



Interactive Exploration of Iridescence Using Rough Bragg Mirrors

Gary Fourneau, Pascal Barla, Romain Pacanowski

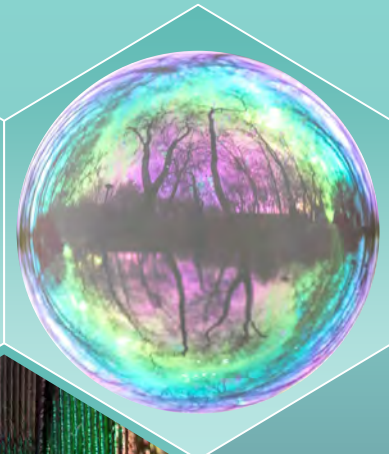
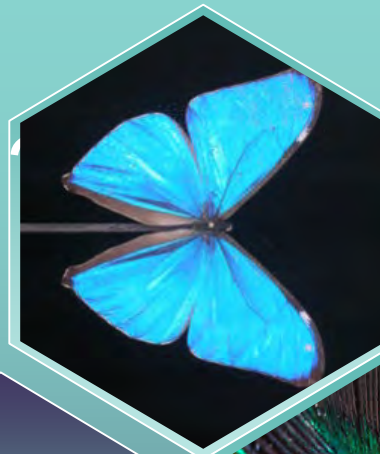
GDR
CIR 2044

APPAMAT

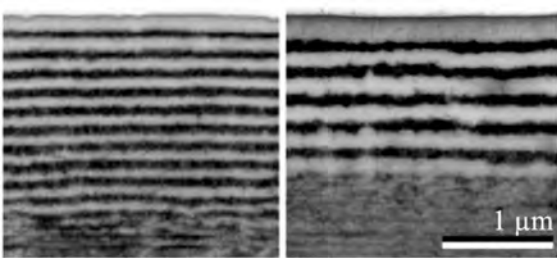
Inria
1
inventeurs du monde numérique

What is iridescence

goniochromism \Rightarrow color changes with viewing angle



nanoscale structures

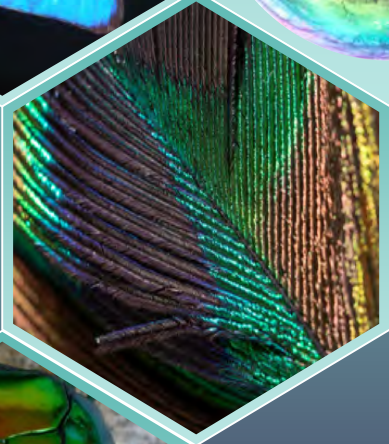


create angle dependant spectra

1 μm

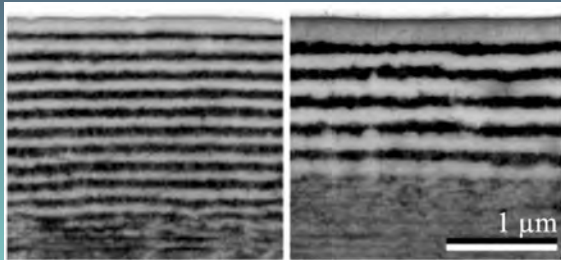
This block contains a microscopic image showing horizontal, layered nanoscale structures. A scale bar in the bottom right corner indicates 1 μm . The text 'nanoscale structures' is positioned above the image, and 'create angle dependant spectra' is positioned below it.

Structural Colors

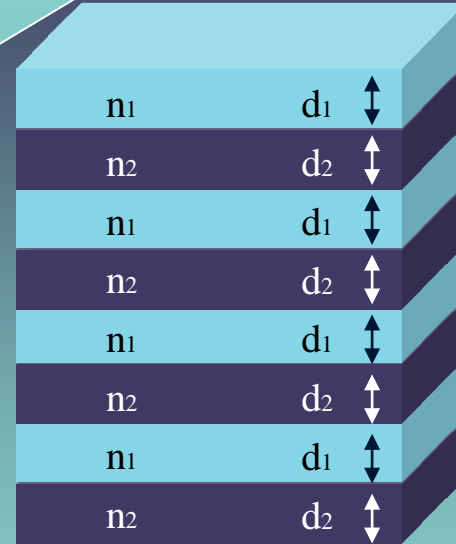


Bragg mirrors

nanoscale structures



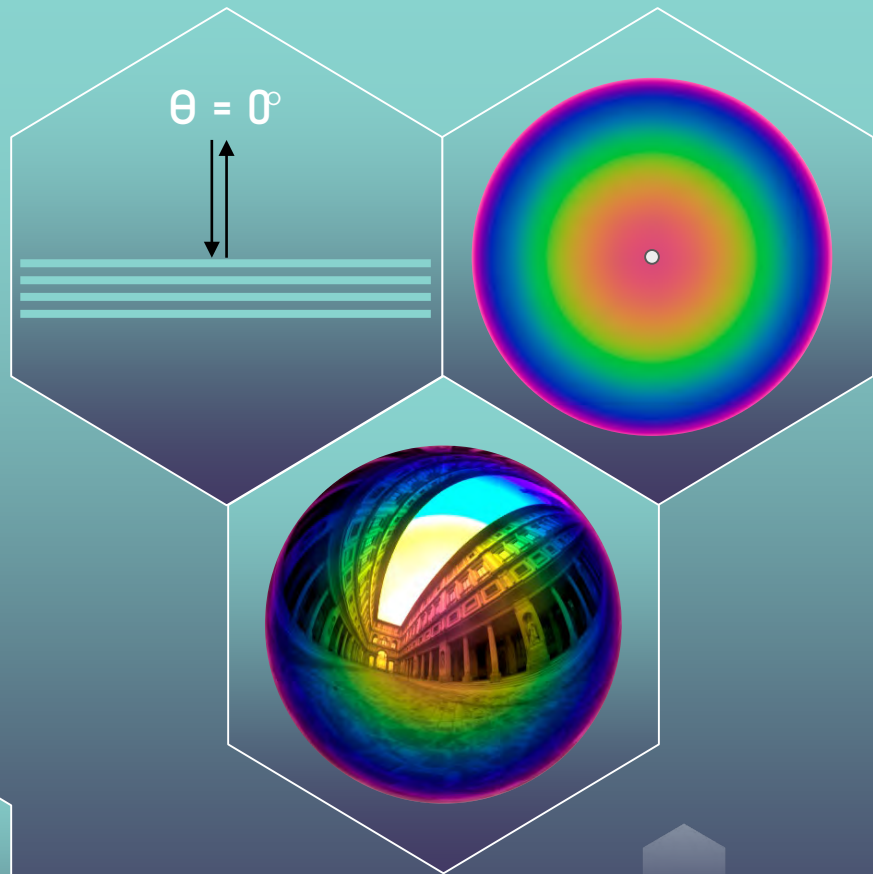
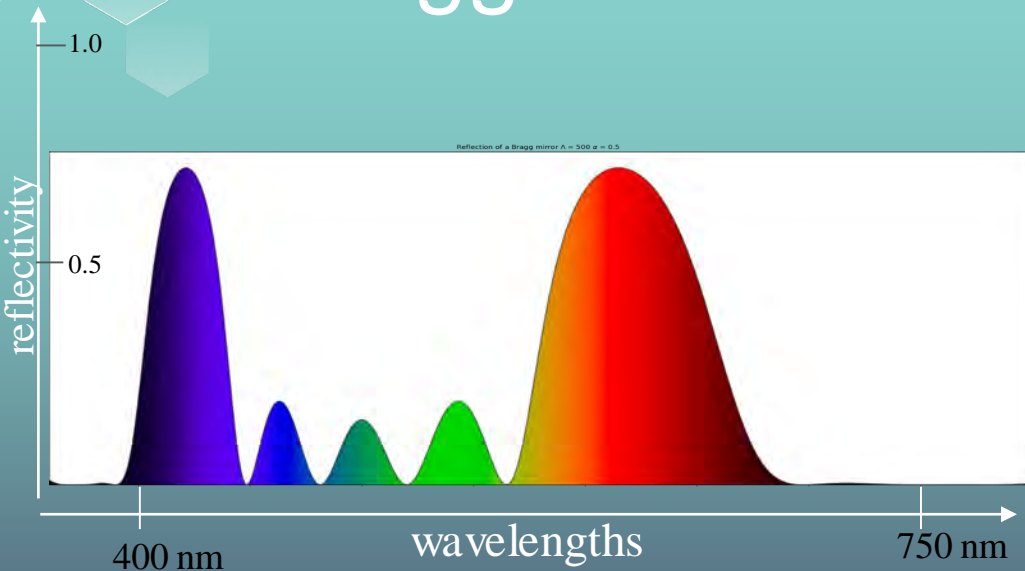
create angle-dependant spectra



