Alice and Joseph in Crystal Land

Crystals can't be examined directly using microscopes; we have to use diffraction techniques. We can represent the structure of the crystals in a virtual space, known as «reciprocal space», using the geometry of the different diffraction spot sites.

Joseph Fourier

Egyptologist, administrator and scientist. As Prefect of France's Isère département in 1802, Joseph Fourier started to study the propagation of heat. He recognised that his calculations would require more sophisticated mathematical tools than those available at the time. He discovered that complex periodic functions could be broken down into a number of simpler functions (sinusoidal like waves), nowadays known as a Fourier series. This information was formulated in his Fourier transform. Researchers use Fourier transforms to understand complex periodic objects like crystals.

Source : Wikipédia

Using maths to visualise crystals

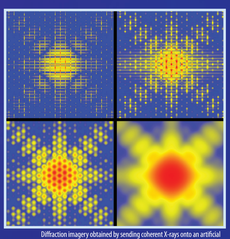
There's a strict mathematical relationship - called a «Fourier Transform» - between this reciprocal space observed by diffraction and the real structure of the crystal (called the «direct space»).
To get a better idea of the process, here are views of the way Alice (in Wonderland) sees crystals - a direct view into the crystal and its atoms - , and the way Joseph (Fourier) sees them - as a pattern of diffraction spots.

Journeying into reciprocal space

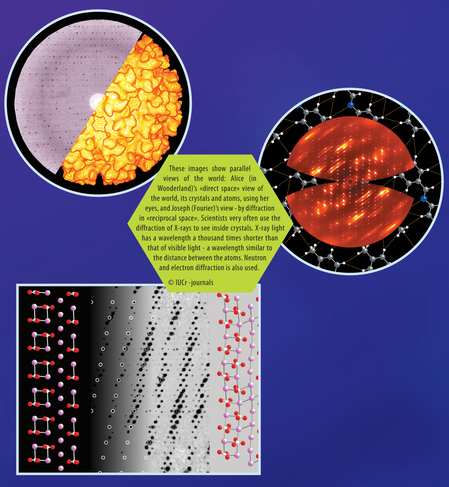
The observation of «reciprocal space» using diffraction imagery shows scientists the symmetry of a crystal, the size of its building blocks, and even a «view» of its atoms: **diffraction provides the fingerprint that distinguishes every crystal**.

Not so complicated:

Diffraction may appear complicated because it provides a reverse image, but this is nothing more than a superposition of sine waves, discovered by Joseph Fourier when he was Prefect of Isère under Napoleon I.



Diffraction imagery obtained by sending coherent X-rays onto an artificial crystal in an electronic circuit. © IUCr - journals



These images show parallel views of the world: Alice (in Wonderland)'s «direct space» view of the world, its crystals and atoms, using her eyes, and Joseph (Fourier)'s view - by diffraction in «reciprocal space». Scientists very often use the diffraction of X-rays to see inside crystals. X-ray light has a wavelength a thousand times shorter than that of visible light - a wavelength similar to the distance between the atoms. Neutron and electron diffraction is also used.

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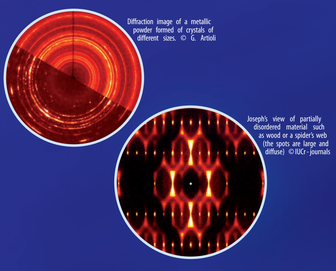

Diffraction image of a metallic powder formed of crystals of different sizes. © G. Artioli

Joseph's view of partially disordered material such as wood or a spider's web (the spots are large and diffuse) © IUCr - journals