Investigation of Superconductivity, Magnetism, and Hydrogen Dynamics at Low-dimensional Heterostructures by Polarized Neutron Reflectometry

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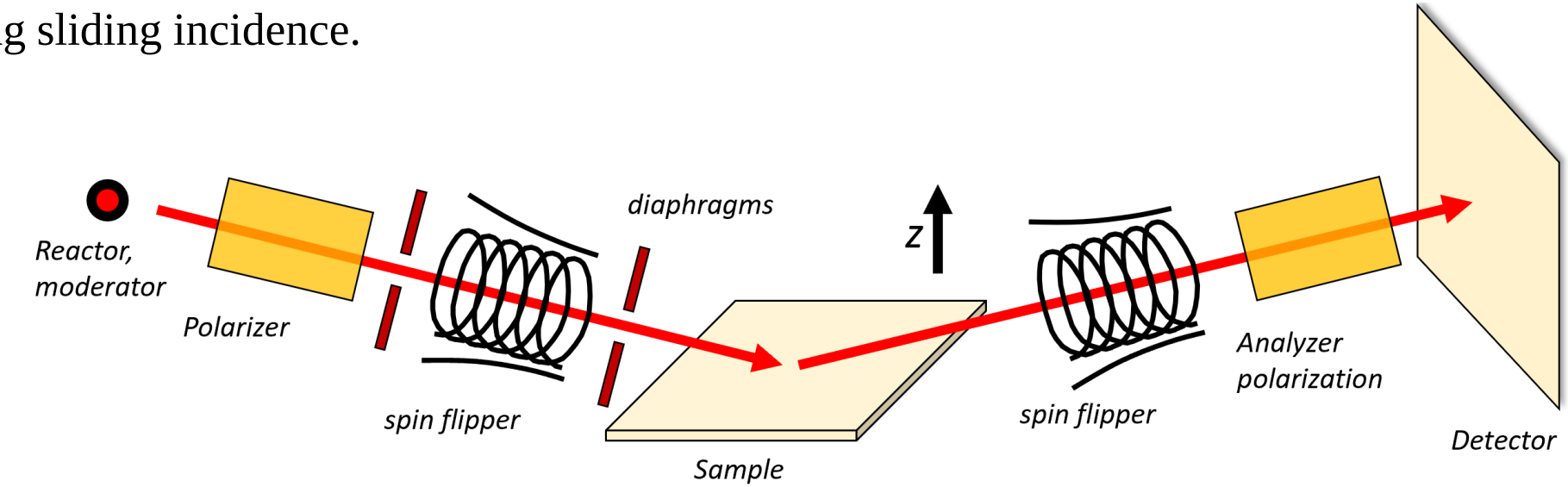
Neutron reflectometry

A neutron beam is directed at the sample, reflected from the sample surface and the reflection angle is measured.

The interaction of incident neutrons with the sample surface leads to their scattering through three main channels: specular reflection, non-mirrorless scattering and small-angle scattering during sliding incidence.



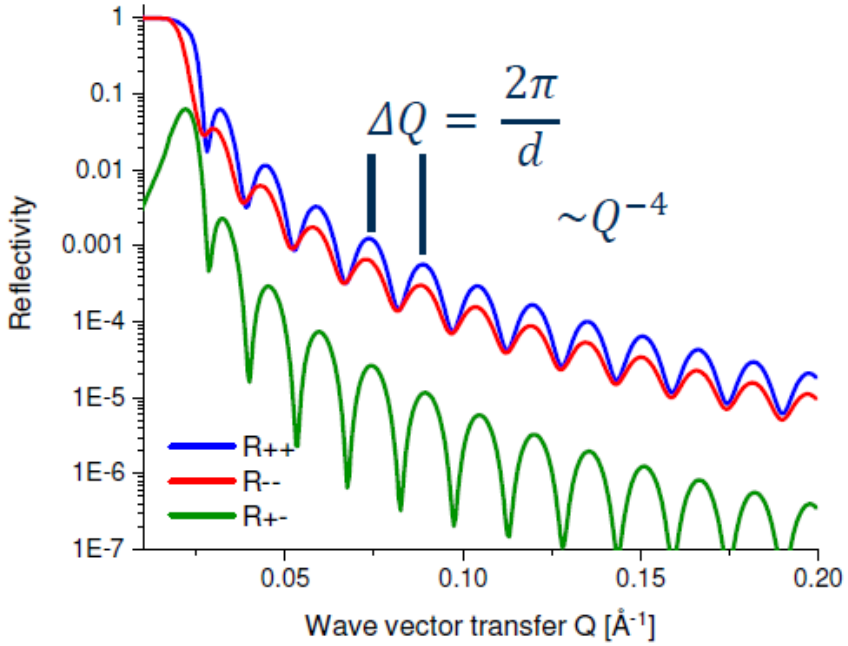
By analyzing the intensity of the reflected beam as a function of the angle or wavelength of the neutrons, information about the structure of the sample can be obtained.