1D photonic crystal

periodic arrangement of thin layers with distinct optical indices and widths

Bragg mirrors



$$d1 = 250$$

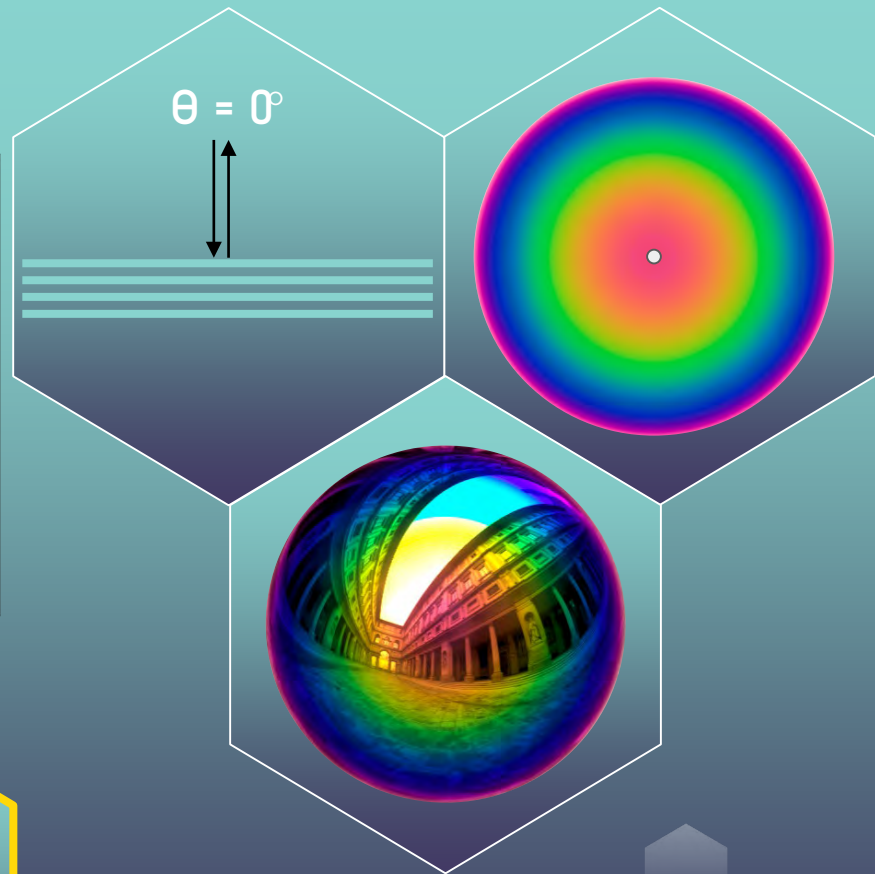
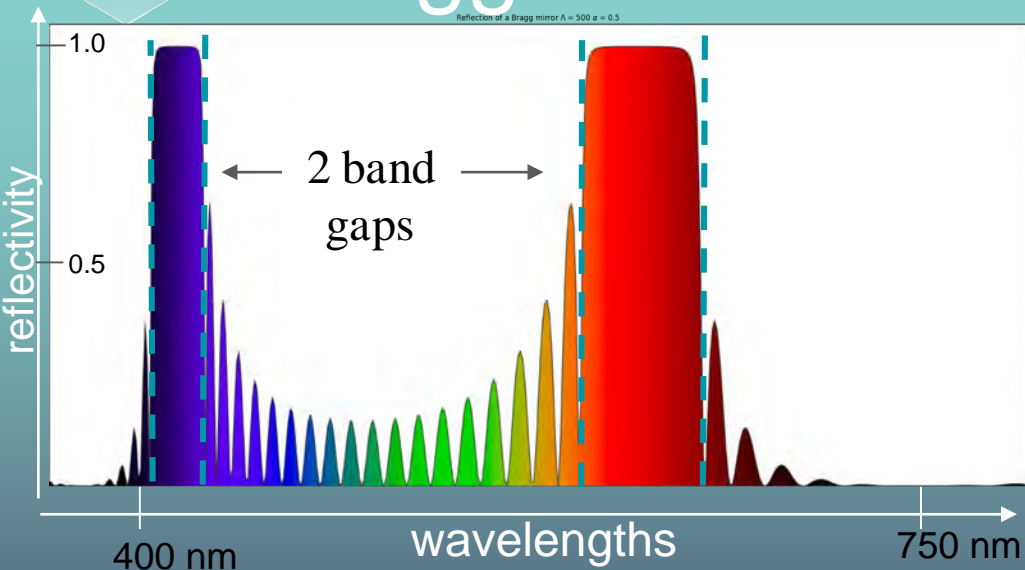
$$d2 = 250$$

$$n1 = 1.0$$

$$n2 = 1.5$$

5 repetitions

Bragg mirrors



$$d1 = 250$$

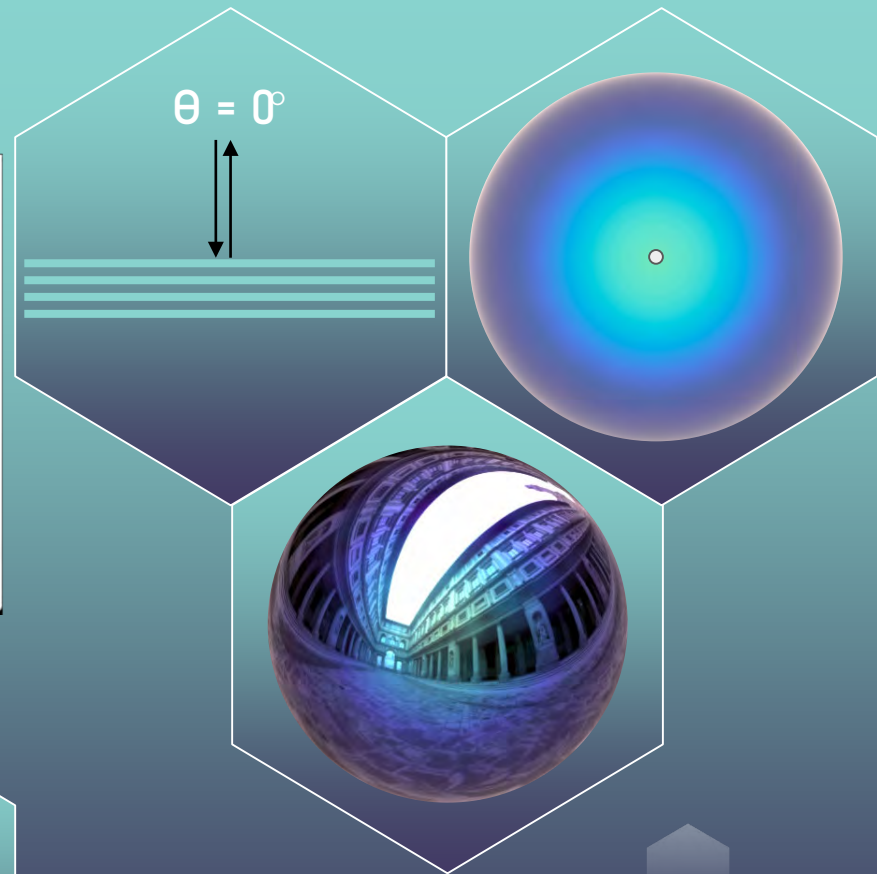
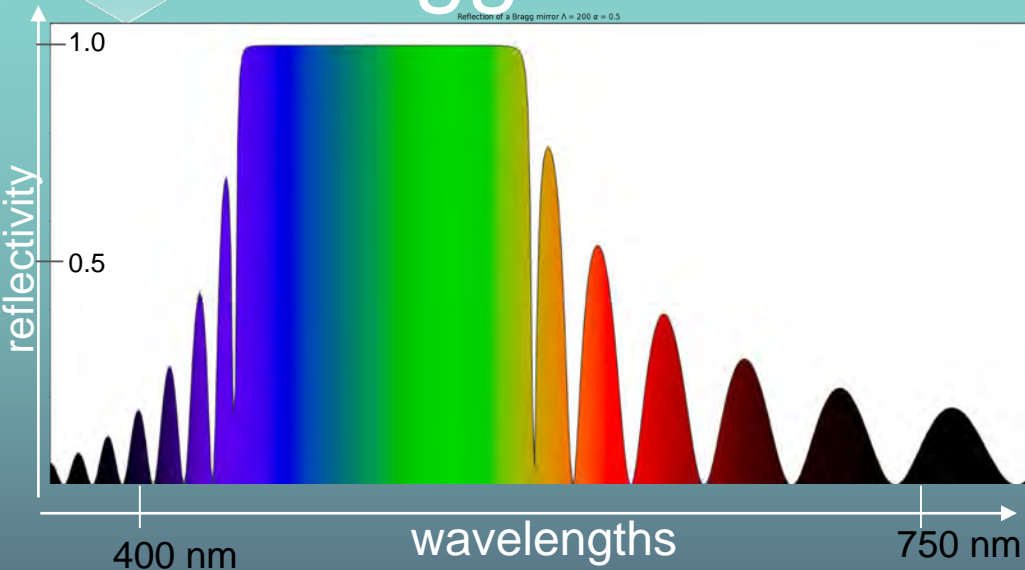
$$d2 = 250$$

