NEUTRON SPECTROMETRY RESEARCH AT PARC

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ABSTRACT

Current research activities on neutron spectrometry at the Philippine Atomic Research Center are reported. Several related activities which include the construction, installation and improvement of ancilliary facilities are also briefly reported. A list of previous reports on neutron spectrometry research at PARC is given.

INTRODUCTION

The Philippine Atomic Research Center has two types of neutron spectrometers installed at the Philippine Research Reactor (PRR-I). These are the Double-Axis Neutron Spectrometer and the Beryllium Detector Spectrometer. The Double-Axis Neutron Spectrometer was initially loaned by the Government of India for the five-year IPA (India-Philippines-IAEA) project which started in January 1965 and was subsequently donated to the PARC upon the termination of the project. This Neutron Spectrometer has been used mainly for the investigations of magnetic materials, liquids and crystal structures. The Beryllium Detector Spectrometer, on the other hand, was locally fabricated and has been used for

investigations of crystal hydrates and ammonium salts.

The present report gives an outline of the neutron spectrometry research and related activities currently being undertaken at PARC by the Physics Department. The report also gives the list of previous works that have been undertaken.

CURRENT RESEARCH ACTIVITIES

1. Investigations on Doped Hematite

The aims of the present study are to determine the atomic ordering, magnetic structures, sublattice magnetizations and magnetic transition temperatures of doped hematite and to study the systematics of the various structural and magnetic properties with the concentration of impurities.

Initial investigations are being made on the x Al_2O_3.(1-x) Fe_2O_3 system.

2. Atomic and Magnetic Ordering in Ternary Alloys

The project involves the determination of the magnetic ordering in ternary alloys of transition metals. These investigations form part of an extensive program on the study of the behaviour of transition metal atoms in various crystalline environments. Samples of CoMnGe and CuMnGe are currently being investigated.

3. Neutron Diffraction Studies on Transition Metal Carbides

Previous work has been made during the IPA Project on manganese-nickel carbide and manganese-zinc carbide. In continuation of the studies of the behaviour of magnetic atoms in carbides, samples of $(Mn, Co)_4C$ with different concentration ratios of Mn to Co are being prepared to study the magnetic properties, particularly the magnetic phase diagram of the system.

4. Magnetic Transitions in Ferrous-Zinc Ferrites

Ferrous-zinc ferrites exhibit a spinel structure. Extensive experimental and theoretical investigations have been made on this type of structures. The aim of the present study is primarily to determine the magnetic transitions in ferrous-zinc ferrites using neutron diffraction methods. The studies also involve the determination of magnetic structures, sublattice magnetizations, as well as structural parameters of the samples. From these studies, the nature of the Verwey transitions and the magnetic interactions among Fe^{2+} and Fe^{3+} ions above and below the Verwey transitions may be elucidated. Similar investigations will be made using the Mössbauer Spectrometry facility of the Physics Department to complement the Neutron Spectrometry results.

RELATED ACTIVITIES

1. Modification of the Liquid Nitrogen Cryostat

A liquid nitrogen cryostat for use in neutron spectrometry has been built during the time of the IPA project. Defects in the design and fabrication exist which prohibit the cooling of the sample down to liquid nitrogen temperatures and the cleaning of the accumulated dirt inside the cryogenic vessel. To remedy these, a new inner vessel has been made. The new design will allow the cooling of the sample not only at liquid nitrogen temperatures but also at intermediate temperatures from liquid nitrogen temperature to about 500°C.

Another cryostat incorporating the new design of the inner vessel has been planned for construction so both the double-axis neutron spectrometer and the beryllium detector spectrometer can be used simultaneously for low temperature experiments.

2. Construction of an Arc Furnace for Materials Preparation

Working drawings of an arc furnace for the preparation of high melting point materials have been made and submitted to the workshop for fabrication. The first phase of the project involves the construction of a single arc furnace. Both the anode and the cathode bodies are water-cooled. A ball and socket assembly allows for the swinging motion of

the tungsten electrode. The construction materials are mostly brass; the hearth is made of graphite and is movable vertically.

The second phase of the project involves the construction of a tri-arc furnace. The anode body remains basically the same as that of the single-arc furnace. The cathode body, however, contains three electrodes each mounted in a ball and socket assembly and a central rod for pulling a single crystal seed from the melt.

Crystals grown from this facility will be used for neutron spectrometry, Mössbauer spectrometry and other physics experiments.

3. Ball Milling Facility for Sample Preparation

A simple stainless steel ball mill has been fabricated in connection with the preparation of materials for neutron spectrometry research.