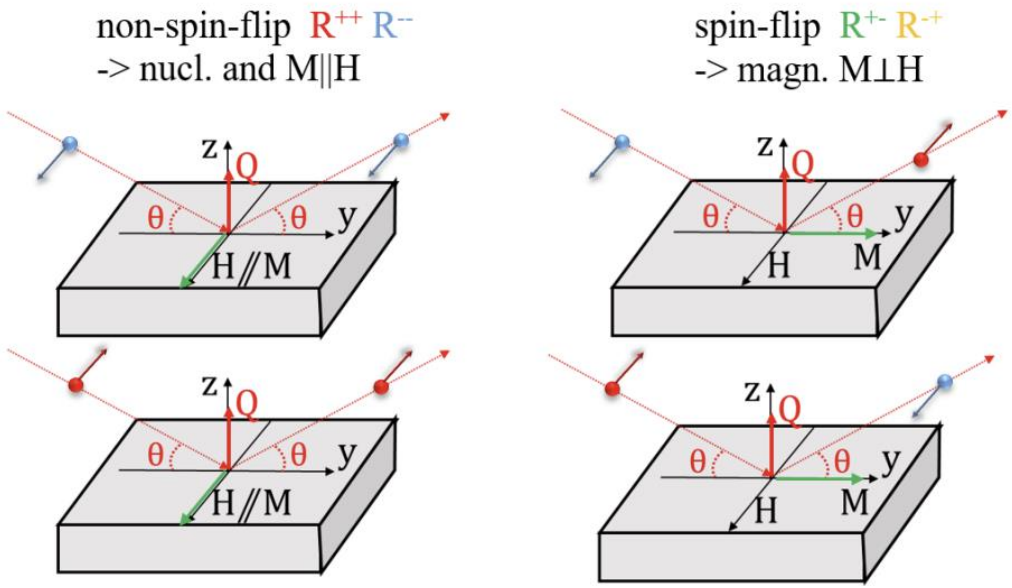
Reflectometry of polarized neutrons

Reflectometry of polarized neutrons is an experimental method for studying metal low-dimensional heterostructures, polymer films, biological systems, the free surface of liquids, and magnetic fluids.

$$U_{mag} = |\mu_n|\boldsymbol{\sigma B} \qquad r = \begin{pmatrix} r_{++} & r_{+-} \\ r_{-+} & r_{--} \end{pmatrix}$$

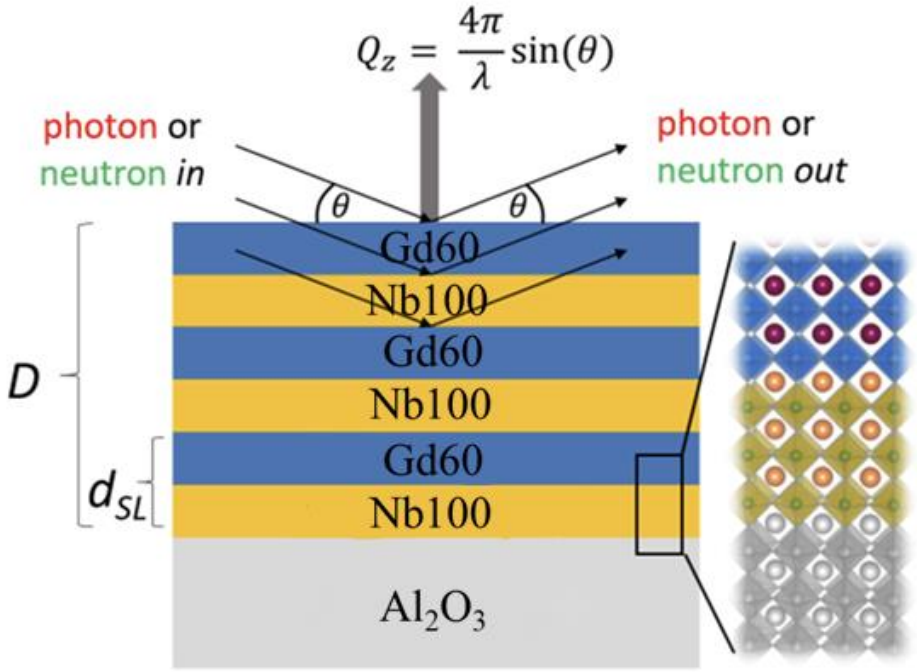
Reflection amplitude
neutron with spin





Superlattice

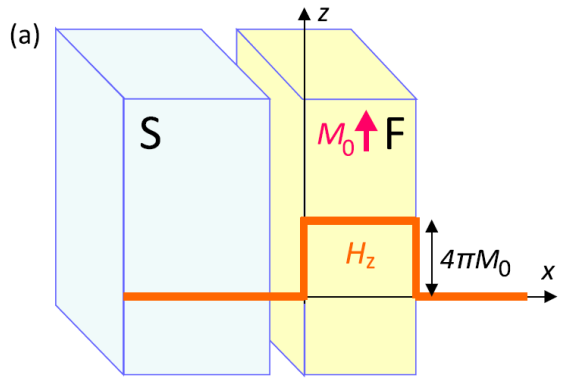
Superlattice is a special type of thin-film, which refers to a periodic structure of layers of two (or more) materials, and the thickness of each layer is typically several nanometers.

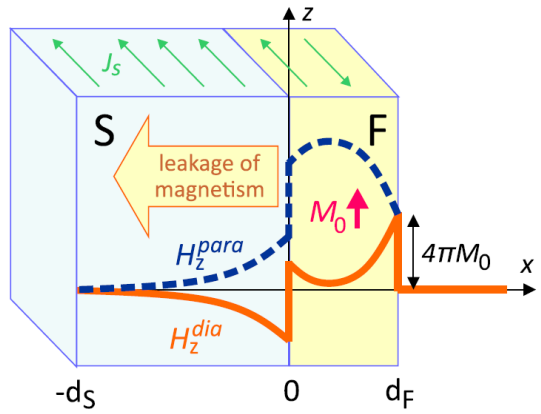


Superlattices:

- Al_2O_3/[Nb100/Gd60]*12/Nb50
- Al_2O_3 /[Nb250/Dy60]*12/Nb50

In superlattices with alternating superconducting (S) and ferromagnetic (F) layers, the spontaneous magnetic field induced in superconducting layers due to the effect of electromagnetic proximity is significantly greater than in S/F bilayers.





