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Neutron reflectivity's day

Today you will learn about specular scattering and non-specular scattering.

Scattering length and contrast matching in Soft Matter.


Theory of Reflection.

Optics apply to Light, Neutrons and X-rays are all waves. Reflect over the different information that can be extracted from each of these waves


Learn to READ a reflectivity curve

Some cases in neutron reflection.


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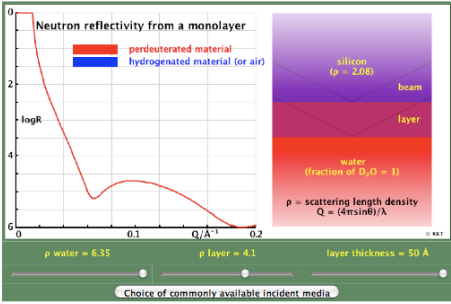
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What is reflectivity?

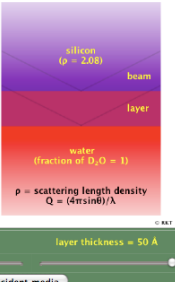
Reflectivity refers to the fraction of incident radiation (amplitude) that is reflected by a surface.

Neutron reflectivity from a monolayer



ρ water = 6.35 ρ layer = 4.1 layer thickness = 50 Å

ρ = scattering length density $Q = (4\pi s \sin\theta) / \lambda$



Why is reflectivity interesting for us?

Reflectivity reveals interfacial structure

- 1. Layer thickness
- 2. Layer composition
- 3. In plane structure

air-water

air-solid

solid-liquid

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Light, X-rays and Neutrons can be treated as waves: Same principles apply to any of them!

What are the advantages of X-rays and neutrons over light?

x-rays and neutrons have much shorter wavelength than light

-> they can explore much smaller spacing (of the order of molecular dimensions).

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beam path

intensity reflectivity profile

40
30
20
10

angle

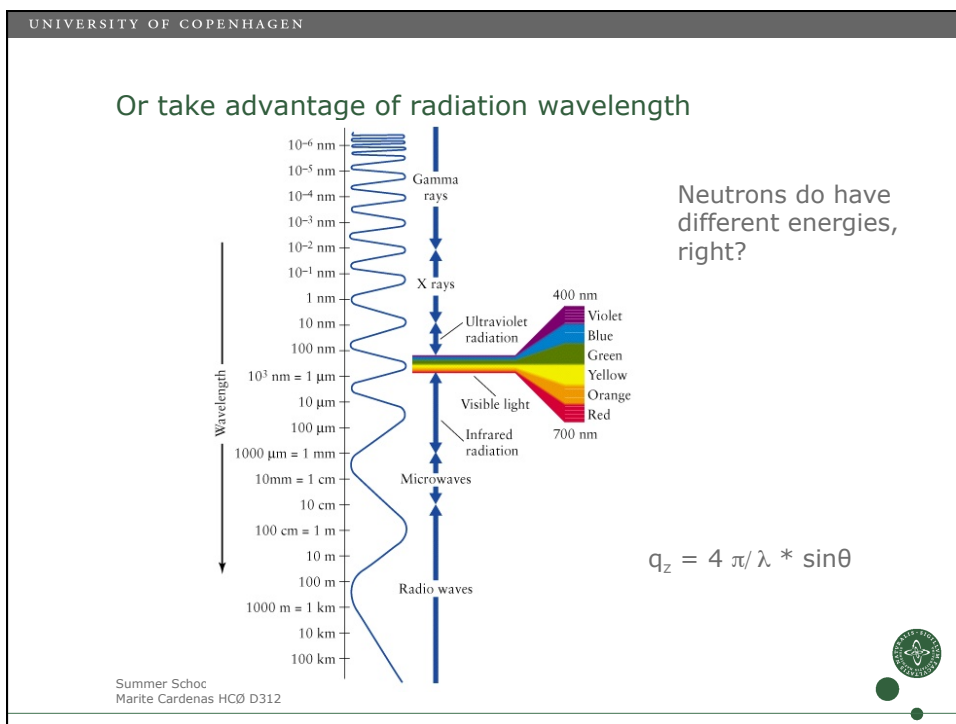
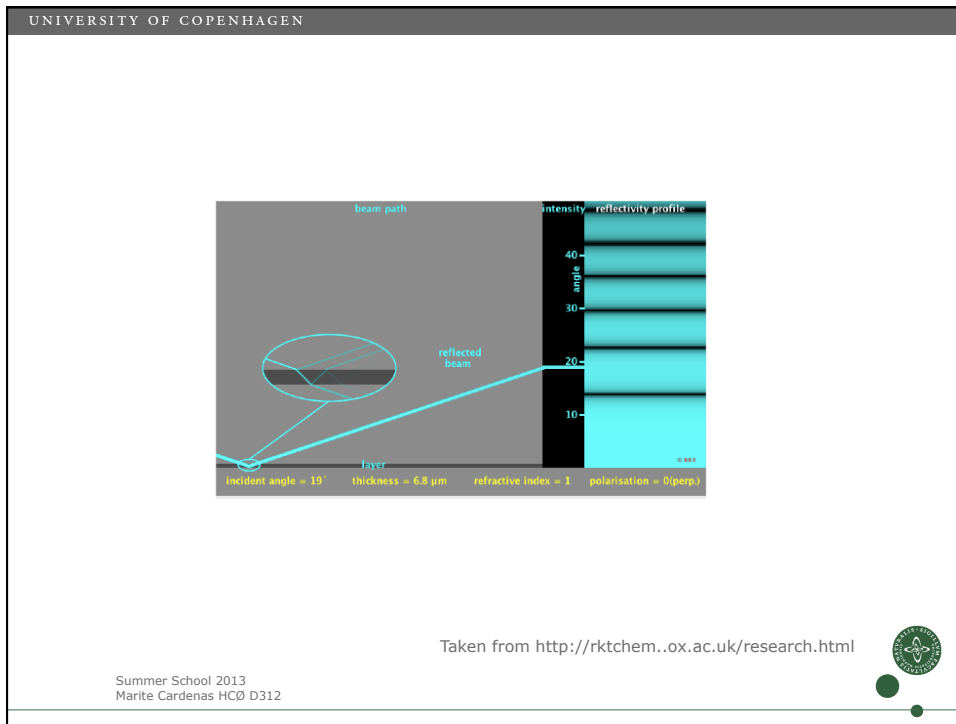
reflected beam

