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Realgymnasium Rämibühl Zürich

Thickness Identification of **2D Materials** by Optical Imaging

Exploring the Relation between Colour and Thickness of $FePS_3$ and $NbSe_2$

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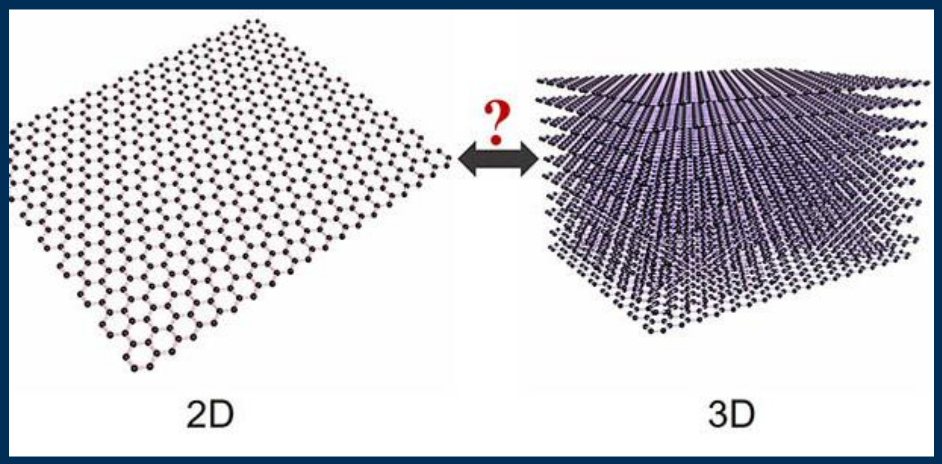
2D Materials



A single or **a few molecular layers**, called 2D materials, were obtained by exfoliation of $FePS_3$ and $NbSe_2$ 3D bulk crystals. Current research is interested in 2D Materials due to their **special properties** and wide range of applications.