$$n1 = 1.0$$

$$n2 = 1.5$$

20 repetitions

Bragg mirrors



$$d1 = 100$$

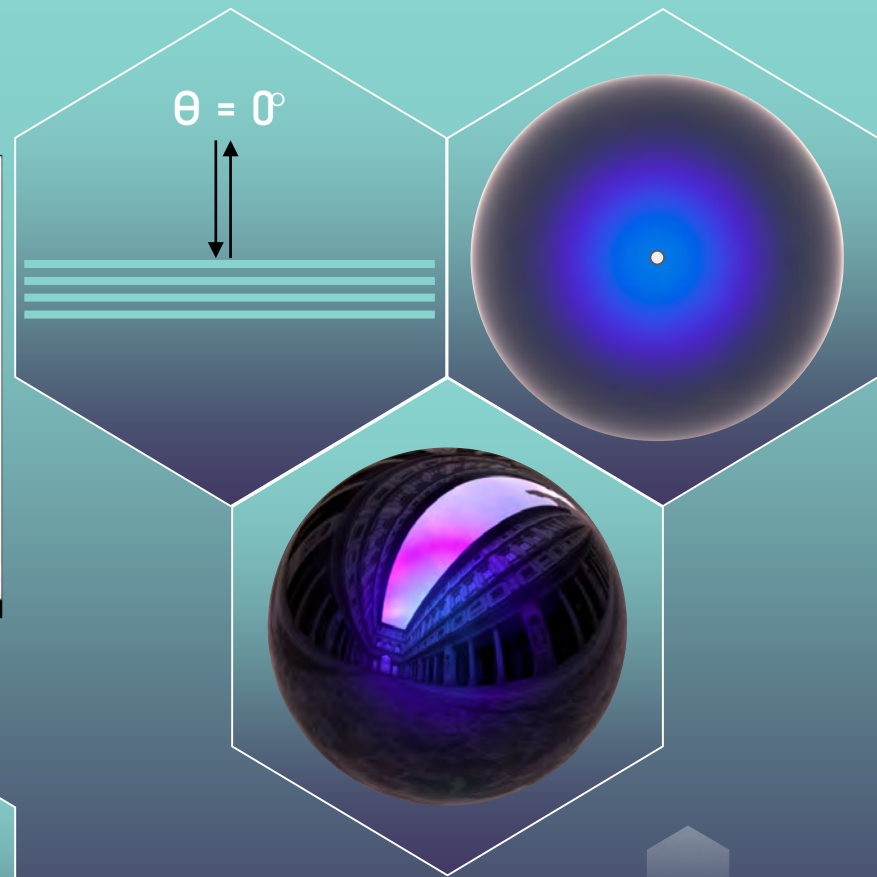
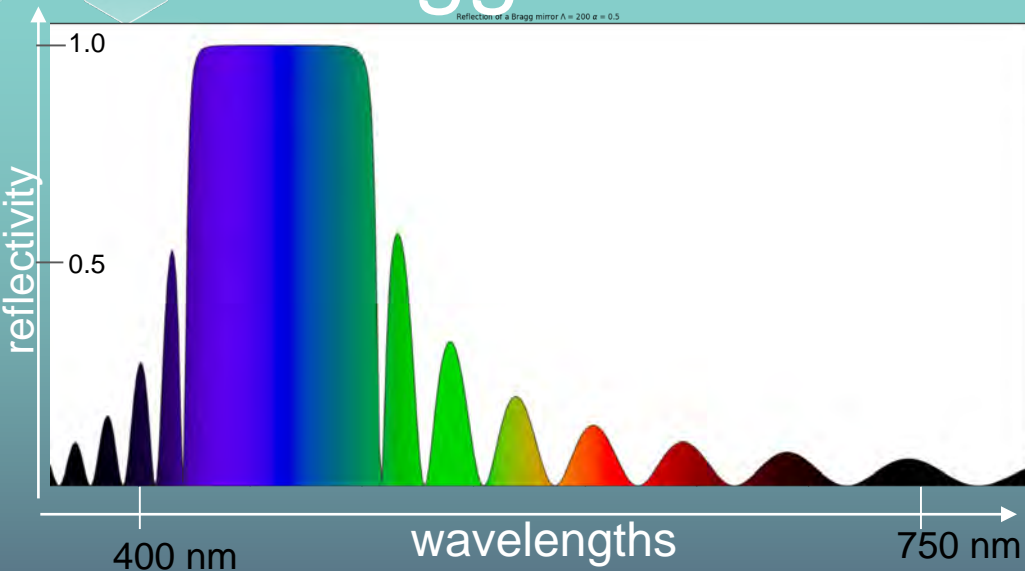
$$d2 = 100$$