4. Installation and Testing of New Vacuum System

A vacuum system has been installed and successfully tested for use at low and high temperature experiments on the Double-Axis Neutron Spectrometer.

The fabrication of vacuum components such as, oil diffusion pumps, vacuum valves, couplings and various fittings have been programmed. The fabrication of these components will allow the setting-up of another vacuum

system facility for use with the beryllium detector spectrometer which will become necessary when simultaneous runs of both the Beryllium Detector Spectrometer and the Double-Axis Neutron Spectrometer are carried out.

5. Neutron Diffraction Electromagnet

The regulated power supply for the locally built neutron diffraction electromagnet has been repaired and tested. The electromagnet will be tested and the magnetic flux will be mapped for various pole gaps.

The design of a ball-race support for mounting of the heavy electromagnet on the neutron spectrometer table is being undertaken.

6. Computer Programs for Neutron Spectrometry

Several computer programs for the analysis of neutron scattering data are available. The adaption of these programs for the PES-DND computer is being made for facilitating the analysis of neutron diffraction data obtained at PARC.

7. Installation of Philips X-ray Diffractometer

A Philips X-ray Diffractometer has been purchased and is currently being installed in the Physics Department Laboratory. The x-ray diffraction facility will complement the research work being undertaken on neutron spectrometry.

8. Improvement of the Beryllium Detector Spectrometer

Experimental work using the Beryllium Detector Spectrometer has temporarily been suspended. Improvements of the facility are being made. Among those that have been completed are the overhauling of the second axis of the spectrometer to check the non-smooth movements of the detector arm; the adjustment of the gear-drive assembly to minimize the backlash in the main arm movements; improvement of angular scales; adjustment of the detector shield; and improvement of the associated electronics and controls.

LIST OF PREVIOUS REPORTS

The following is a list of previous works that have been made on neutron spectrometry at PARC.

1. Removal of Second Order Neutrons by Oriented Single Crystal Filters. Nucl. Instrum. & Meth., 37 (1965) 121-124.

2. Computer Programs for X-ray and Neutron Diffraction Work. Philippines Nucl. Journal, 1 (1966) 37-41.

3. Neutron Diffraction Studies on MnAl, Mn_2Ni_2C, and $MnZn_3$. Philippines Nucl. Journal, 1 (1966) 23-27.

4. Neutron Diffraction by Liquid Zinc. Physical Review, 173 (1968) 241-248.

5. Neutron Crystal Spectrometry. Instrumentation and Techniques. PAEC(D)PH 671.

6. A Modified Electronics System for the Beryllium Detector Spectrometer. PAEC(D)PH 674.

7. A Quasi-crystalline Model for Liquid Zinc. PAEC-IPA(D)PH 676.

8. A Program to Calculate Data for Two-Dimensional Single Crystal Experiments. PAEC(D) 693.

9. Study of the Static and Dynamic Structure of Solids by Neutron Spectrometry. PAEC(D) 685.

10. A Neutron Diffraction Study of the Crystal Structure of Sodium Thiosulfate Pentahydrate, $Na_2S_2O_3.5H_2O$. PAEC(D) 691.

11. Lectures on Crystallography and Neutron Diffraction. PAEC-IPA(D)PH 681.

12. Seminars on Neutron Crystal Spectrometry. PAEC-IPA(D)PH 661.

13. Neutron Diffraction by Liquid Zinc. PAEC(D)PH 675.

14. Removal of Second Order Neutrons by Oriented Single Crystals. PAEC(D)PH 652.

15. Crystallographic D-Space Program PRRI-XNDS. PAEC-IPA(D)PH 664.

16. Structure Factor Program PRRI-NSF. PAEC(D)PH 665.

17. Neutron Diffraction Studies on Manganese Alloys. PAEC-IPA(D)PH 662.

18. Pair Correlation Function of Liquid Zinc. PAEC-IPA(D)PH 673.

19. Study of Liquids Using Thermal Neutrons. PAEC-IPA(D)PH 672.

20. Neutron Diffraction Studies Using Neutron Spectrometer. PAEC(A)AR 651 p.79.

21. Neutron Diffraction Refinement of the Crystal Structure of Potassium Copper Chloride Dihydrate, $K_2CuCl_4.2H_2O$. Acta Crystallographica B26, 827 (1970).

22. Study of the Rotational Behavior of the Ammonium Ion in NH_4Cl and NH_4Br Crystals. PAEC(A) 6910 p.67.

23. Study of the Vibrational Motion of the Water Molecule in $K_2C_2O_4 \cdot H_2O$. PAEC(A) 6910 p.67.

24. Study of the Lattice Parameter of Pd_2MnGe. PAEC(A) 6910 p.68.