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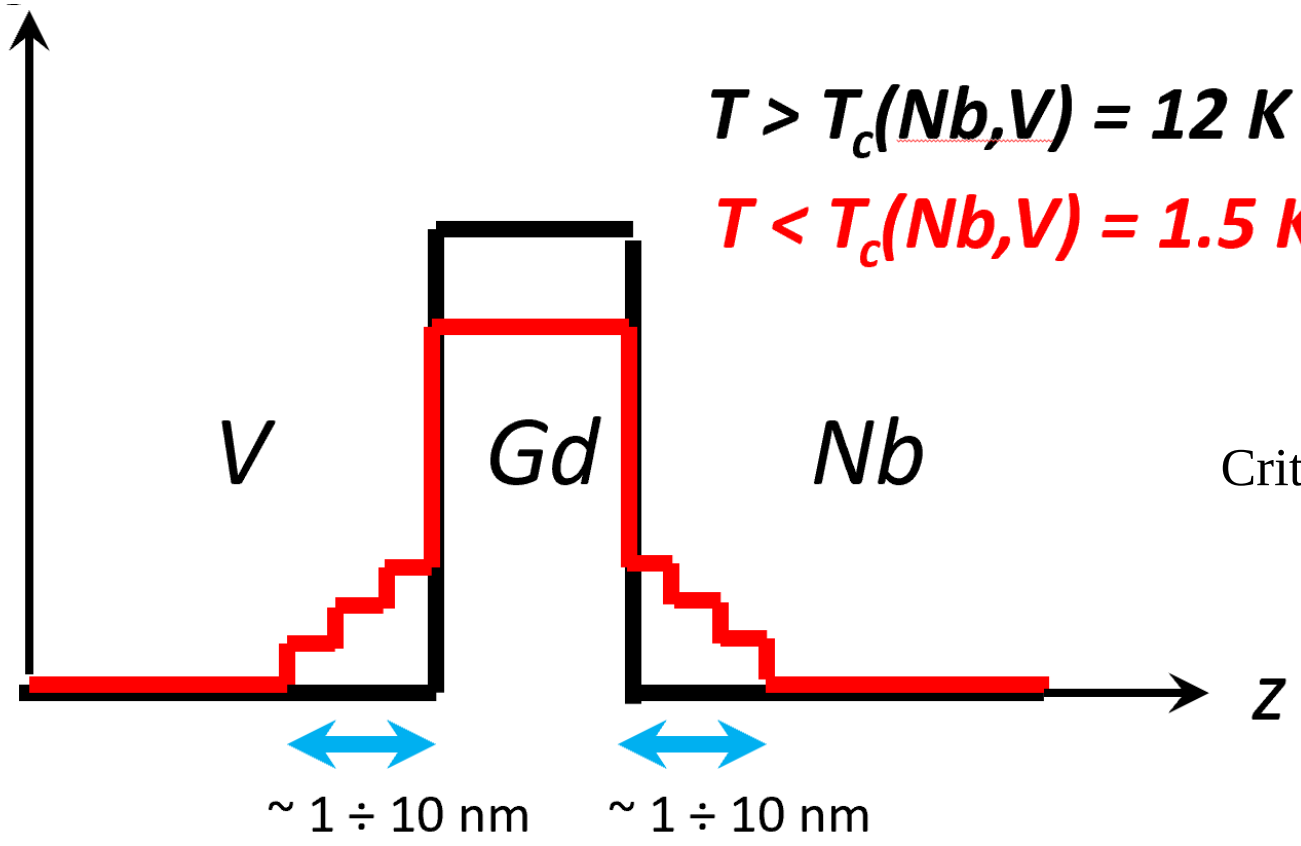
Magnetization