$$n1 = 1.0$$

$$n2 = 1.5$$

20 repetitions

Bragg mirrors



$$d1 = 100$$

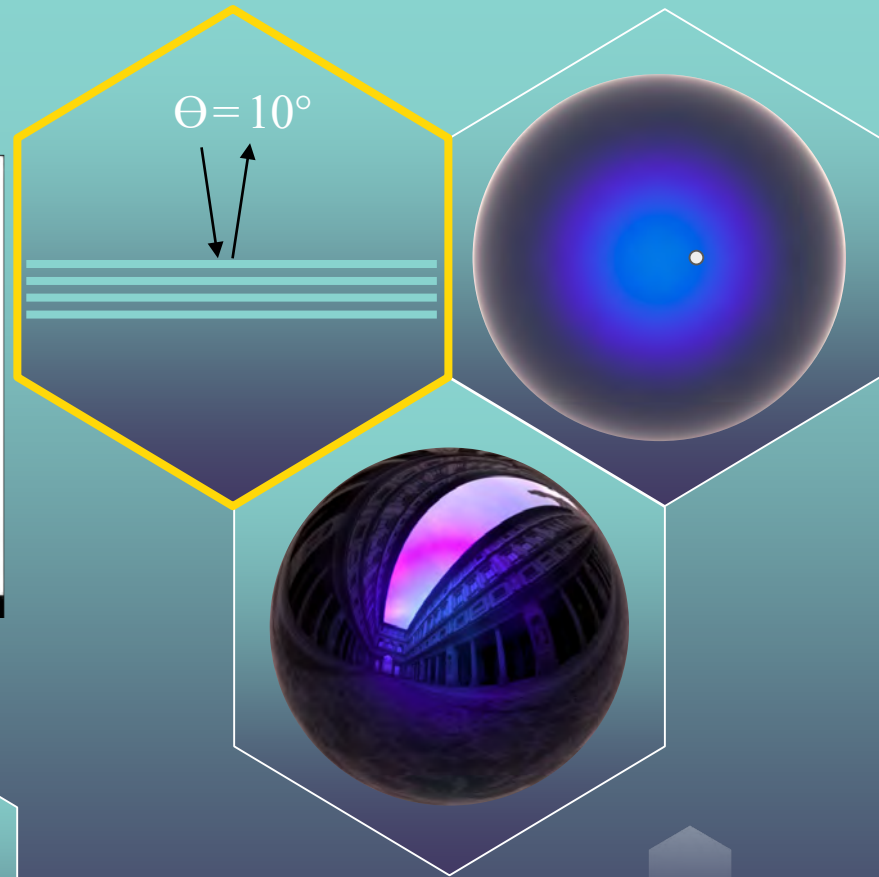
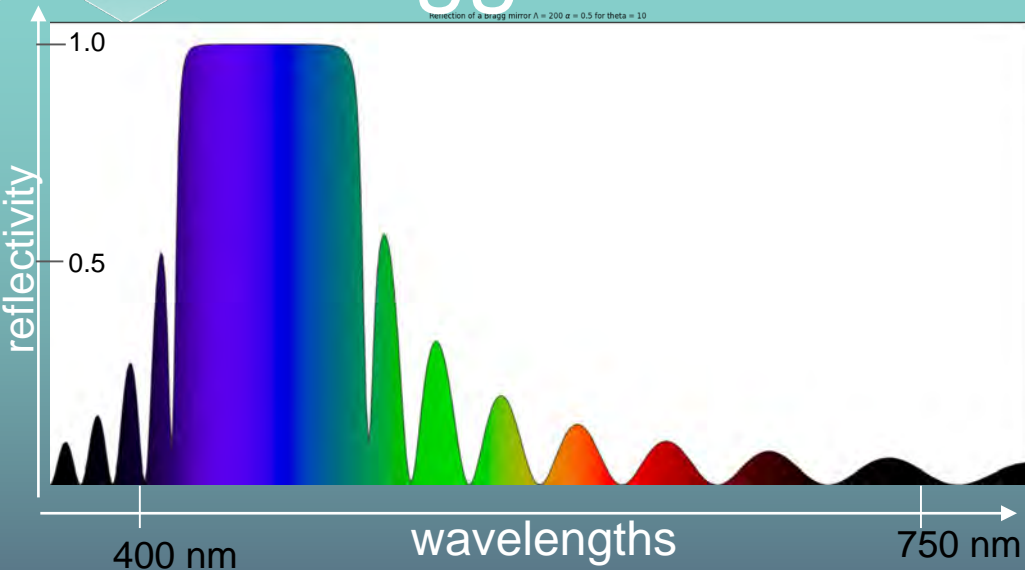
$$d2 = 100$$

$$n1 = 1.0$$

$$n2 = 1.3$$

20 repetitions

Bragg mirrors



$d1 = 100$

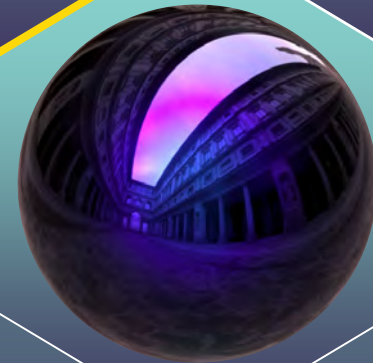
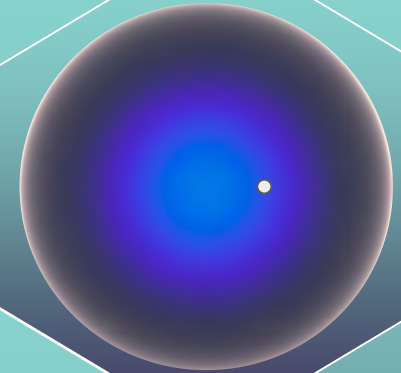
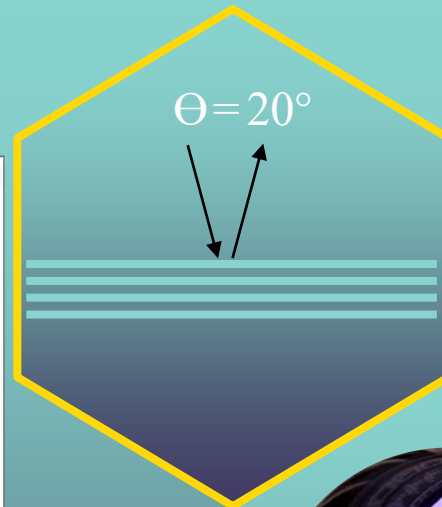
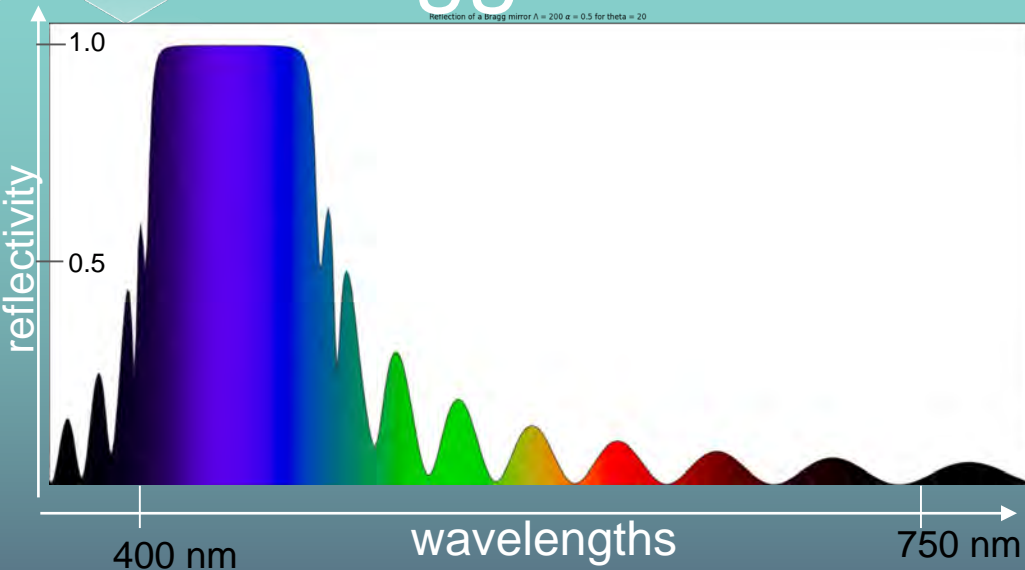
$d2 = 100$