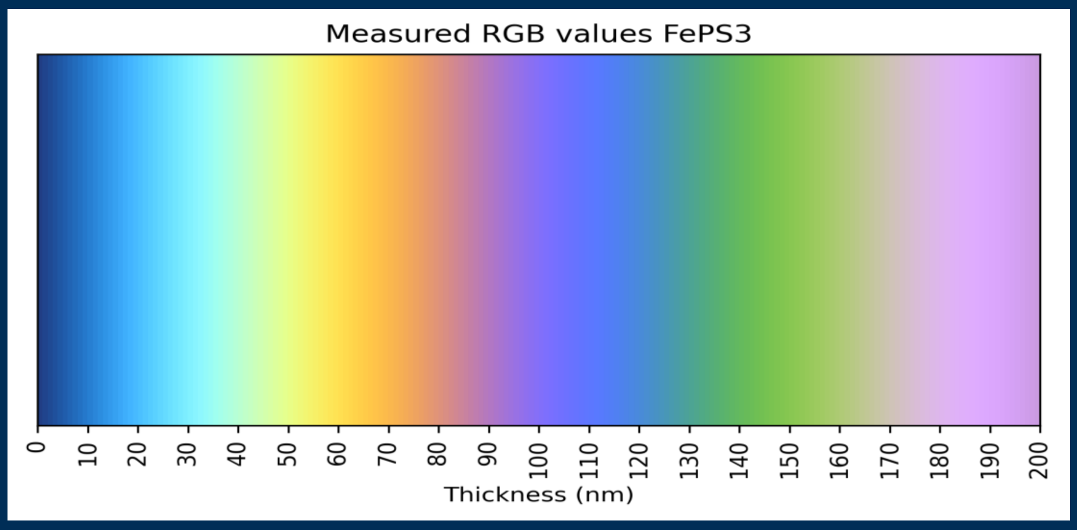
Research Question

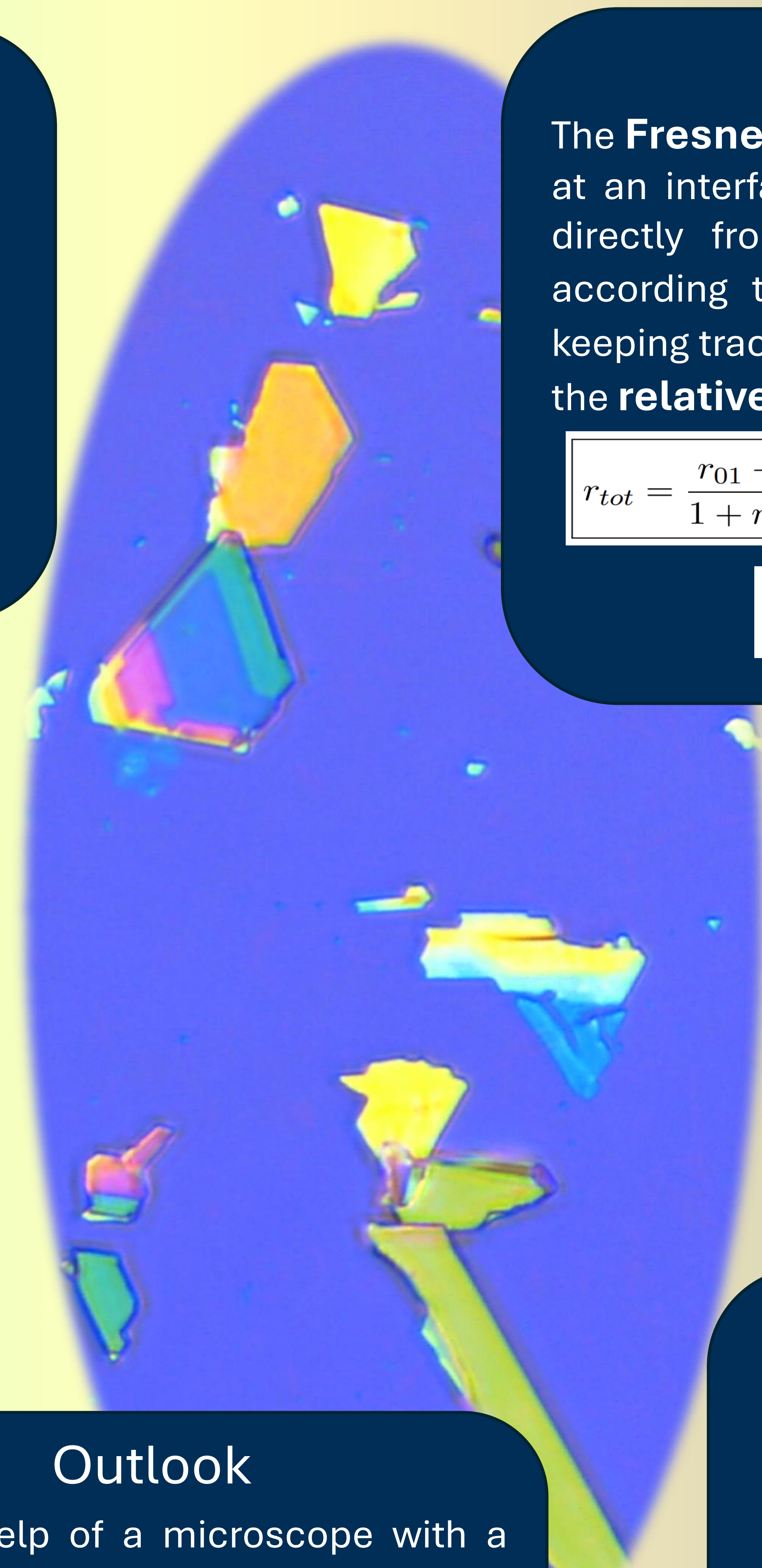
"How does the optical contrast and **the colour** of a three-layer system, consisting of thin flakes of the insulator $FePS_3$ and of the metal $NbSe_2$ on SiO_2/Si substrate, change as a function of **flake thickness**?"

Aim

The goal of this study is to assess the **feasibility and precision** of thickness identification of 2D Materials by optical imaging. The procedure is **much faster and cheaper** than conventional measurements with the Atomic Force Microscope.

