Physics 410/510

Experiment X-7

Diffractometer: Measurement of Atomic Vibrational Amplitudes and Atomic Electron Distributions

In this experiment, you will measure the Debye-Waller factor, i.e., the motion of atoms, in an aluminum lattice, and the atomic form factor, i.e., the charge distribution, in iron atoms. If you are not familiar with the elements of x-ray diffraction by crystals, it is recommended that you do the powder pattern (X-6) first. The attached chapters of the book by Warren may help in doing this experiment. Also, the attached papers are very useful. Read them!

1. Familiarize yourself with the diffractometer and the counting equipment. Read the notes attached to the x-ray power supply. Using CuK_α radiation obtain the integrated intensities of the lines from the pressed aluminum powder by measuring the areas (with planimeter) above background as recorded on the chart. Measure all reflections from (200) to (420).
   Using the appropriate function, construct a log plot vs. $(\sin\theta/\lambda)^2$ such that the slope will give the Debye-Waller factor for aluminum. From this determine the mean square amplitude of vibration. Compare with values in literature (International Tables for Crystallography, Vol. III).

2. Using a low-order aluminum reflection as a standard, measure the atomic scattering factor for the (110) and (200) reflections for the pressed iron powder. Use MoK_α radiation. Compare this with the values to be expected for the isolated iron ion with different numbers of 3d electrons.
   In you report discuss the various sources of error especially those other than involved with the actual taking of data. For example, extinction, surface effects, preferred orientation.

References:

B.E. Warren, "X-ray Diffraction," Addison-Wesley, Reading, 1969, Chapters 1-5, 11.
B.D. Cullity, "Elements of X-ray Diffraction," Addison-Wesley, Reading, 1956, in particular Chapters 4 and 7.
H.P. Klug and L.E. Alexander, "X-ray Diffraction Procedures," John Wiley, New York, 1954, Chapter 5.
R.W. James, "Optical Principles of the Diffraction of X-rays," Especially Part 3, Chap. 1 and 3.
C.S. Barrett and T.B. Massalski, "Structure of Metals," McGraw Hill, New York, 1966, 3rd ed.
W.P. Davey, "A Study of Crystal Structure," McGraw Hill, New York, 1934.

Papers:

R.J. Weiss, Revs, Modern Phys. 30, 59 (1958).
B.W. Batterman, Phys. Rev. 115, 81 (1959).
Batterman, Chipman and DeMarco, Phys. Rev. 122, 68 (1961).
B.W. Batterman, Transactions of the American Crystallographic Association 1, 1965.

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