$n1 = 1.0$

$n2 = 1.3$

20 repetitions

Bragg mirrors



$d1 = 100$

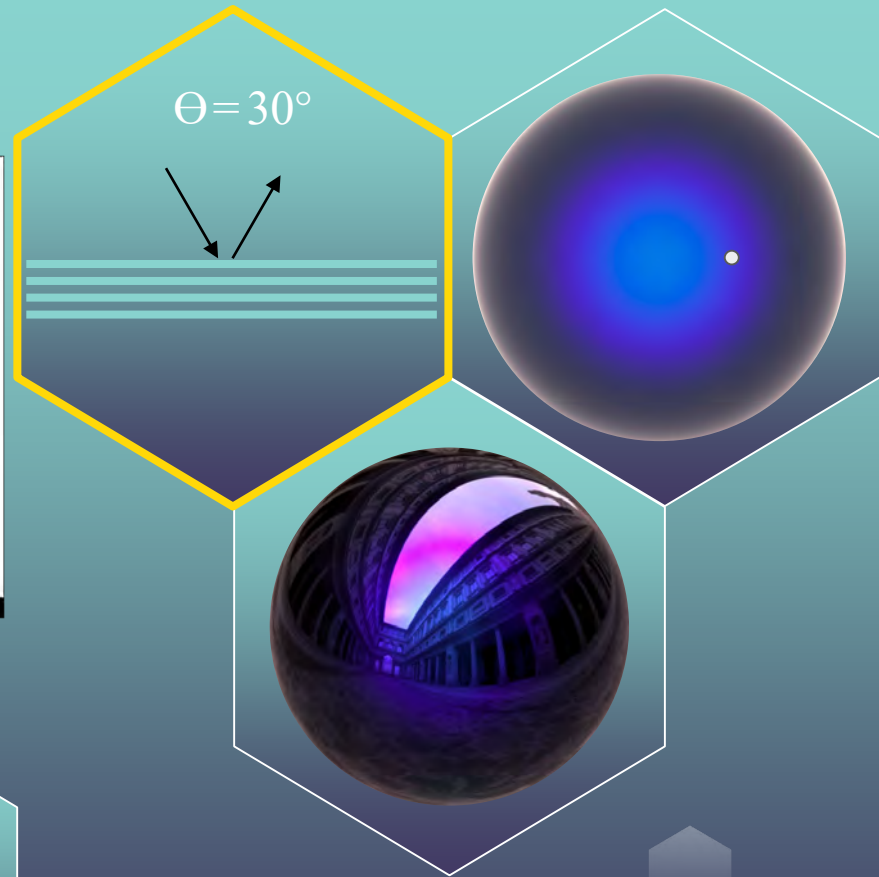
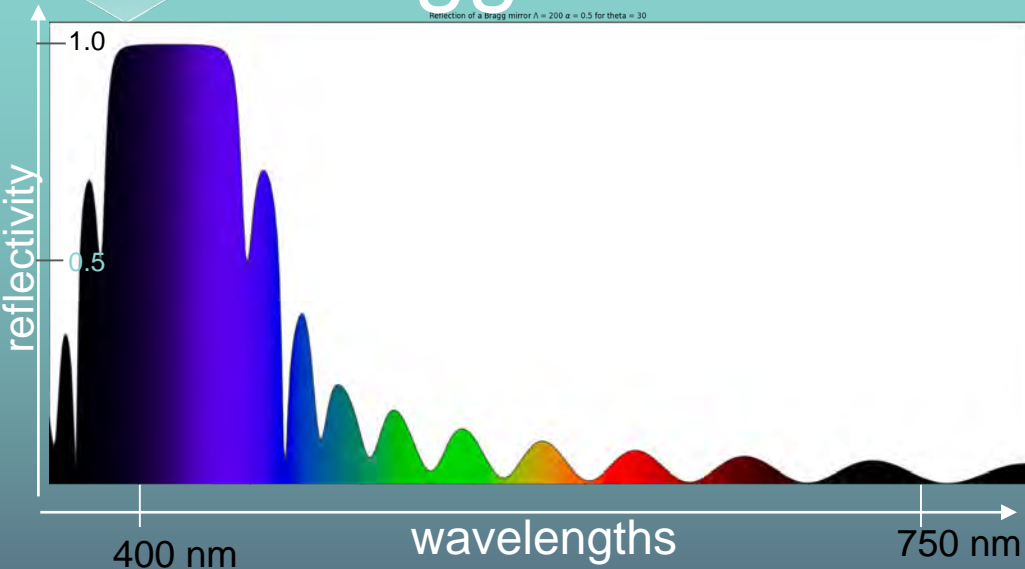
$n1 = 1.0$

$d2 = 100$

$n2 = 1.3$

20 repetitions

Bragg mirrors



$d1 = 100$

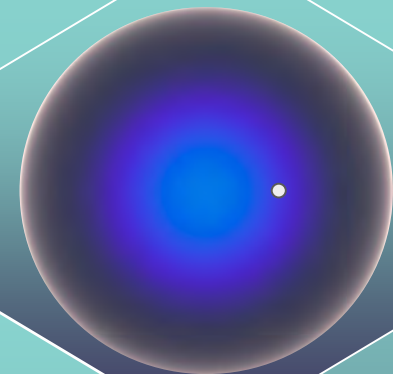
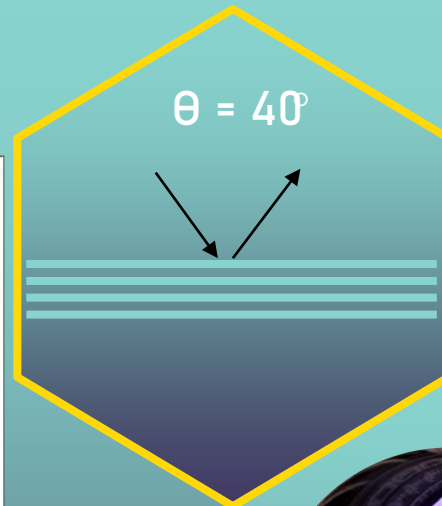
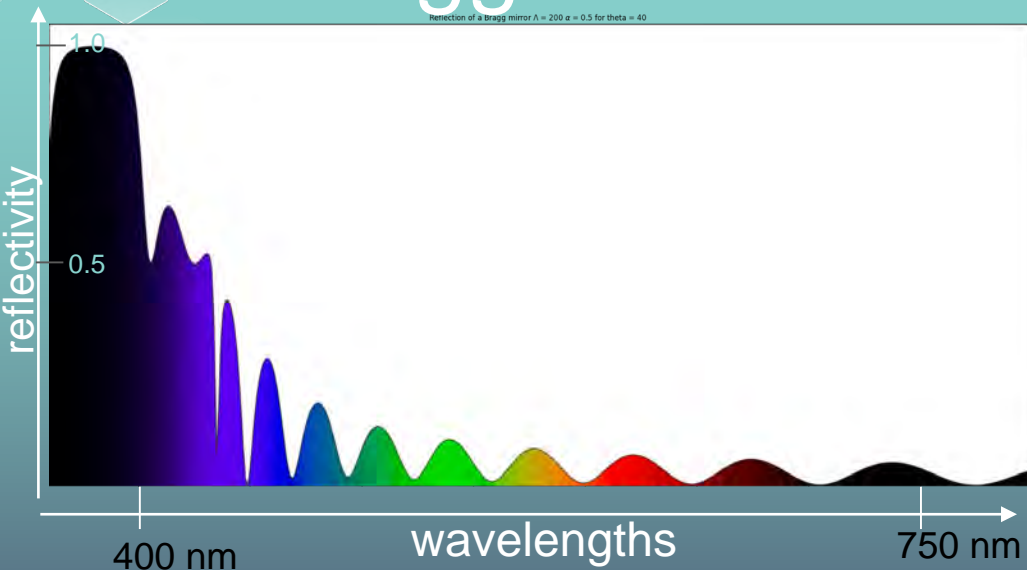
$d2 = 100$

