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SCIENCE RESEARCH COUNCIL

Research Reactor Committee

HERALD REACTOR FACILITIES AND UTILISATION

COLD NEUTRON SOURCE

After completion of the refrigerator by Elliott Electronic Tubes Ltd. in June, the plant was operated continuously for fourteen days as part of the acceptance tests. During this period the plant operated successfully at power levels above 500 watts for most of the time. There were no blockages of the refrigerator during the test period, but excessive oil consumption by one of the compressors had been observed. Following shut down of the plant the cause of the high oil consumption was investigated by the compressor manufacturers and many tests were carried out on site, but finally the compressor was returned to the factory for rebuilding. The oil consumption is now satisfactory although a complete explanation of the cause of the fault has not been given.

During the examination of the faulty compressor it became apparent from the increase in noise level that a bearing in the compressor fluid drive was failing. The manufacturers of the drive units decided that the mounting was unsatisfactory and agreed to re-build them incorporating an additional bearing in the design. These two faults, together with minor modifications to the refrigerator, took three months to rectify and it was not until 8th October that the final acceptance test could be made.

Following the hand-over of the refrigerator by Elliott's the installation of the transfer lines by AWRE was completed. The refrigerator has been connected to an electrically heated dummy load suspended on the outside of the biological shield of the reactor and is now to be tested in this configuration. These tests are expected to last one month, during which time experience will be gained by the operating staff. The transfer pipes will then be connected to the cold source proper, routine operation starting in January, 1966. The new beam tube collimator, liquid nitrogen cooled beryllium filter and neutron velocity selector to be used by Reading University with the cold neutron source are now installed, and will be used to measure the neutron gain produced by the source.

BIRMINGHAM UNIVERSITY BEAM EXPERIMENTS

Cold Neutron Scattering

During the last three years the research programme on the C1G hole has been devoted to the development of cold neutron inelastic scattering apparatus. Measurements made so far (1) have been on benzene, diphenyl, and the three isomers of terphenyl in the temperature range 40 - 250°C in both solid and liquid phases. Diffusive motions in the liquid state were studied by an analysis of the broadening of the quasi elastic peak and the results compared with three theoretical models. Results show that simple, perfect gas, diffusion does not take place but that interactions between the molecules must be considered. From the results a diffusion time of 10^{-12} seconds is obtained and activation energies for the diffusive modes produced.

At larger energy gains the interactions are with the intra-molecular modes and the interest in this type of measurement lies in the fact that the terphenyls are potential reactor moderators. In the case of benzene

the results can be directly compared with a model of its internal vibrations.

The limitations in these experiments were due to the energy resolution of the apparatus which in turn was dictated by the available flux of neutrons at 4 Å. The advent of the cold neutron source should make possible more detailed and extensive measurements.

A narrow slit rotor is being manufactured and a 4K channel magnetic core store for the on-line analysis of the data will be delivered shortly. In addition major modifications have been made to the shielding that have reduced the background by an order of magnitude.

The immediate programme is to examine the scattering from water at high temperature and pressure making use of a high pressure sample holder obtained from PNR group at Harwell.

The modified apparatus will be available in time to make use of the enhanced neutron flux from the cold source.

The present complement consists of a research associate and two research students.

Neutron Radiography

Experiments on neutron radiography have been carried out and comprise thermal and cold beam work (2,3,4) and resonance radiography measurements using the neutron crystal spectrometer (5,6,7). The work has been reviewed by J. P. Barton (8).

The current staff complement on radiography is one Research Associate and one research student.

READING UNIVERSITY BEAM EXPERIMENTS

Crystal Defect Studies

Using the first neutron velocity selector (9) experiments have been in progress on the neutron scattering from defects in quartz and silicon (10). These measurements have been in the range 6 - 16 Å. The measurements on defects produced by the reactor irradiation of quartz have extended the wavelength range beyond that used in previous work. Measurements are also being made on fused silica (amorphous) and there is a similarity in the wavelength dependence of the neutron scattering by defects in irradiated quartz and the scattering from fused silica. These measurements are being continued at higher levels of irradiation and analyses of the wavelength dependencies in terms of defect distributions are being carried out. Measurements are also being made on neutron irradiated silicon and neutron irradiated germanium. There is indirect evidence from other physical properties that, whereas neutron irradiation of germanium produces both point defects and larger regions of disorder, in silicon, neutron irradiation produces primarily point defects. This should show up quite conclusively in the long wavelength neutron scattering measurements.

It has been decided that, following the interpretation of stored energy release in graphite proposed by Mitchell and Taylor (11), further measurements are required of the long wavelength neutron scattering from defects in irradiated graphite. A set of measurements on four graphite samples has been started. During the year, an attempt was made to study the scattering of neutrons by defects introduced by electron irradiation.

This attempt was unsuccessful owing to lack of electron intensity, in spite of the fact that a very high electron dose was used for the irradiation. It is planned to repeat this experiment when the cold source is in operation.

Measurements have been completed on the scattering of silicon containing phosphorus impurity. The results showed that the relaxation of silicon atoms around the phosphorus impurity was less than 20% and a note about this work is being prepared for publication.

The measurements above have all been carried out with the first velocity selector, first on hole G1C and subsequently in its new position on G2C.