$T > T_c(Nb,V) = 12\ K$

$T < T_c(Nb,V) = 1.5\ K$

Critical temperature of Gd = 5-6 K

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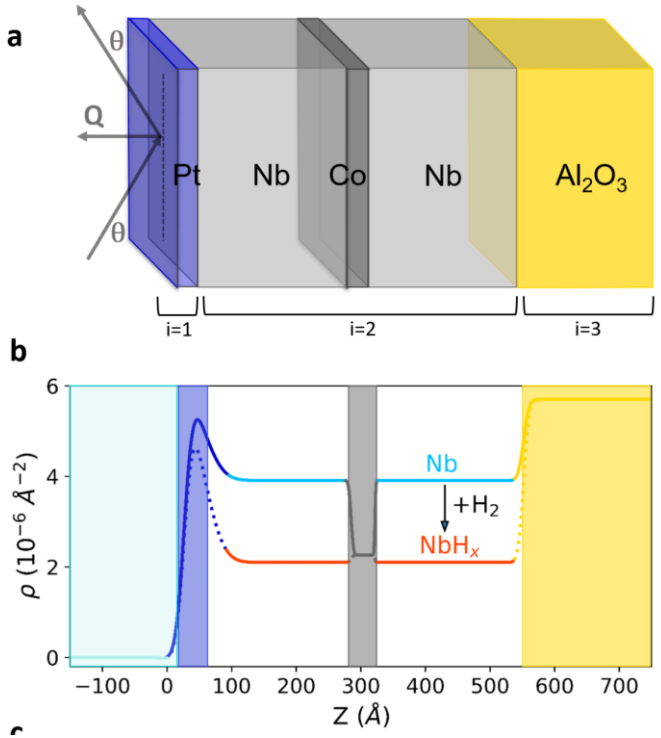
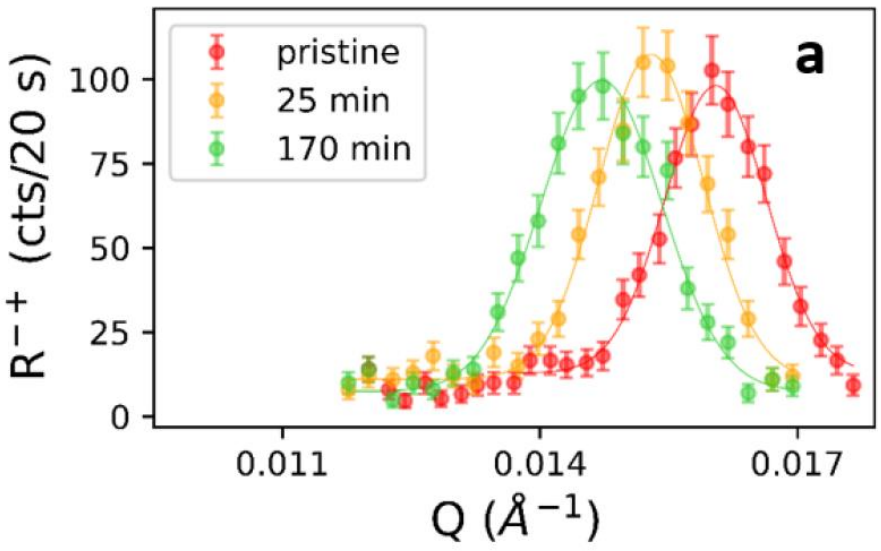
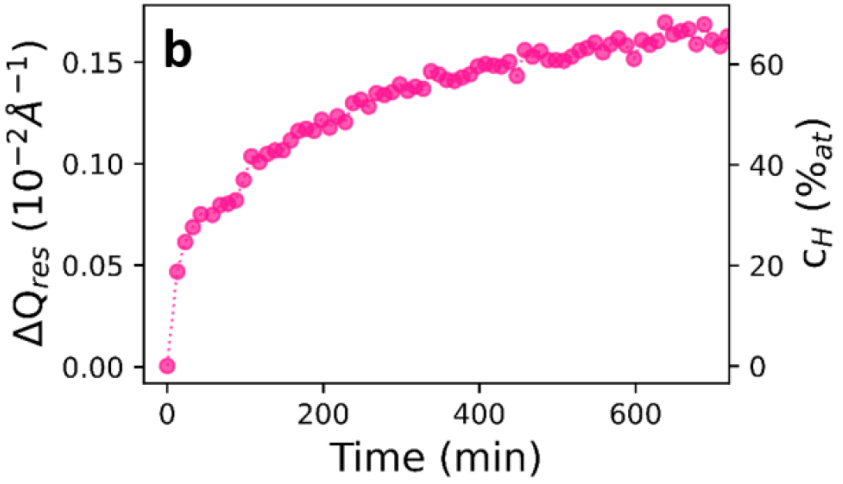
Resonance neutron reflectometry for hydrogen detection

Thanks to the high neutron scattering ability of hydrogen, neutron reflectometry has become a powerful method for directly determining the hydrogen content and its effect on the structure, because even small amounts of hydrogen can elicit a substantial electronic response.







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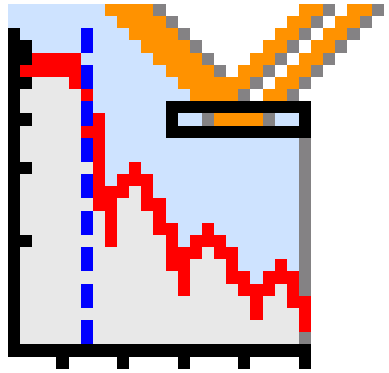
Programs used in our project:

MATLAB

Spectra Viewer

ORIGIN® 2019
Graphing & Analysis



X'Pert Reflectivity

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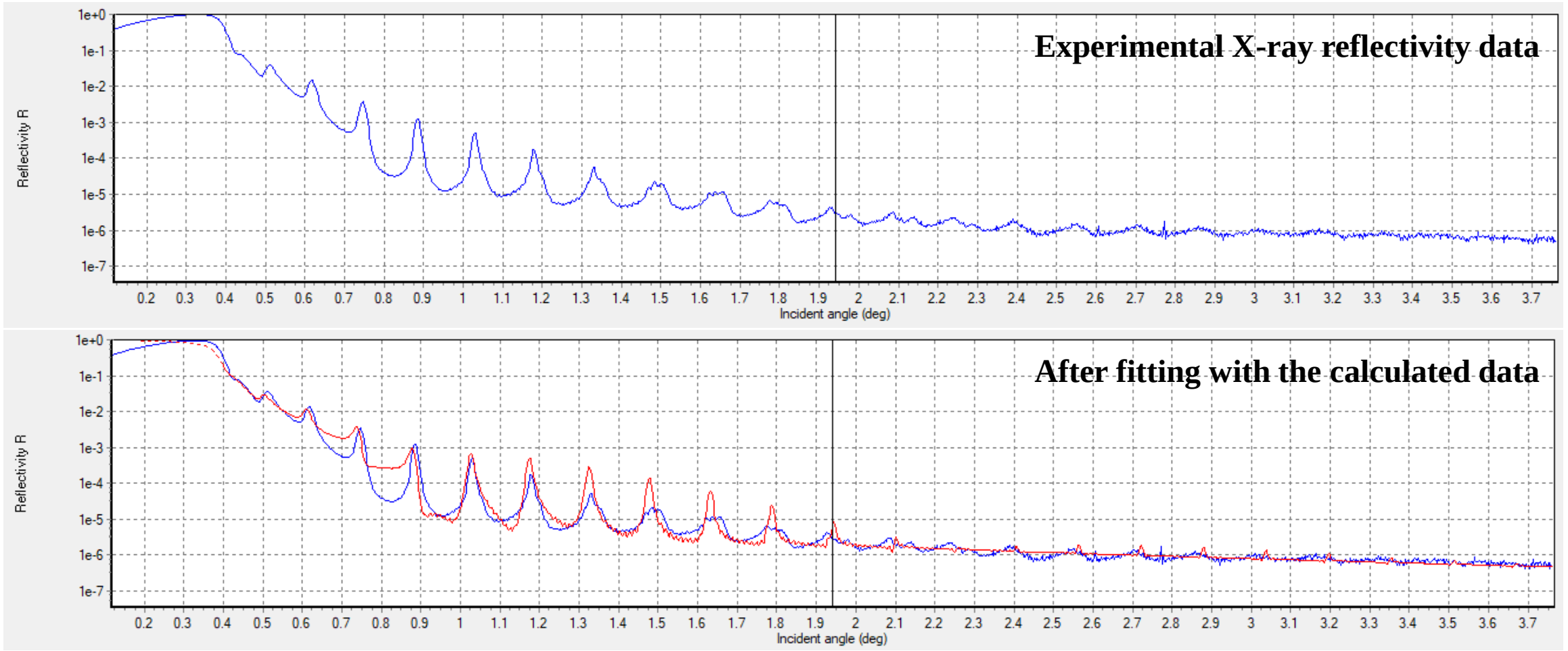
1- X'Pert Reflectivity