$n1 = 1.0$

$n2 = 1.3$

20 repetitions

Bragg mirrors



$$d1 = 100$$

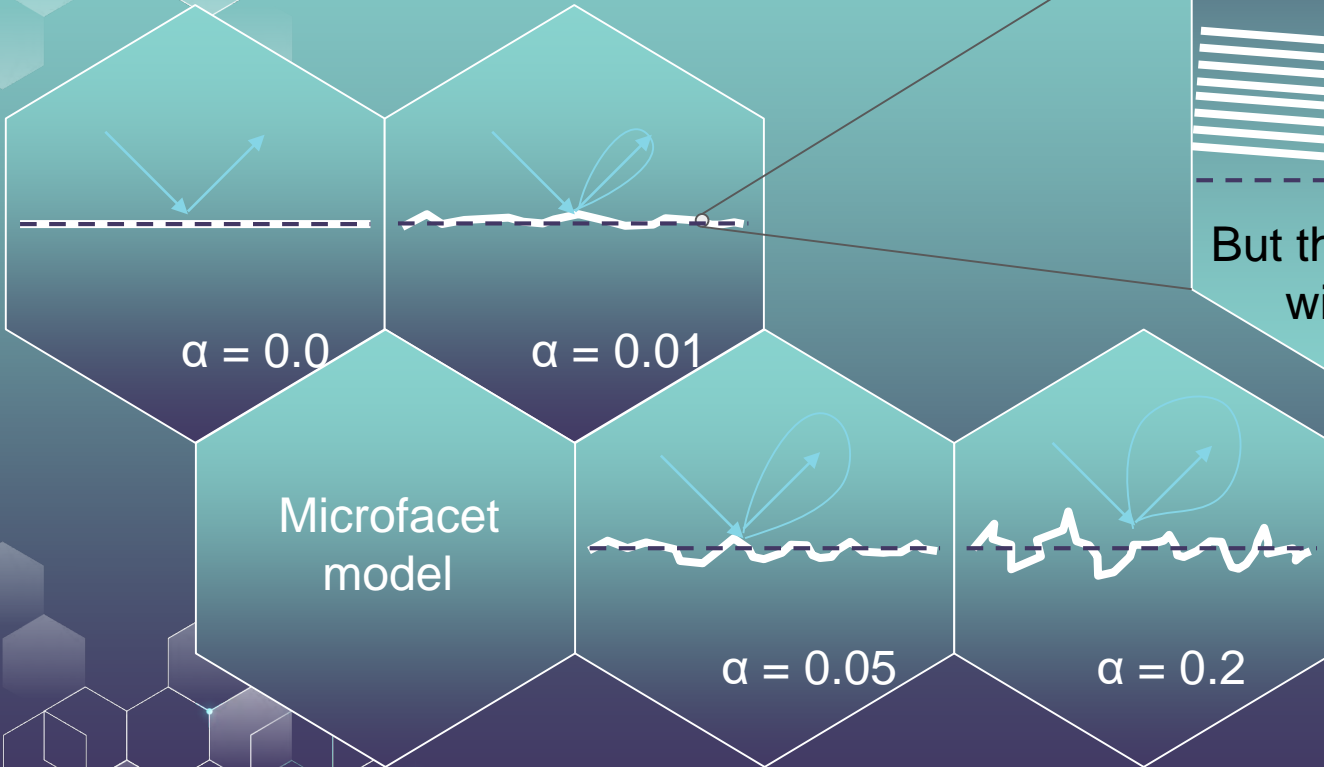
$$d2 = 100$$

$$n1 = 1.0$$

$$n2 = 1.3$$

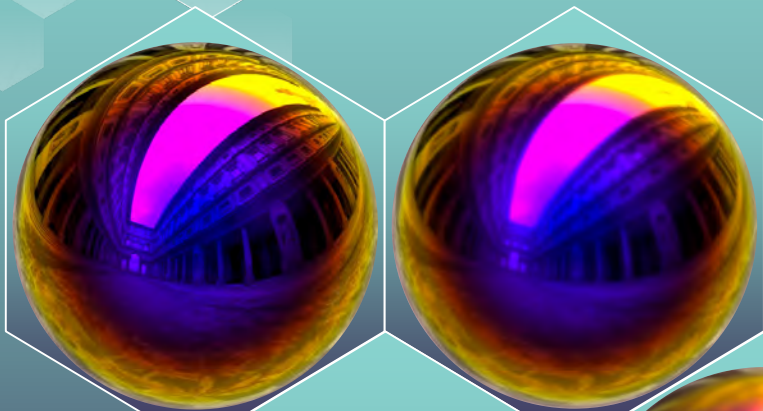
20 repetitions

“Rough” Bragg mirrors

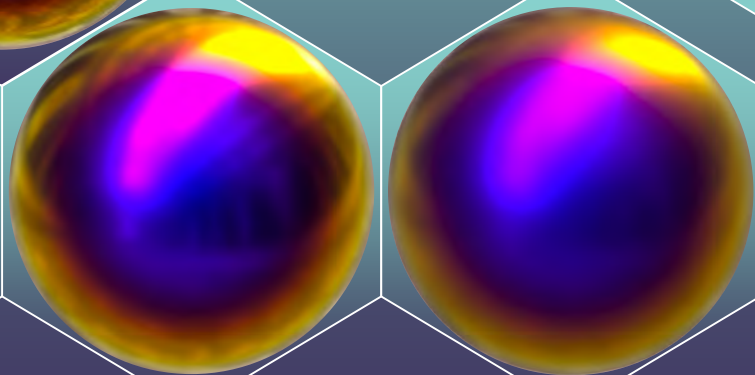


At a nanoscopic scale
the surface is smooth

But the local normal is not aligned
with the geometric normal



$d1 = 188$
 $d2 = 188$
 $n1 = 1.0$
 $n2 = 1.5$



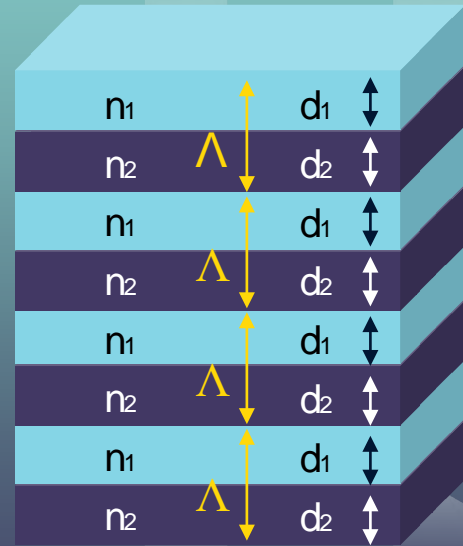
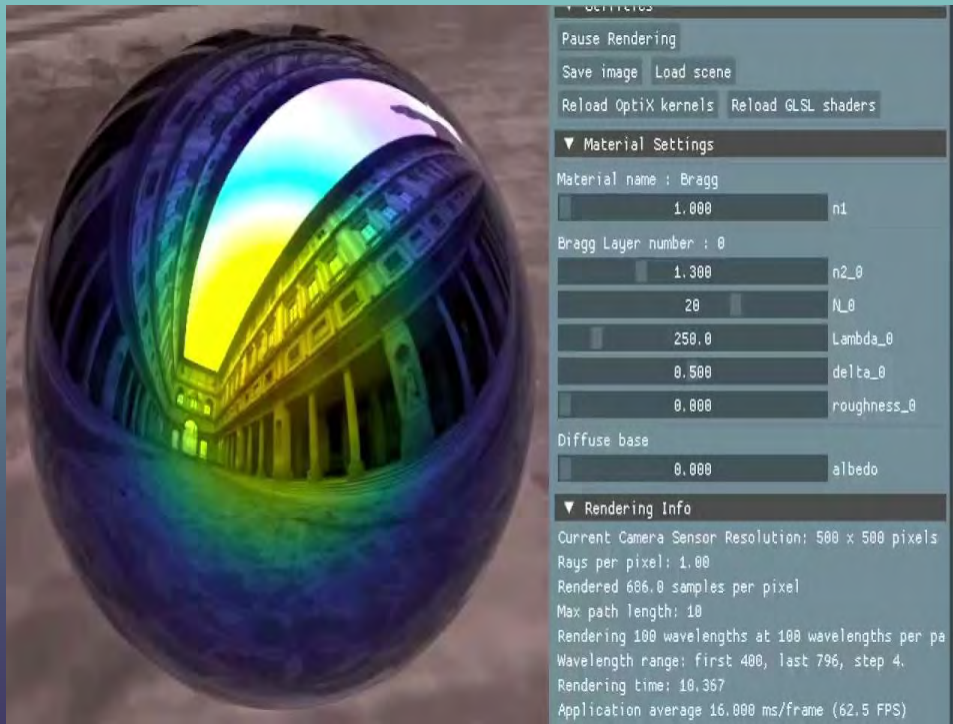
D

