Re: Meanwhile, back in the lab...

Source: http://sci.tech−archive.net/Archive/sci.physics/2005−05/msg02662.html

- *From*: mmeron@xxxxxxxxxxxxxxxxxx
- *Date*: Thu, 19 May 2005 21:18:16 GMT

In article <d6isdlnvs1@xxxxxxxxxxxxxxxxxxxxxxxxx>, glhansen@xxxxxxxxxxxxxxxxxxxxxx (Gregory L. Hansen) writes:
>In article <v_5je.95$25.20243@xxxxxxxxxxxxxxxxx>,
> <mmeron@xxxxxxxxxxxxxxxxxx> wrote:
>>In article <d6i7e3$h7v$1@xxxxxxxxxxxxxxxxxxxxxxxxx>,
>>glhansen@xxxxxxxxxxxxxxxxxxxxxx (Gregory L. Hansen) writes:
>>>In article <1116467397.252775.237190@xxxxxxxxxxxxxxxxxxxxxxxxxxxxx>,
>>>Sbharris[atsign]ix.netcom.com <sbharris@xxxxxxxxxxxxxx> wrote:
>>>>Greg, was my last question to you too difficult to answer off hand?
>>>>
>>>>The question I have is this: what happens when you run "few mev"
>>>>protons or neutrons through single crystals of (say) graphite at small
>>>>angles in comparison to the plane defined by the sheets of C atoms.
>>>>With the beam passing orthogonally (the 001 direction) through the
>>>>common plane defined by the stacked sheets, you'd get one attenuation
>>>>coeefficient. And presumably at right angles to that, so the particles
>>>>were passing straight down the "alleys" between the sheets (the 112
>>>>direction) you'd get another coefficient. In both cases these would
>>>>related to the average density of the crystal in the direction of
>>>>interest. But now, what happens when you tilt the thing just a little
>>>>in either direction from 112??? Do the particles now go off greatly to
>>>>one side or the other? And is the effective shielding coefficient per
>>>>mass a LOT greater in the direction where the particles DON'T go, than
>>>>you could get with other materials?
>>>>
>>>
>>>
>>>Sorry, I didn't see it before. I search for "hansen", so that's a sure
>>>way to catch my attention. Otherwise, whether I read a message or not is
>>>more or less by chance.
>>>
>>>But the angle of incidence still equals the angle of reflection, and that
>>>angle is relative to a scattering plane. The Bragg peaks in an ideal
>>>crystal are delta functions, any real crystal has peaks of a certain
>>>width, the Darwin width(?), that depends on its size and quality.
>>
>>Oh, no. The Darwin width of a perfect crystal with unlimited size is
>>still finite. Imperfections, absorption and other issues may broaden
>>it further but even an ideal crystal doesn't give a delta function.

>
>Really? I'll have to check on that, but I thought I remembered Fourier
>transforming lattices and finding delta functions in the limit of infinite
>crystal size.
>

Yes, true. But consider, what goes into this simple "the diffraction pattern is the Fourier transform of the lattice" picture? The assumption that all scatterers are illuminated by the same wave. This is not quite true in this case.

Since the atomic structure is not very relevant here, you may consider the crystal as a set (infinite, if you wish) of parallel, partially silvered mirrors. So, you've a plane wave impinging on this ensamble. Some fraction of it reflects of the first mirror. the rest continues, some fraction reflects of the second mirror, and so on and so on. The reflected magnitude is obtained by summing up all the reflections, with the appropriate phase factors, of course. But, note that all the reflections *are not* obtained with a wave of same amplitude. The wave impinging on the second mirror is a tad fainter than this on the first, because part of it has already been reflected. The wave impinging on the third mirror is a tad fainter yet, by the same factor. And so on. As the incoming wave propagates into the crystal it grows progressively weaker, thus it can be characterized by a finite effective penetration depth (so called "extinction length"). And the sum of the partial reflection amplitudes is a sum of terms which are not only shifted by a constant phase but also progressively diminishing. Such sum gives you not a delta function but a distribution of finite width, which is inversely proportional to the extinction lenght. And that's the Darwin width. You can say that, in effect, the extinction makes the crystal, from the point of view of the wave, into one of finite depth. And all of this is the result of the fact that the reflections are "in series".

Note that in the case of a 2D diffraction, say, from a diffraction grating, the reflections are "in parallel", not "in series". Thus, there is no extinction and the reflections are indeed (in the limit of a perfect, infinite grating) delta functions.

Note also that the description I gave above, though qualitatively correct, is still incomplete because it doesn't include multiple reflections (such as "the fraction of the wave which got reflected back from layer #12, then bounced forwrd again from layer #3, penetrated till layer 37, got reflected back again, etc. etc." and all possible combinations of the like). To include this it is better to get away from adding reflections and, instead, solve the wave equation with the appropriate boundary conditions on all the reflecting surfaces. This is in effect what Darwin did.

Mati Meron | "When you argue with a fool,
meron@xxxxxxxxxxxxxxxxx | chances are he is doing just the same"
.

- ***Follow−Ups***:
    - ***Re: Meanwhile, back in the lab...***
        - *From:* Gregory L. Hansen
    - ***Re: Meanwhile, back in the lab...***
        - *From:* Jan Panteltje

- ***References***:
    - ***Meanwhile, back in the lab...***
        - *From:* Gregory L. Hansen
    - ***Re: Meanwhile, back in the lab...***
        - *From:* Sbharris[atsign]ix.netcom.com
    - ***Re: Meanwhile, back in the lab...***
        - *From:* Gregory L. Hansen
    - ***Re: Meanwhile, back in the lab...***
        - *From:* mmeron
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        - *From:* Gregory L. Hansen

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