The structure of crystals could not, at the time, be seen directly with a microscope, but had to rely on diffraction. The geometry of the locations of the different diffracted beams/spots allow the structure to be represented in a virtual space which is called "reciprocal space".

**Using mathematics to see crystals**

A precise mathematical relationship, the "Fourier Transform", exists between the "reciprocal space", observed by diffraction, and the real structure of the crystal in "direct space".

In order to "understand" this relationship, think of Alice (in Wonderland), who has a direct view of the world of the crystal and its atoms, and that of Joseph (Fourier), who can only see those produced by the diffraction spots!

**Travelling into "reciprocal space"**

The direct observation of a "reciprocal space" via diffraction enabled crystallographers to see the symmetry of a crystal, the dimensions of its building block or "unit cell" and finally to "see" the atoms themselves: the diffraction pattern is a fingerprint which identifies each crystal.

**To understand more…**

Diffraction may appear complicated because it provides an inverse image, but this is nothing more than a superposition of sine waves, whose calculation was discovered by Joseph Fourier when he was the state representative "préfet de Grenoble" under Napoleon the First.

Joseph Fourier [Image]

Joseph Fourier was the state representative "préfet de Grenoble" under Napoleon. He discovered a complex periodic function can be decomposed into a sum of simpler functions (sine wave-like), which are now known as Fourier series. This information is encoded by his Fourier transform. Researchers can use Fourier transforms to "see" inside the particle crystals.

**These images are in parallel with...**

These images are in parallel with the vision of Alice (in Wonderland), who has eyes to see the world directly, the crystal and the atoms in "direct space" and that of Joseph (Fourier), who sees them in a diffraction in "reciprocal space". To see inside a crystal researchers detect the long distances. A beam of light with a wavelength is directed into a point just right for reflection. The reflection of each atom in the crystal produces a diffraction pattern.

**Joseph's vision of an object that is partially disordered, like wood or the threads of a spider's web (the spots are diffuse and large)**

Source: [Image]

Joseph Fourier was an Egyptian scholar and administrator. In 1802, he studied the propagation of heat and revealed powerful mathematical tools for those endeavors. He discovered a complex periodic function can be decomposed into a sum of simpler functions (sine wave-like), which are now known as Fourier series. This information is encoded by his Fourier transform. Researchers can use Fourier transforms to "see" inside the particle crystals.

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