Instrument Development at the Harwell Linac

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The philosophy of the choice of spectrometers has been to concentrate on spectrometers able to use the epithermal range of neutron energies. The first seven spectrometers on the following list are ready, the others are in construction and will be installed during 1981. They are arranged on the two sides of the target shield as shown in the figure.

1) Total Scattering Spectrometer (TSS). A standard fixed angle diffractometer with a time focussed counter bank near 150°, of 0.12 steradian solid angle, and single counters in pairs at 90°, 58°, 35°, 20° and 10° which view curved boron carbide slits following the Debye-Scherrer cones. It has an incident flight path of 5.5 m and a scattered flight path of 0.46 m. The Q resolution $\Delta Q/Q = 0.01$; the useful Q range is from 0.6 to 60 Å^{-1}. The instrument is used to measure structure factors from ordinary and metallic glasses, molecular liquids, and liquids under pressure, and for phase diagram and time-dependent studies of diffraction patterns.

2) Back Scattering Spectrometer (BSS). A longer flight path of 12 m and a time focussed counter bank 2 m from the sample at 170° gives resolution $\Delta Q/Q = 0.003$, with solid angle of 0.056 steradians. The Q range available without frame overlap is from 5 Å^{-1} to 100 Å^{-1}. The instrument is for powder diffraction to high spatial resolution, for Debye-Waller factor determinations, and for particle size and strain broadening measurements.

3) Active Sample Diffractometer (ASD). This simple diffractometer has a short incident flight path of 1.6 m so that the sample lies within the target cell inside the biological shield. The scattering angle is 155° to give a Q resolution $\Delta Q/Q \sim 0.02$. Active samples can be lowered into position through the shield from the target services room above the cell. It will be used for irradiated samples, samples containing unstable isotopes, and high fission cross-section samples.

4) Inelastic Rotor Spectrometer (IRS). This has a single nimonic rotor giving incident energy monochromatic neutrons in the 200 to 400 meV range. It has a large scattering angle range from 4° to 140° but its major counter bank is from 4° to 11° so as to reach energy transfers in the 50 to 150 meV range with low scattering vectors Q below 5 Å^{-1} with $\Delta\hbar\omega/\hbar\omega = 5\%$ resolution. This enables vibrational spectrometry to be done with low multiphonon broadening and vibrational harmonic contamination. It also enables magnetic inelastic studies to be done within the limitation imposed by the form factor.

5) Constant Q Spectrometer (CQS). This crystal analyser spectrometer is for coherent inelastic studies using single crystal samples. It works with relaxed vertical collimation (60 x 10 mm^2 at the sample), and uses the MARX principle to obtain the energy scan. The germanium analyser is in transmission geometry so that the reflecting planes may be readily changed. The counter is a 50 element glass scintillator bank. At $|\underline{Q}| = 4\ \text{Å}^{-1}$, energy scans at a specified $\underline{Q}$ value are possible from 10 to 140 meV using Ge(511) planes. It will be suitable for high energy transfer phonon and magnetic excitation studies because of the good intensity and resolution of its incident neutrons.

6) Single Crystal Spectrometer (SCS). This is a development instrument constructed by the Rutherford Laboratory under Dr. Forsyth. Its basic counter array is a 32 element glass scintillator array covering scattering angles from 20° to 148° in the scattering plane. Later versions will include a secondary counter on the opposite side of the specimen which will test out two-dimensional position-sensitive detectors. It will be used for refinements of single crystal structures to high spatial resolution.

7) Resonance Detector Spectrometer (RDS). This development instrument has been constructed within a long vacuum pipe so as to allow low angle forward scattering with a total flight path of about 10 m. With a scattering angle of around 1° and a ^{238}U foil, neutrons are detected at 6.67 eV allowing energy transfers up to 1.2 eV with scattering vector $|Q| \sim 5$ Å^{-1}. γ rays from the foil will be detected by an intrinsic germanium detector with facility for γ ray energy discrimination. Initial studies will be on magnetic excitations.

8) Transmission Cross-section Spectrometer (TCS). This simple spectrometer is being operated in collaboration with Harwell's Nuclear Physics Division. It measures removal cross-sections over the range from 1 meV to 1000 eV. It uses converging-diverging geometry to allow good statistics with small samples. It will be used for basic nuclear data studies, for correction factors to diffraction studies, and also for test experiments on structure factor, vibrational spectra, and defect studies.

9) Liquids and Amorphous Diffractometer (LAD). This is a spectrometer for the Spallation Neutron Source (SNS) which will be installed on the Harwell Linac to relieve the load on total scattering studies until the SNS is operating.

10) High throughput Chemical Spectrometer (BFS). This is also an SNS instrument which will eventually be transferred to the SNS. It is a simple beryllium filter design with a long 12 m incident flight path and short 250 mm scattered flight path so as to allow reasonable incident energy resolution without precise definition of the scattered neutron energy. It will be used for vibrational spectroscopy studies.

11) Polarisation Filter Spectrometer (PFS). This is a total scattering spectrometer with full polarisation analysis constructed by the Rutherford Laboratory. Polarisation analysis will be done by two samarium absorption filters. At a fixed scattering angle of say 10° this will be used for the separation of magnetic from nuclear structure factors, and the separation of coherent from spin-incoherent diffraction patterns.

12) Small Angle Spectrometer (SAS). This is a development instrument. It has a velocity selector to give a $\Delta\lambda/\lambda \sim 10\%$ wavelength band over a 1 cm^2 beam area. A flexible scattered flight path area allows a 400 element position sensitive scintillator array with 1 cm^2 mesh to be placed up to 4 m away. Position analysis within a fixed time gate then allows small angle scattering with inelastic discrimination.

Data Collection

The data collection system is essentially complete. Each spectrometer has its own time-of-flight scaler and front-end computer (DEC 11V03 running on RT11) containing identical data collection programmes written in assembler code. These are linked by a relatively slow serial link to the hub computer containing the hard-copy, display and magnetic tape facilities. (DEC 11/40 with 112K core running on RSX). Communication with any experiment is through any of several terminals located in the computer rooms, experimental halls or offices. Each run is archived into a data-base system together with a header block of 256 words containing all information thought relevant to subsequent analysis. These are mostly stored on a large 60 M Byte disk. For each spectrometer, suites of FORTRAN programmes are being written to perform instant analysis of data. For example, automatic location of diffraction peaks, together with their widths and intensities, is already possible. Also the computation of the constant Q scan from the Constant Q Spectrometer can already be done automatically.

Figure 1. The Harwell Linac Condensed Matter Cell