$$f_r(i, o) = \frac{D(h)G(i, o, h)R_\lambda(i, h)}{4|i.n||o.n|}$$

Interactive exploration in a Progressive spectral renderer

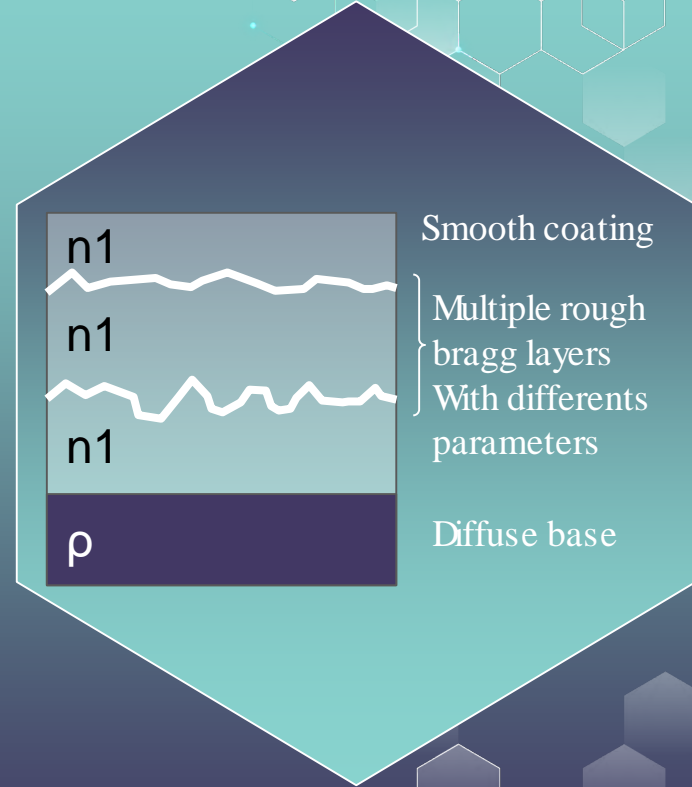
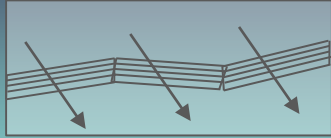
$$\text{Lambda} = d1 + d2$$

$$\text{delta} = d1 / (d1 + d2)$$



With multiple layers

Transmission through a Bragg layer is ballistic



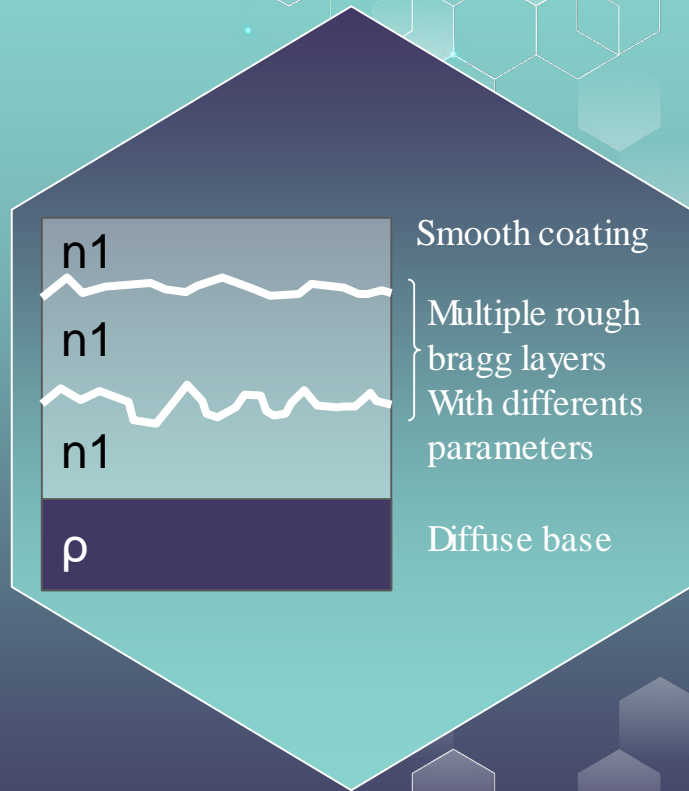
With multiple layers

Transmission through a Bragg layer is ballistic



Sum the contribution of every micro-facet on CPU

$$T_\lambda = 1 - R_\lambda$$
$$\iint T_\lambda G D d\omega$$



With multiple layers

Transmission through a Bragg layer is ballistic



Sum the contribution of every micro-facet on CPU

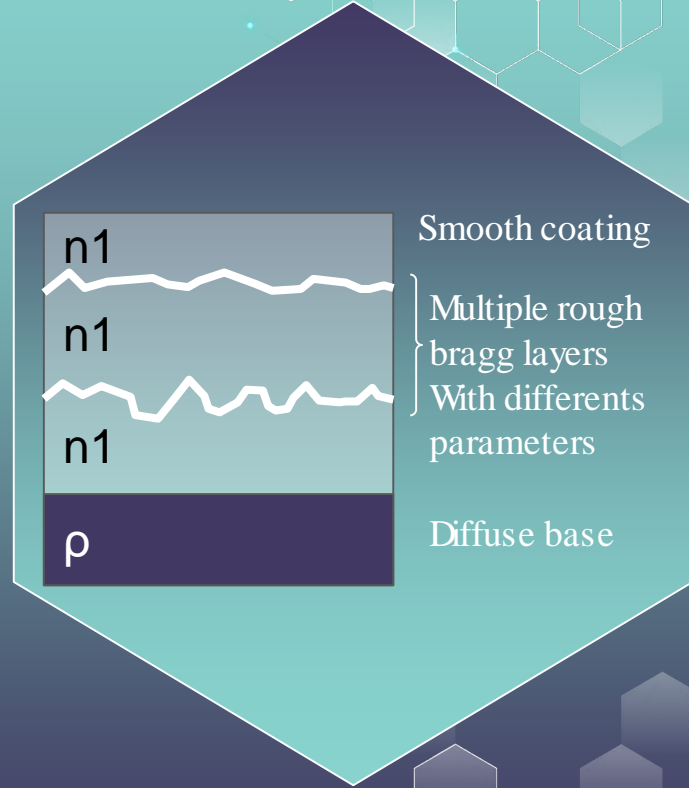
$$T_\lambda = 1 - R_\lambda$$
$$\iint T_\lambda GD d\omega$$

