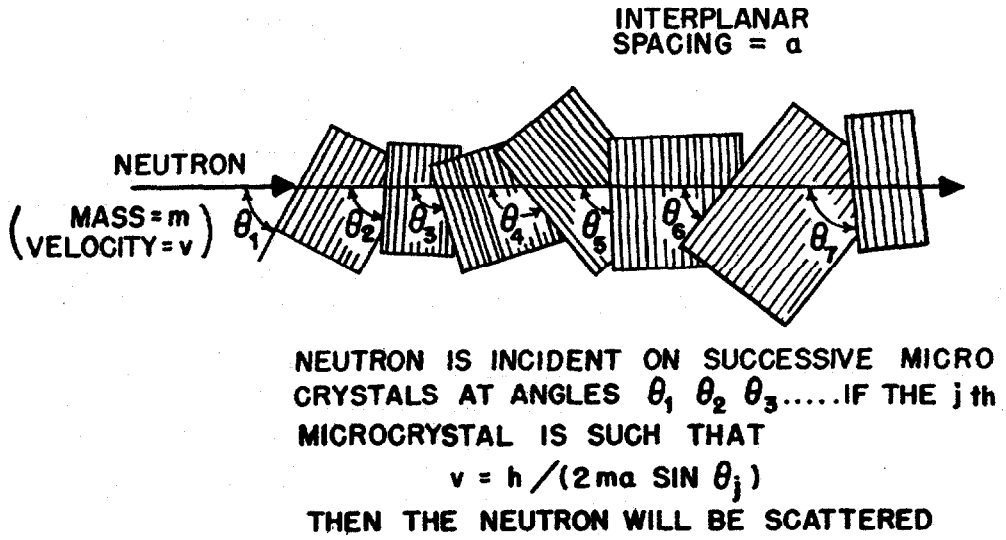

Figure 25. Scattering of neutrons by microcrystals.

of water, in which a neutron source has been placed, can be analyzed and found to have a Maxwellian distribution.

Microcrystalline substances scatter neutrons much better than regular crystalline substances. This can be understood by tracing the course of a neutron through a microcrystalline medium, Figure 25. If the Bragg condition is not fulfilled when the neutron arrives at the first microcrystal, then the neutron will pass on through. Otherwise, it will be reflected. When the neutron arrives at the next microcrystal, it must once again pass the test of not fulfilling the Bragg condition if it is not to be scattered. Were there but one crystal the neutron would have but one test to pass. However, with many randomly oriented microcrystals, the neutron has a large chance of being scattered. For a single large crystal, only those neutrons whose velocity satisfies the Bragg condition will be scattered. For the microcrystalline structure, sooner or later all velocity neutrons of the original beam will be removed as the beam passes from one crystal to the next.*

There is one very important difference between x-ray and neutron scattering. If the crystal is composed of two isotopes, the x-ray scattering is not particularly different from that which would be observed for a single isotope species, since *x-ray* scattering depends on the *extranuclear* properties of an atom. Since the extranuclear properties of two isotopes are very nearly the same, x-ray scattering is insensitive to isotope differences. On the other hand, in *neutron* scattering, the *nucleus* itself enters into the scattering process. Nuclei are such that in addition to determining the magnitude of the scattering cross sections, the *phases* of the scattered neutrons are determined.

Consider a neutron being scattered by two isotopes. If the first species has a scattering cross section σ_1 then the amplitude of the scattered neutron wave is proportional to $\sqrt{\sigma_1}$. Similarly, the the second species scatters with amplitude proportional to $\sqrt{\sigma_2}$. Suppose we write these amplitudes in a sum and difference form:

*This effect was observed in early experiments on silica: Phys. Rev. 54:771 (1938); 55:1101 (1939). See also recent data in Phys. Rev. 70:815 (1946); 73:741 (1948).

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