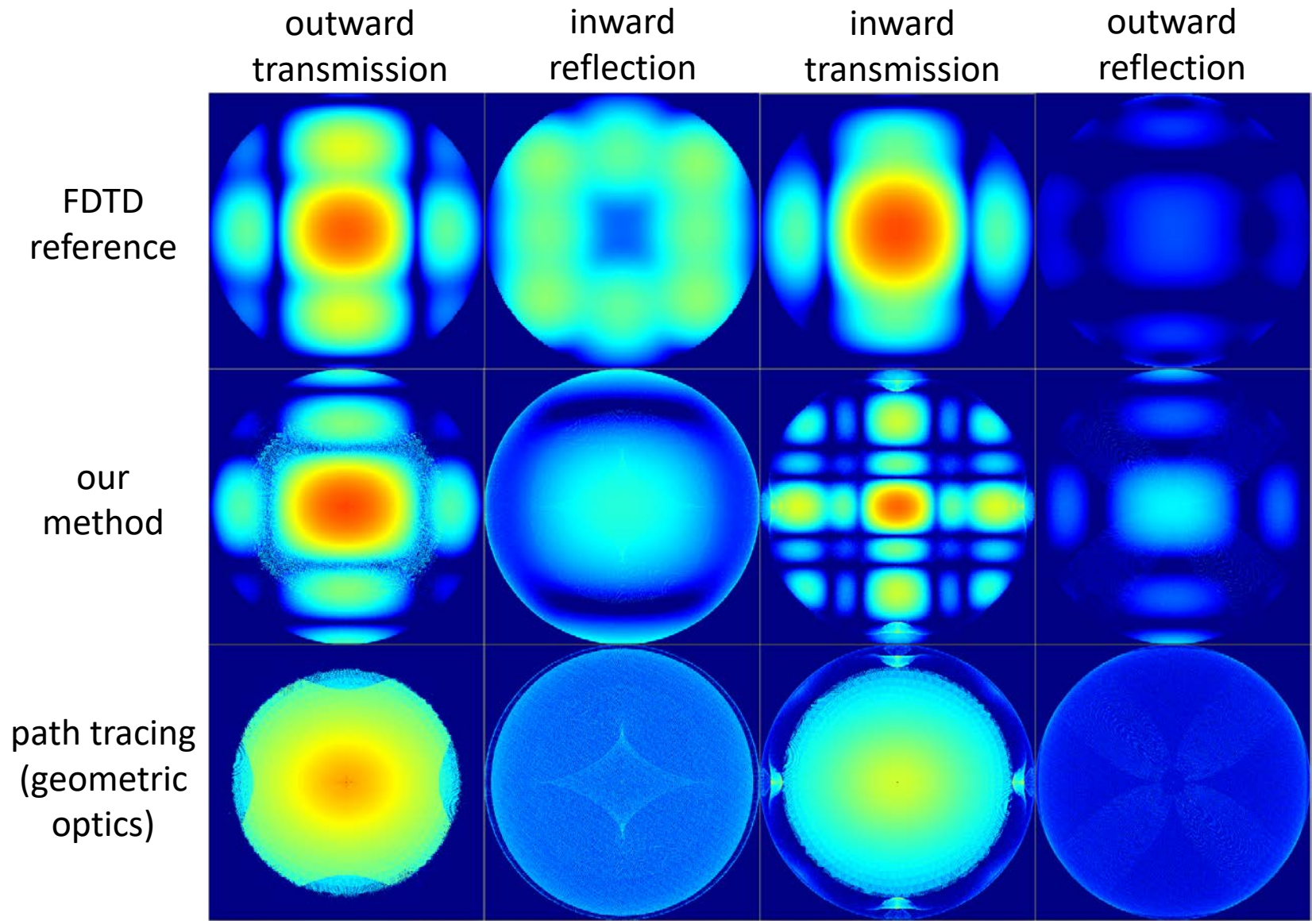


Results

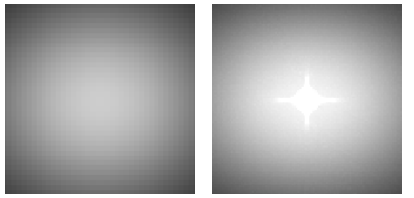
- BSDF slices in false colors for validation.
- Index of refraction: $n = 2$.
- BSDF is normalized.
- Linearly polarized incident light with $\lambda = 850\ \mathrm{nm}$.
- Microgeometry (A):



axicons



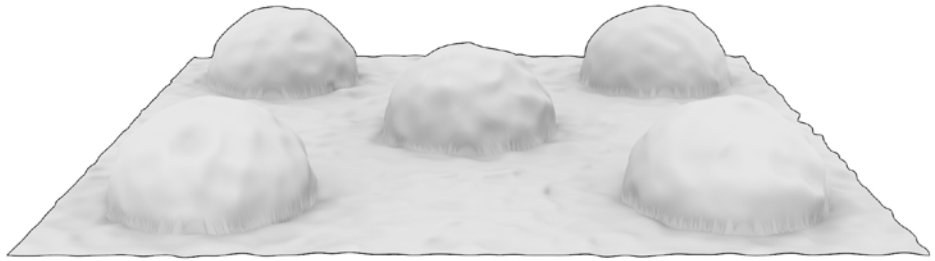
Our inclusion of multiple scattering captures the characteristic beam shape transmitted by elliptic axicons. This is hard to obtain with FDTD due to lower resolution.



Close-ups: FDTD ours

Scalar diffraction (single scattering)

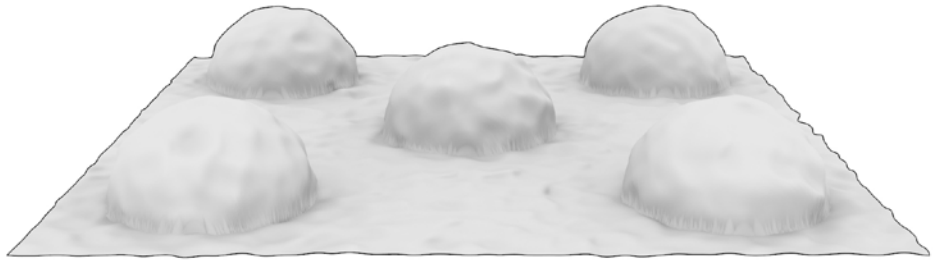
- Microgeometry (A):



noisy hemispheres

Our method (scalar diffraction + multiple scattering)

- Microgeometry (A):



noisy hemispheres

Thanks for watching

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