Experimental Results



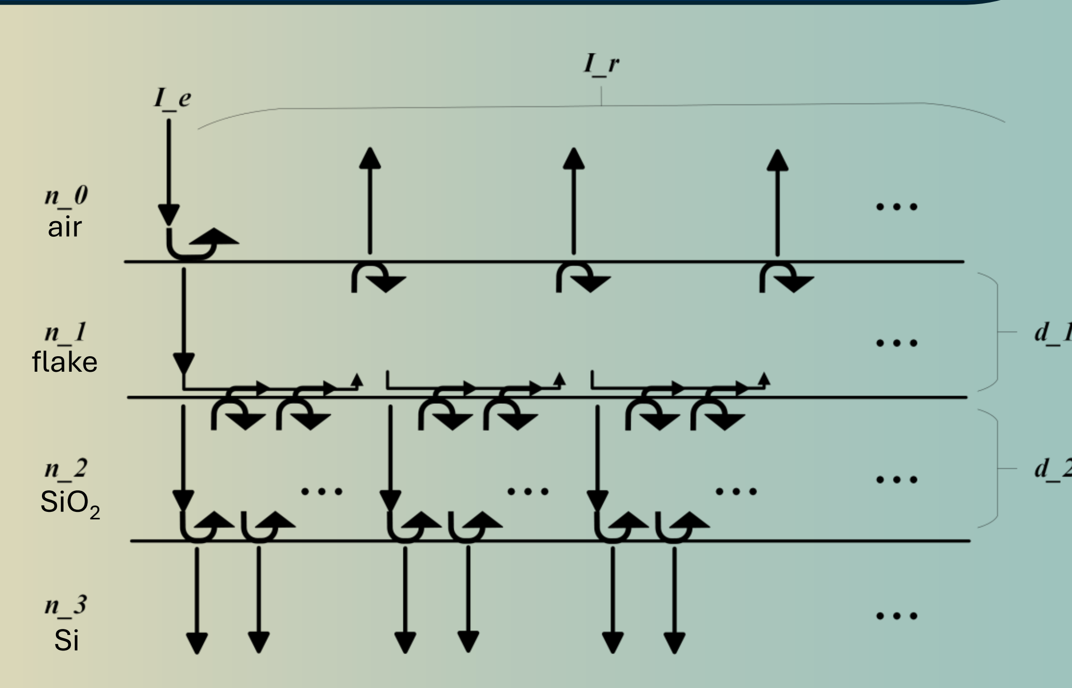


Theoretical Model

The **Fresnel equations**, which describe how light behaves at an interface of two different materials, can be derived directly from the Maxwell equations. Combining them according to the **light rays** in the graphic below and keeping track of **interference** yielded the final equation for the **relative reflectivity** of the three-layer system:

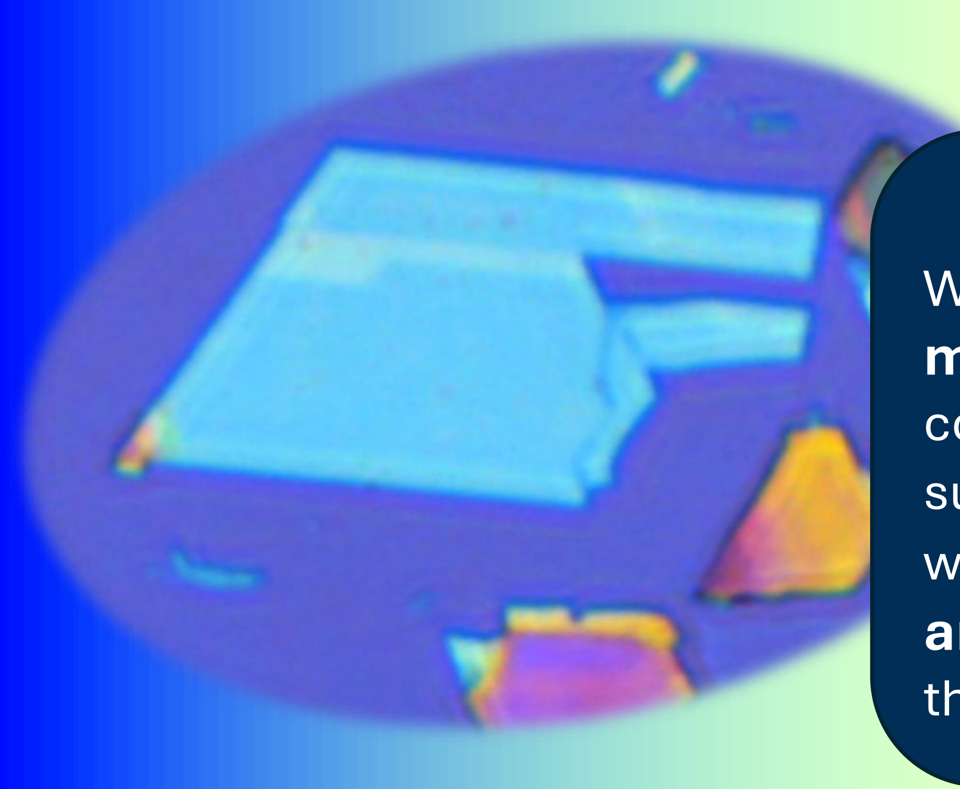
$$r_{tot} = \frac{r_{01} + r_{12}e^{-i2\Delta\phi_1} + r_{23}e^{-i2(\Delta\phi_1+\Delta\phi_2)} + r_{01}r_{12}r_{23}e^{-i2\Delta\phi_2}}{1 + r_{01}r_{12}e^{-i2\Delta\phi_1} + r_{01}r_{23}e^{-i2(\Delta\phi_1+\Delta\phi_2)} + r_{12}r_{23}e^{-i2\Delta\phi_2}}$$

$$\Delta\phi_1 = \frac{2\pi n_1 d_1}{\lambda} \qquad r_{01} = \frac{n_0 - n_1}{n_0 + n_1}$$



Applying the Results

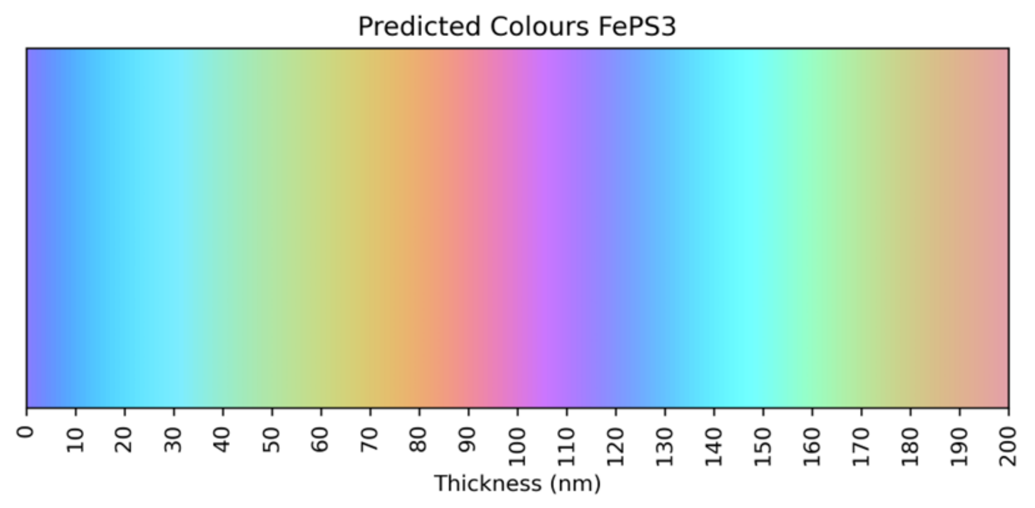
An application in Python was written to **overcome the hurdles and imprecision** of manual colour comparison. A test with the experimental data revealed, that its predictions are **precise** enough to be **used in the production** of 2D Materials for research.



Outlook

With the help of a microscope with a **mobile platform**, the application could be used to scan the whole substrate chip **automatically**. Thus, we have developed **a fast, large-scale and cheap** method to determine the thickness of 2D materials.

Theoretical Prediction



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