Bouncing neutrons and how they help scientists look at tiny things

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How do you look at small stuff? Simple: you shoot neutrons at it and look how they bounce! This method can reveal an inner structure of materials unobtainable by any other technique, and it is used in the development of a wide range of products, ranging from hair-products to medicines. The problem is that neutrons are tricky particles: they are difficult to produce and cumbersome to detect. As a solution to these limitations, the new European Spallation Source (ESS) is being constructed in Lund. At this facility, neutrons will be produced at a never before seen pace. This will require a new type of detectors, capable of keeping up with the intense numbers of neutrons bouncing every second. One of these detectors is the Multi-Blade, and it was the purpose of this thesis to examine if the current prototype works as expected.

I. What are thermal neutrons?

The neutrons used to bounce of the materials were *thermal* neutrons. These are neutrons with highly specific energy, namely the same energy as air particles have in normal indoor temperature. This is a very low energy, which gives the thermal neutrons some nice properties.

Thermal neutrons, as all neutrons, are electrically neutral particles. They are also very slow, which makes them bounce *elastically* of the sample under study. This means that the neutrons do not transfer any energy, and that the material is unharmed by the measurement. These two properties makes thermal neutrons an excellent choice as probes.

II. How are they used to measure things?

The procedure used to examine materials can be seen below in Fig. 1.

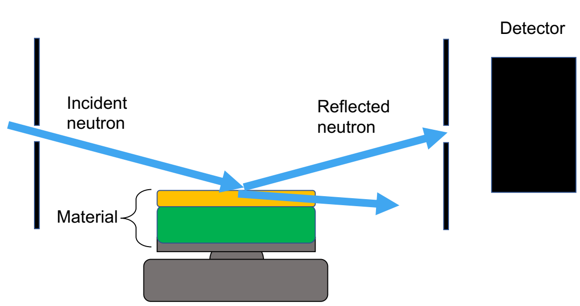

Fig. 1. Neutrons are sent in a thin beam, hitting the sample at an angle and bouncing to the detector. At the detector the number of reflected neutrons are counted.

The measurement is performed by shooting the neutrons at the sample and counting how many are reflected. This gives valuable information about the material under study, since the way neutrons bounce is heavily dependent on the type of material. You can compare it to throwing a tennis-ball in a pile of sand, and then another on a concrete block: the way they bounce gives you a hunch of what you threw the ball at.

III. How are they detected with the Multi-Blade?

Since neutrons are neutrally charged, they are very difficult to see. The solution the Multi-Blade offers is to first convert the neutrons to charged particles, which are easy to spot! When these charged particles are seen, it tells you that the neutron was there. This technique will enable the detector to spot neutrons very rapidly, which is required at ESS. It is therefore highly important that the detector is completed, so full potential of the neutrons produced at ESS can be used.

IV. What was the result of the thesis?

The purpose was to analyse a large amount of data collected from measurements with the Multi-Blade detector. The goal was to look at the data, convert it to physics, and see if the test material could be identified. This is seen in Fig. 2.

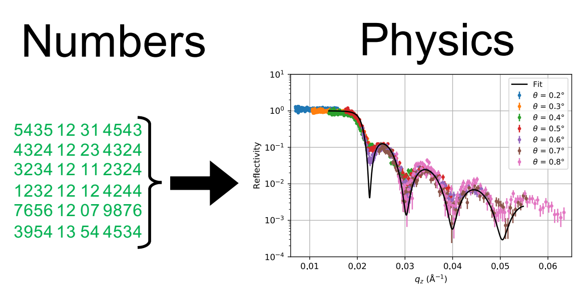

Fig. 2. Illustration of how data collected from measurements were analysed to find the physics.

This was successful, and the material could clearly be identified from the data. This is a highly important result, since it shows that the current prototype of the detector works as expected. Because of this result, the investigations can proceed to check other properties of the Multi-Blade. This thesis has been one step towards the final installation of the Multi-Blade at ESS.[1]

[1] The complete thesis can be found at: https://www.dropbox.com/s/jucraltd416pq38/Alexander_Master_Thesis.pdf?dl=0.