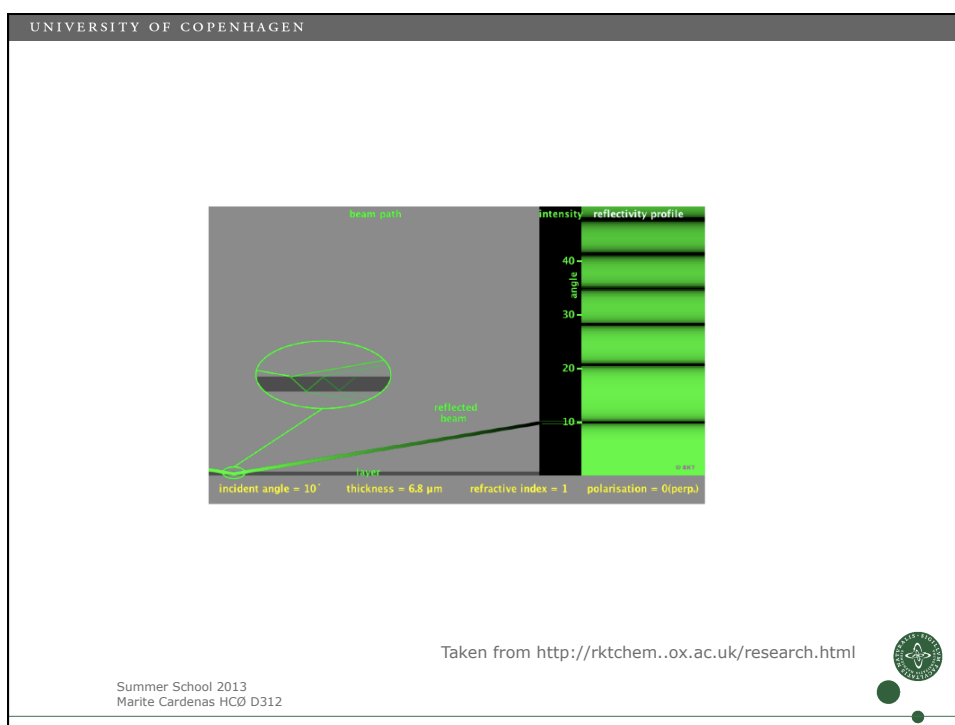
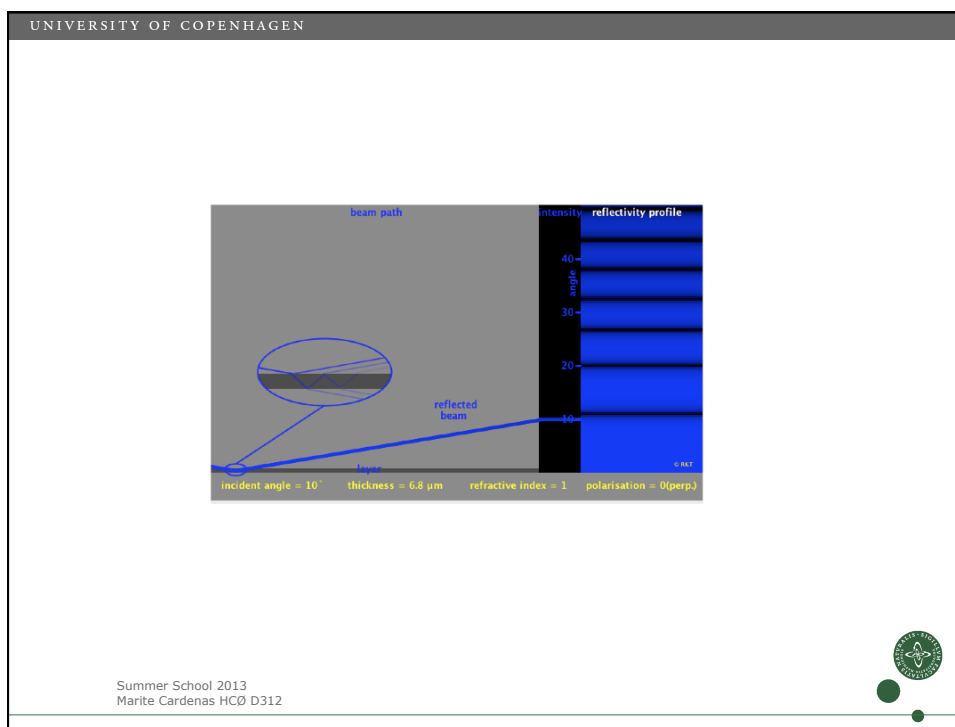
layer