Al_2O_3//[Nb(250A)/Dy20A)]x12/Nb(50A)

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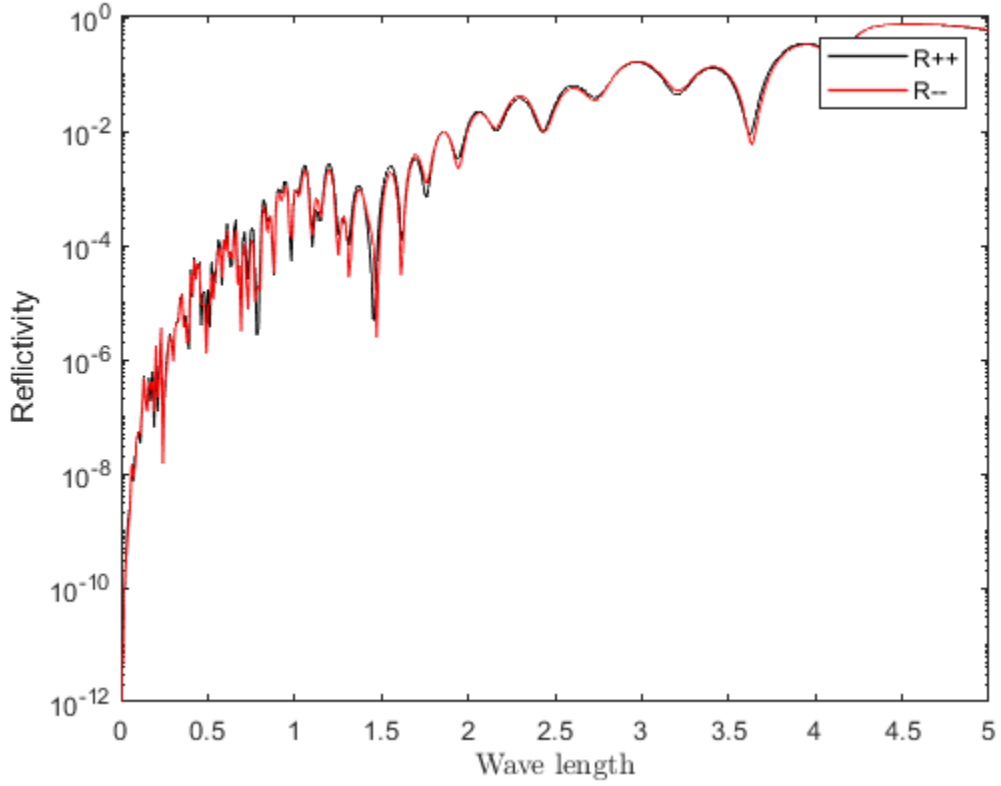
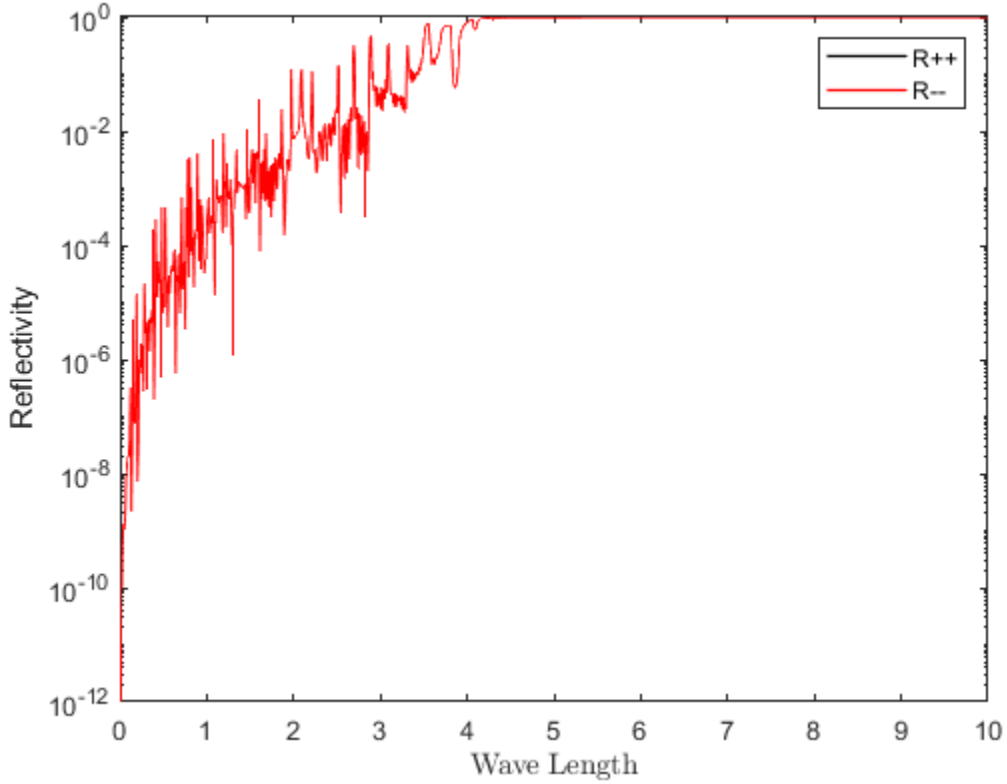
2- MATLAB Code