Computation of an achromatic filter

$$F_\alpha$$

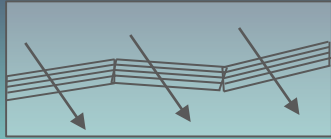
Compute only if T_λ changes

$$\int_0^{\pi/2} T_\lambda(\theta_d) F_\alpha(\theta_i, \theta_d) d\theta_d$$



With multiple layers

Transmission through a Bragg layer is ballistic



Sum the contribution of every micro-facet on CPU

$$T_\lambda = 1 - R_\lambda$$
$$\iint T_\lambda G D d\omega$$

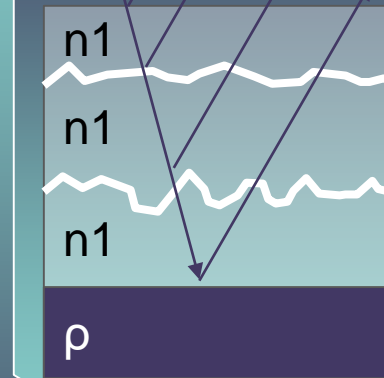
Computation of an achromatic filter

$$F_\alpha$$

Compute only if T_λ changes

$$\int_0^{\pi/2} T_\lambda(\theta_d) F_\alpha(\theta_i, \theta_d) d\theta_d$$

Single reflection



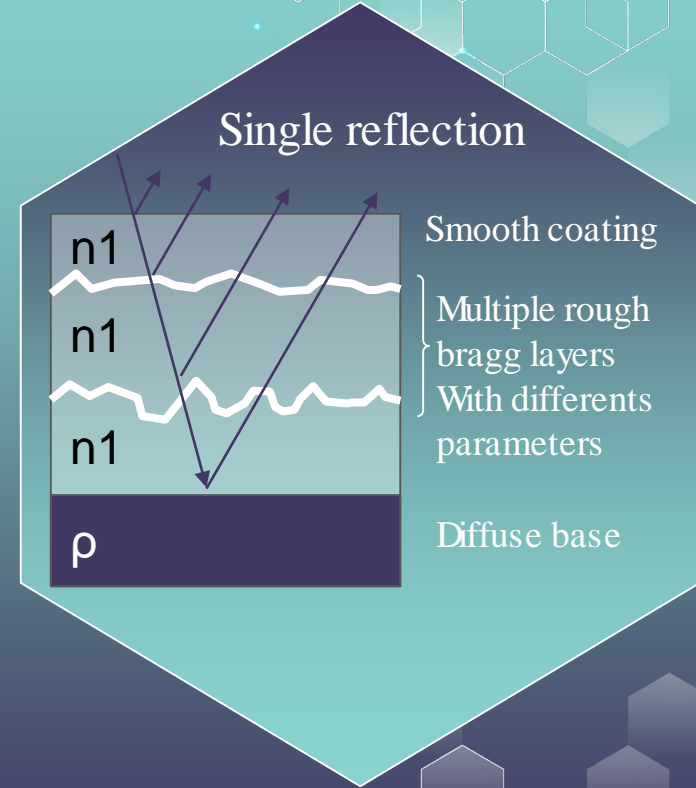
Smooth coating

Multiple rough Bragg layers
With different parameters

Diffuse base

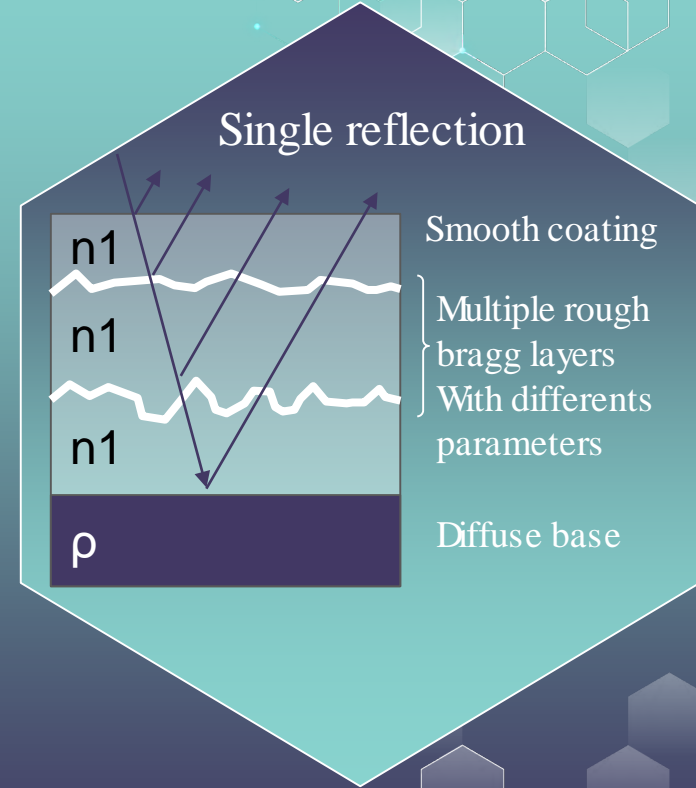
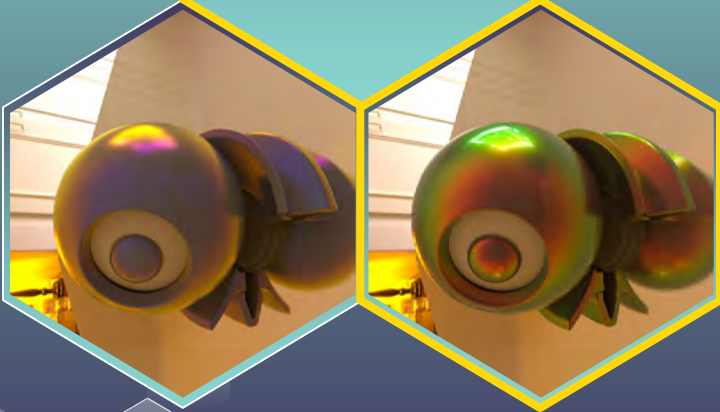
With multiple layers

Grey diffuse
base



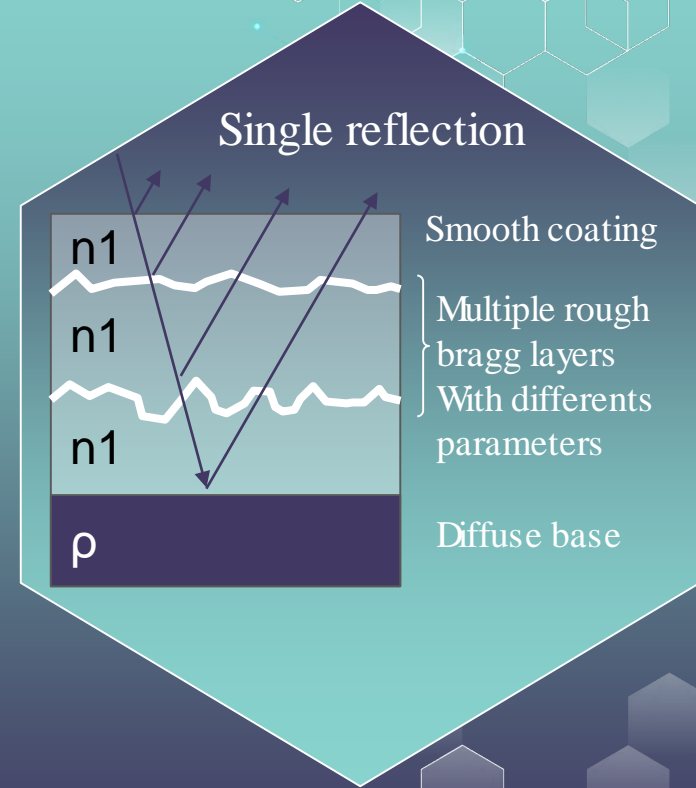
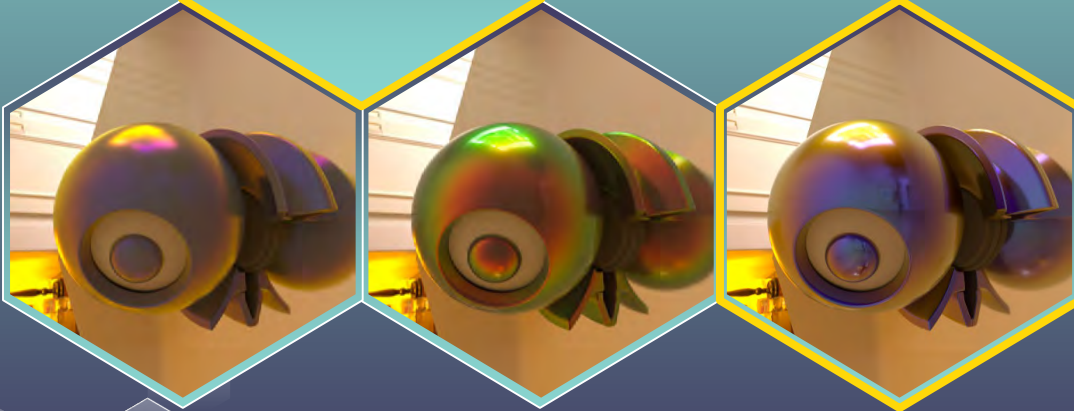
With multiple layers

Smooth coating
(notice the hazy
gloss)



With multiple layers

Smooth Bragg
On Rough Bragg



A decorative graphic on the left side of the slide, consisting of a grid of hexagons. Some hexagons are solid light blue, while others are white outlines. Small blue dots are placed at the vertices of the hexagons, and thin white lines connect some of them, creating a network-like structure.

Thank you for your
attention