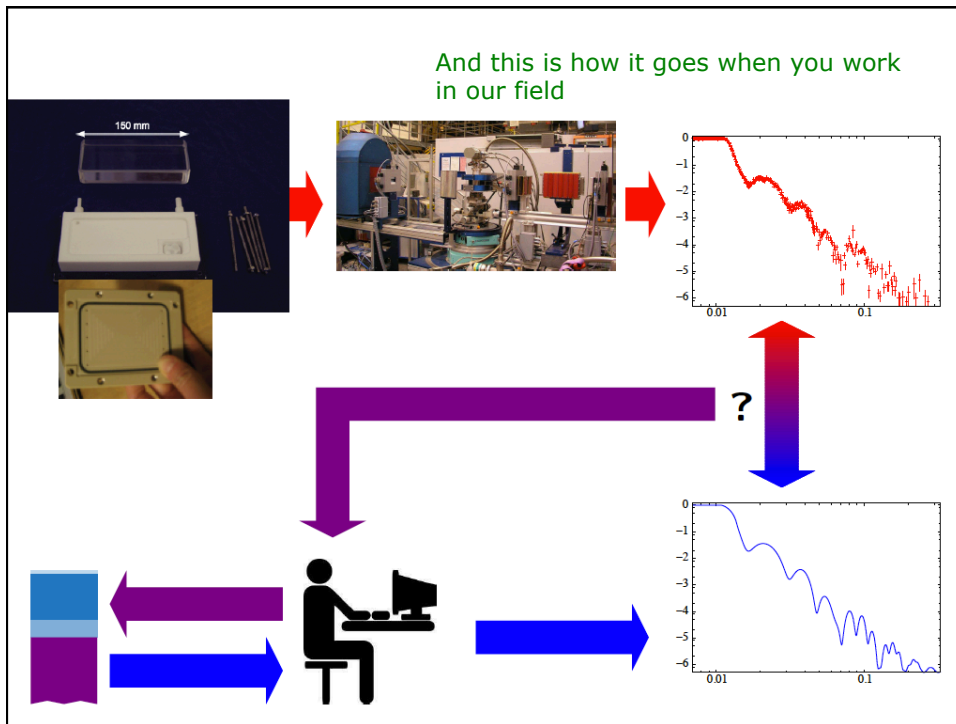
incident angle = 14° thickness = 6.8 μm refractive index = 1 polarisation = 0(perp.)