Al_2O_3/Nb100/Gd60]*12/Nb50



Al_2O_3/[Nb250/Dy60]*12/Nb50



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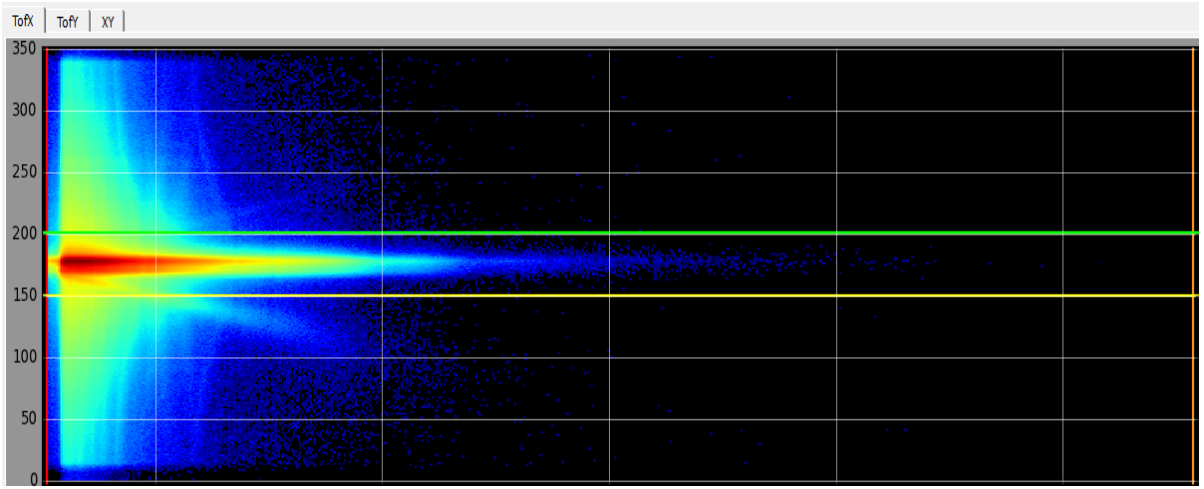
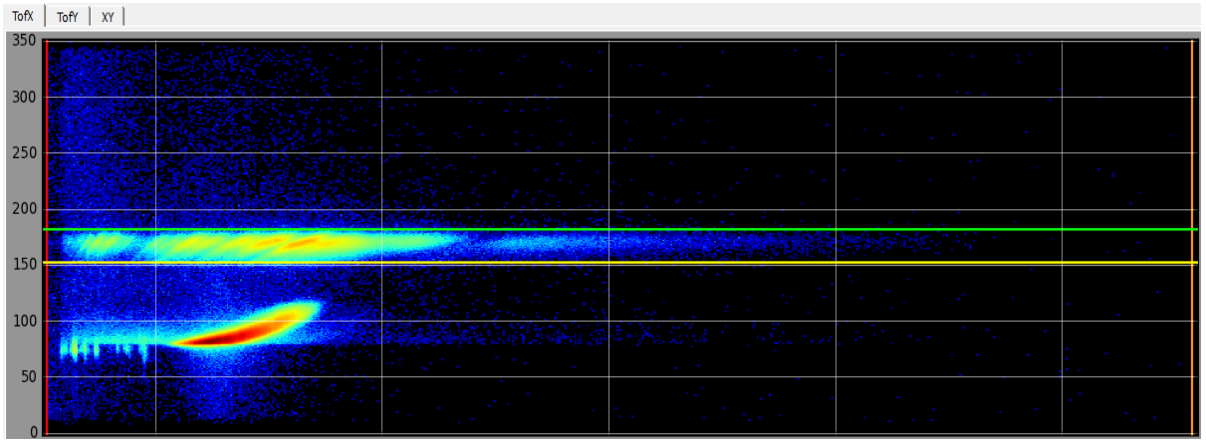
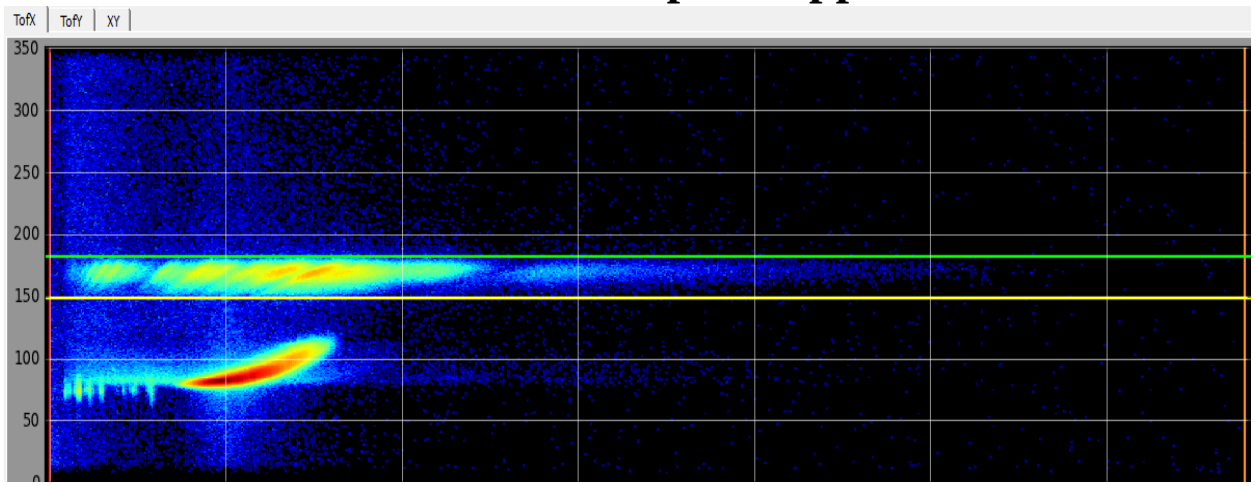
3- Spectra Viewer for : Al_2O_3/Nb100/Gd60]*12/Nb50



