Experiment 16

Bragg Reflection

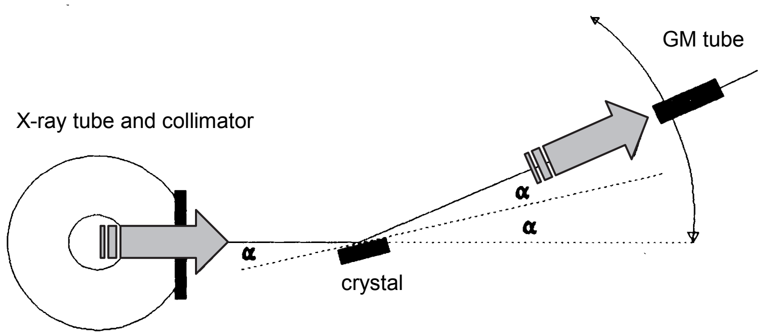
Name:
……………………………………………...

Aim

To measure the distance between the lattice planes in a crystal by using X-ray diffraction.

Set-up

The set-up consists of a rotatable crystal, placed between a fixed X-ray tube and a Geiger-Müller tube. The GM tube is connected to a rate meter.



The GM tube is mounted on a rotatable measuring arm. The rotations of the crystal and the GM tube are coupled: to rotate the crystal over an angle α, the GM tube has to be rotated over an angle of $2{\cdot}\alpha$. As a consequence, the GM-tube always measures the intensity of the X rays reflected by the lattice planes of the crystal (see the diagram above).
The X-ray tube produces X rays with two different wavelengths: 0.138 nm and 0.154 nm. When varying the angle α, the X rays with a wavelength λ of 0.154 nm give the highest maximum of reflected radiation.

Read the introduction on page 19 of the booklet *ISP Experiments* about X-ray diffraction.

Measurements

1 Switch on the X-ray tube: set the *time interval* button to 50 minutes, switch on the *power* button, and press the X-ray button. The device is ready for measuring when the red indicator lights up.

2 Move the measuring arm with the GM tube along the scale of the device between roughly 25° and 50°. By observing the rate meter, find the angle where the count rate clearly increases quite fast for a slight variation of the angle. The angle found in this way is roughly the first order maximum for the 0.154 nm wavelength radiation.

Angle (roughly): ………°

3 Position the measuring arm at an angle 1° less than the angle found above, and measure the intensity I (in pulses per 10 s) of the reflected radiation two times. Shift the measuring arm over an angle of 0.5°, and repeat the intensity measurements. Continue to do this until the measuring arm is at an angle of 1° past the angle found in measurement task 2. Record your measurements in the table below. For each of the angles, calculate the average intensity I_{avr} of the reflected radiation, and record your results in the table below.

observed angle GM tube ($2{\cdot}\alpha$)	angle between beam and crystal (α)	I (pulses/10s)		I_{avr} (pulses/10s)

Note: In working out the assignments below, you will need the equipment set-up twice for checking your answers in Assignments 3 and 4.

Assignments

1 The angle when measuring the highest intensity is the first order maximum. Calculate the distance d between the lattice planes (or: the lattice constant) of the crystal. In doing this, use the formula $n \cdot \lambda = 2 \cdot d \cdot \sin \alpha$ (see the booklet *ISP Experiments*, page 19).

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Lattice constant of the crystal: d = ……… nm

2 The table below shows the lattice constants of some substances. Identify the substance of the crystal in this experiment.

substance	LiF	NaCl	KCl	RbCl
lattice constant d (nm)	0.201	0.281	0.314	0.327

The crystal used is ………

3 The X-ray device emits radiation with a wavelength λ of 0.154 nm. This radiation will also give a second order maximum. Calculate the angle α of this second order maximum. In doing this, use the lattice constant d found in Assignment 1 and the formula $n \cdot \lambda = 2 \cdot d \cdot \sin \alpha$.

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Second order maximum for λ = 0.154 nm: α = ……°

Check your answer by measuring this angle with the equipment set-up.

4 The X-ray device also emits radiation with a wavelength λ of 0.138 nm. Also this radiation will give a first order maximum. Calculate the angle α of this first order maximum.

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First order maximum for λ = 0.138 nm: α = ……°

Check your answer by measuring this angle with the equipment set-up.