Taken from <http://rktchem..ox.ac.uk/research.html>

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The refractive index

The real part can be expressed as:

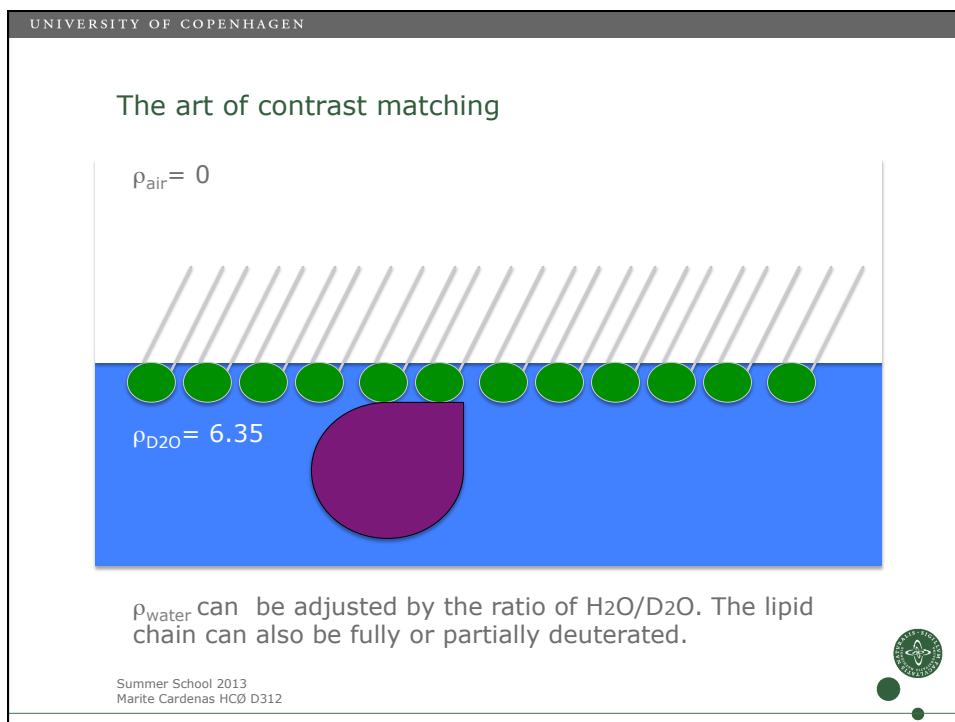
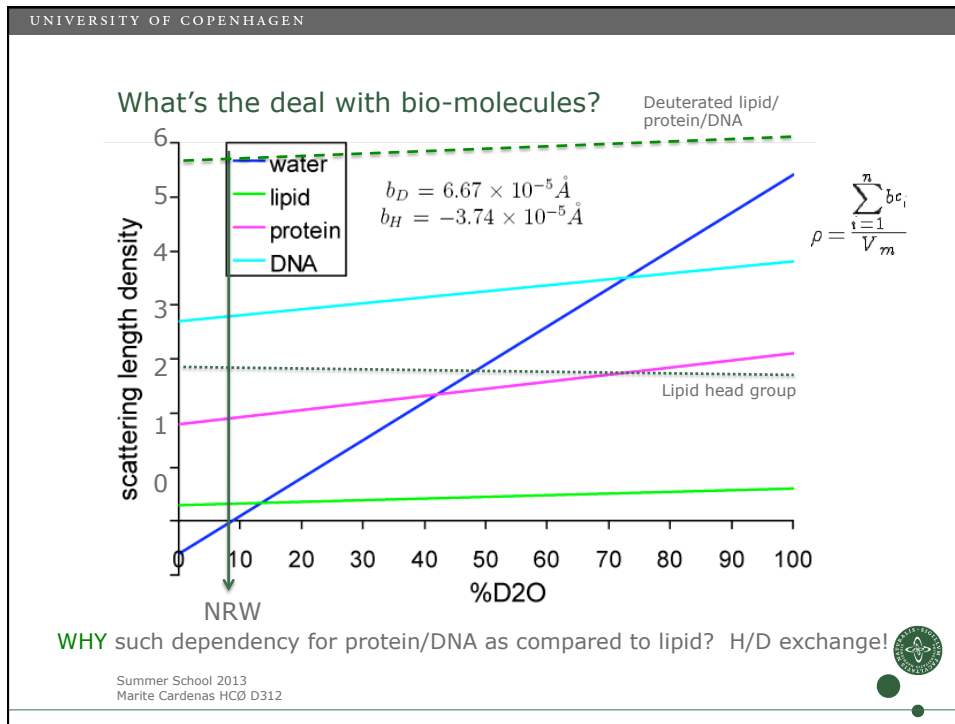
$$n = 1 - \frac{\lambda^2}{2\pi} * \rho$$