Empty beam



Spectra pp



Spectra np

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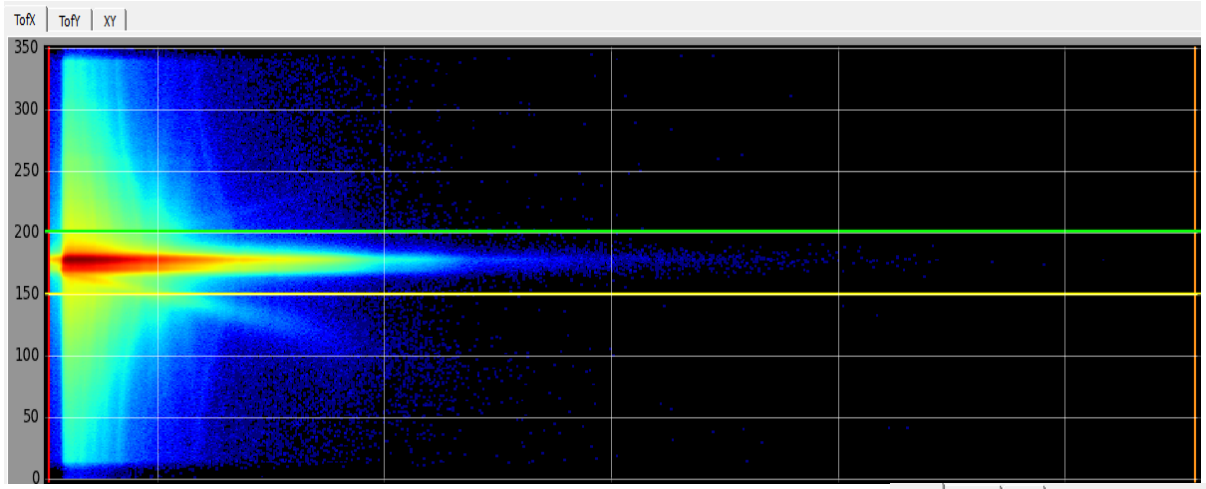
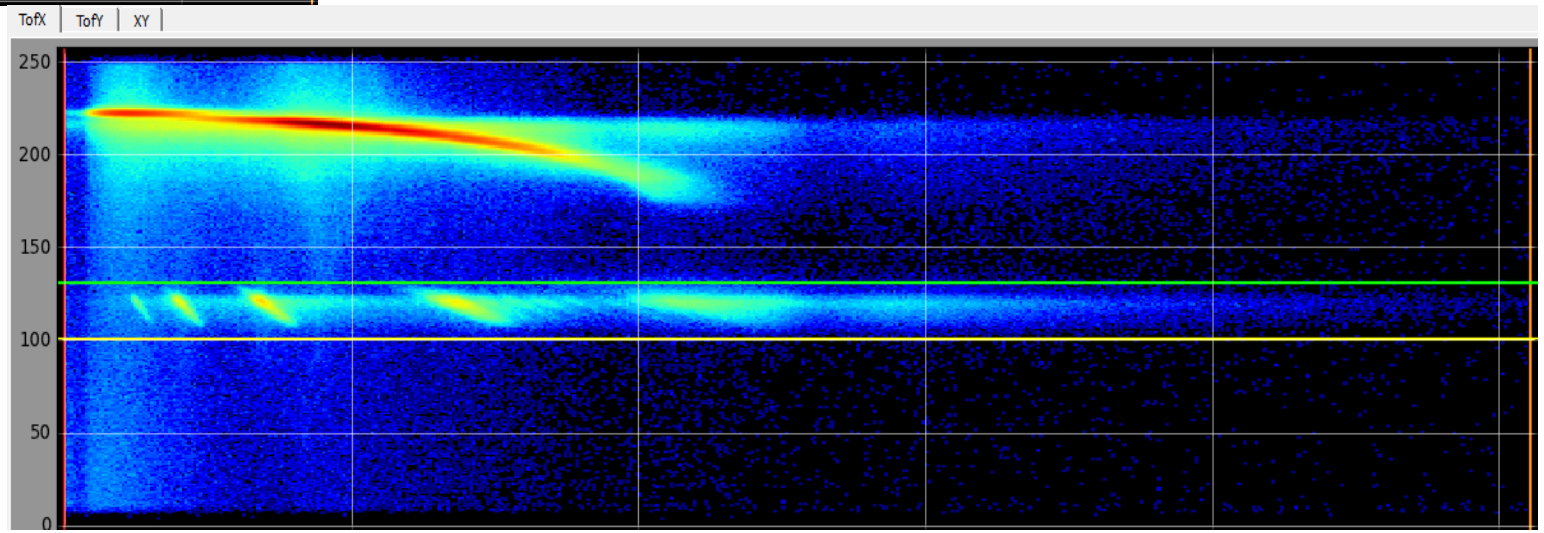
3- Spectra Viewer for : Al_2O_3/[Nb250/Dy60]*12/Nb50