A second velocity selector has been built and is now in position on hole G1C, ready to start measurements as soon as the cold source equipment is installed. The plan is to use this apparatus for work at the very long wavelength end, 9 - 16 Å, keeping the other apparatus on G2C to look at the region 6 - 10 Å where, in many cases, the ambient temperature flux is sufficient. The selector on G1C will also be used to continue the cold source optimisation study and replaces the slow chopper spectrometer which was used by AWRE to begin this work. Complete out-of-pile equipment is available for the continuous operation of both instruments. Owing to the delay in the installation of the cold source, measurements have so far been made on only one position. It is expected that both will be in full operation from the beginning of December.

The current staff complement on defect studies is one Staff member and two research students.

Nuclear Fission

An experimental investigation on nuclear fission has been carried out by a research student in collaboration with AWRE Beam Physics Section. The salient features of the work (12) are the mass and energy distributions of fission fragments arising from thermal neutron induced fission of U-235. Fine structure is observed in the mass yields appropriate to both before and after prompt neutron emission and conclusions are made about the fragment yield. The measurements have also enabled the pulse height response of surface barrier counters to fission fragments to be evaluated. The results show that the response depends upon both the energy and the mass of the fission fragment (13,14).

SAMPLE IRRADIATION SERVICE

From April to November, 1965 sample irradiations have been done for the following:

Reading University Physics Department	-	Professor E.W.J. Mitchell
Queen Mary College, London. Department of Chemistry	-	Dr. D. S. Urch
Manchester University Department of Chemistry	-	Dr. G. W. Newton

Imperial College, London Department of Chemistry	-	Dr. L. V. Rees
Cambridge University Cavendish Laboratory	-	Dr. R. E. Offord
Chelsea College, London Department of Chemistry	-	Dr. J. D. Donaldson
Welsh College of Advanced Technology Department of Applied Physics	-	Dr. B. Thomas

GENERAL

An AEA Experimental Officer has been recruited to assist SRC beam programmes.

At the request of Dr. D. A. Read of Leeds University the AWRE Neutron Beam Section made diffraction studies of a sample of iron-vanadium at ambient and liquid nitrogen temperatures to discover if magnetic ordering existed at the low temperatures. The results were inconclusive. A request has been made for a larger sample and research student assistance but the latter is not forthcoming.

A PDP 8 computer with auxiliary store and peripheral logic circuitry has been ordered by AWRE and delivery is expected in May, 1966. Although intended initially for AWRE experiments it is envisaged that it could form part of a data processing system on HERALD capable of handling SRC experiments also.

SUB-COMMITTEE ON EXPERIMENTAL FACILITIES

In June, 1963 a Sub-Committee of the Research Reactor Committee was set up to supervise the project for providing the liquid hydrogen source in HERALD and to review progress on the liquid nitrogen irradiation facilities. It was chaired by Dr. J. M. Valentine until recently. In addition to its main function it proved to be a useful forum for the discussion of problems relating to University utilisation of HERALD in general, before bringing them to the attention of the main Committee.

It is recommended that the Sub-Committee should continue to supervise University utilisation of HERALD, in general, until such time as there is a more formal users committee set up to deal with University utilisation of AEA Reactors. Some changes or additions to the membership of the Sub-Committee might be useful to deal with the anticipated business.

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Reports relating to University work on HERALD

1. The scattering of cold neutrons by hydrogenous materials by F. Szabo, Ph. D.Thesis, Birmingham University, 1965.

2. Determination of the characteristic curves of various film-scintillator combinations used in neutron radiography by E. J. Oakes. Submitted for M. Sc Thesis, Birmingham University, 1965.

3. Radiographic examination through steel using cold neutrons by J. P. Barton and accepted by British Journal Applied Physics.

4. Radiography using cold neutrons by J. P. Barton, British Journal Applied Physics 16, 1051, 1965.

5. Radiography with resonance energy neutrons by J. P. Barton, Phys. Med. Biol. 10, 209, 1965.

6. Radiography using the neutron crystal monochromator by J. P. Barton, J. Sci. Insts. 42, 540, 1965.

7. A neutron crystal monochromator by J. M. A. Reichelt, AWRE Report O-98/65.

8. Concepts in neutron radiography by J. P. Barton. Submitted for Ph. D Thesis, Birmingham University, 1965.

9. A long wavelength neutron velocity selector. C. D. Clark, E. W. J. Mitchell, D. W. Palmer and I. M. Wilson. J. Sci. Insts. (in print), 1965.

10. Long wavelength scattering defects in quartz. I. M. Wilson. Presented to Bristol Conference on Solid State Physics, Jan. 1965.

11. The mechanism of stored energy release at 200°C in electron irradiated graphite. E. W. J. Mitchell and M. R. Taylor. Nature, November, 1965.

12. Study of fission fragments from U-235 by time-of-flight technique by G. Andritsopoulos, Ph. D Thesis, Reading University, 1965.

13. Simultaneous measurement of flight times and energies of fission fragments by G. Andritsopoulos (Reading University), T. Cornell and A. L. Rodgers (AWRE). I.A.E.A. Symposium on Physics and Chemistry of Fission, 1965.

14. The pulse height response of a surface barrier counter by G. Andritsopoulos (Reading University), E. E. Maslin and A. L. Rodgers (AWRE), Paper to Symposium on Semi-Conductor Junctions. Inst. Phys. & Phys. Soc. 1965.

15. The Research Reactor HERALD at AWRE Aldermaston, by J. J. McEnhill, A. L. Rodgers and M. C. J. Todd. Journal of the British Nuclear Energy Society, October, 1965.