For X-ray,
 $\rho = \sum n_i f_i \frac{e^2}{mc^2}$
 f_i is the atomic factor for specie I

For Neutron,
 $\rho = \sum n_i b_i$
 n_i is the number density for the nuclear specie i
 b_i is the scattering length of nuclear specie i

The graph plots the real part of the refractive index, ρ , against the element. A blue line represents a linear relationship, while a red line shows a jagged, oscillating pattern, likely representing experimental data or a more complex theoretical model.

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The art of contrast matching

$\rho_{\text{air}} = 0$

$\rho_{\text{water}} = 0$

The diagram shows a horizontal interface between air (top) and water (bottom). A lipid bilayer is represented by a row of green circles (heads) with grey and blue lines (tails) extending upwards. A purple vesicle is shown below the interface, partially submerged. The text $\rho_{\text{air}} = 0$ is in the air region, and $\rho_{\text{water}} = 0$ is in the water region.

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The art of contrast matching

$\rho_{\text{air}} = 0$

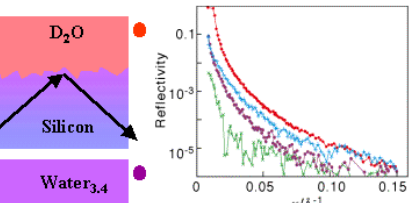
$\rho_{\text{water}} = \rho_{\text{lipid 2}} = \rho_{\text{D2O}}$

The diagram shows a horizontal interface between air (top) and a D2O solution (bottom). The lipid bilayer is shown with green heads and grey/blue tails. A purple vesicle is shown below the interface, partially submerged. The text $\rho_{\text{air}} = 0$ is in the air region, and $\rho_{\text{water}} = \rho_{\text{lipid 2}} = \rho_{\text{D2O}}$ is in the solution region.

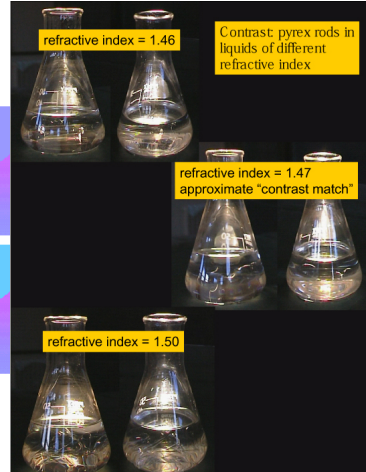
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The art of contrast matching



Polished silicon(111) normally has a thin 2 nm oxide layer and there is a measurable roughness of the surface. The largest contrast is between silicon and either D₂O or H₂O and these give the stronger reflected signals. Note that the neutron beam enters and exits through the solid



refractive index = 1.46
Contrast: pyrex rods in liquids of different refractive index

refractive index = 1.47
approximate "contrast match"

refractive index = 1.50

Taken from <http://rktchem..ox.ac.uk/research.html>

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SO NOW YOU SHOULD BE READY FOR THE REAL STUFF!

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