Empty beam



Spectra pp

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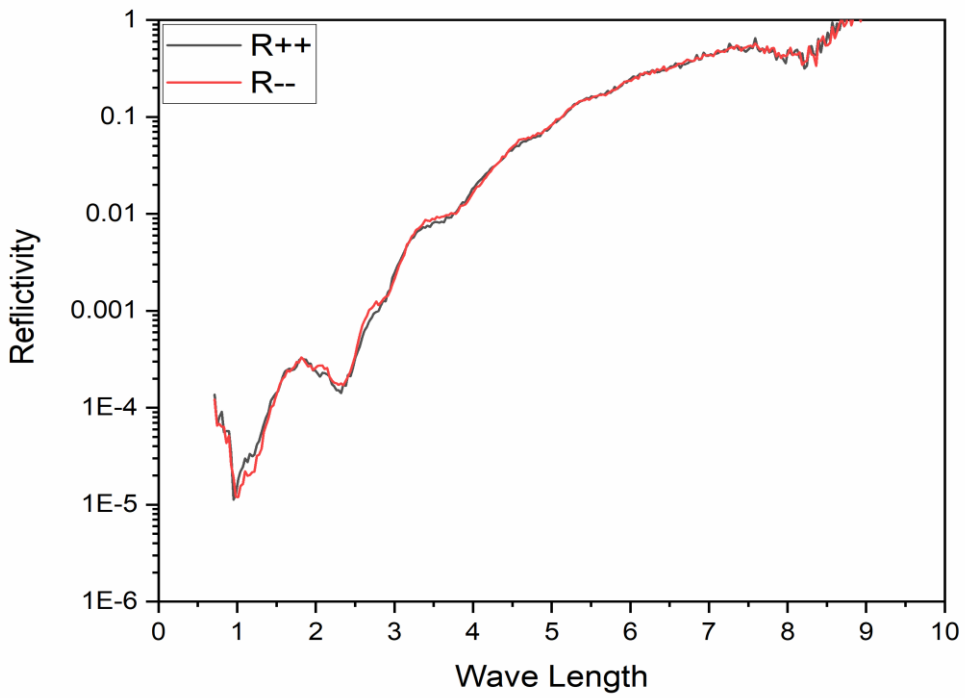
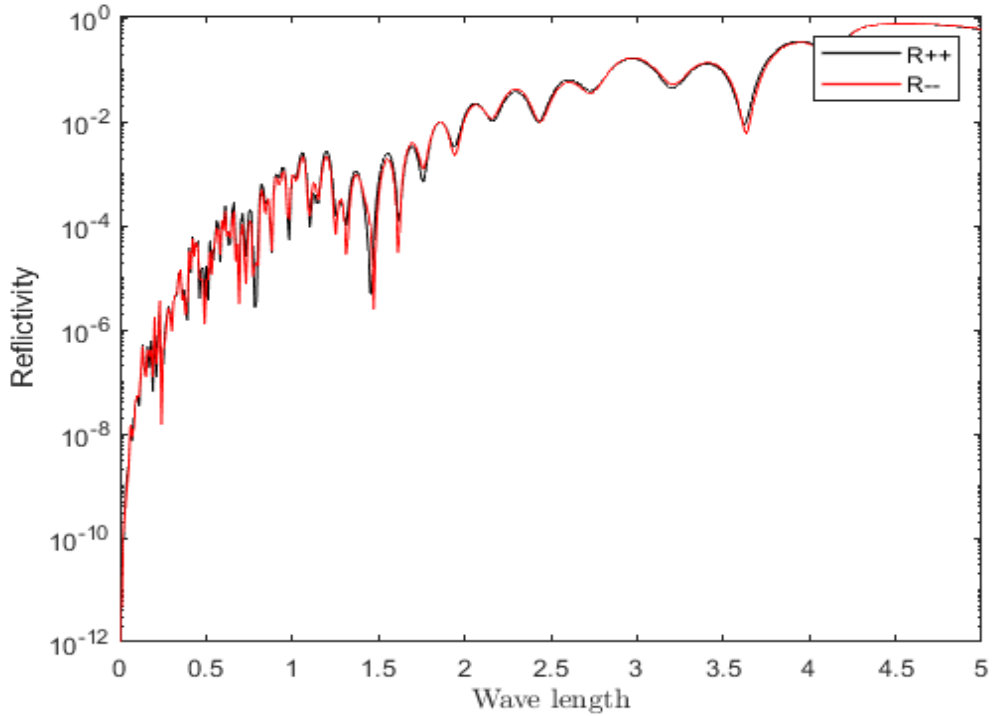
4- Comparison between the Experimental data and calculated data



Experimental data



Calculated data

In the next time we should do smooth for the calculated data.

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Thank you for your attention