OAK RIDGE NATIONAL LABORATORYOPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.
POST OFFICE BOX 2008, OAK RIDGE, TENNESSEE 37831-6285**ORNL****FOREIGN TRIP REPORT**

ORNL/FTR-3805

DATE: October 26, 1990

SUBJECT: Report of Foreign Travel of J. A. Fernandez-Baca,
Research Staff Member, Neutron Scattering Section, Solid
State Division, ORNL

TO: Alvin W. Trivelpiece

FROM: J. A. Fernandez-Baca

PURPOSE: To perform a neutron scattering experiment at the Institut
Laue-Langevin (ILL), Grenoble, France.

SITES VISITED: 9/26-10/10/90

Institut Laue-Langevin,
Grenoble, FranceABSTRACT: The traveler performed a neutron scattering experiment
to study the high-energy ($E > 30$ meV) spin dynamics of
the itinerant antiferromagnet $\text{Mn}_{90}\text{Cu}_{10}$. This experiment
was conducted at a unique instrument located at the hot-
neutron source at the ILL. The traveler also held various
scientific discussions with ILL research staff members and
visiting scientists.**DISCLAIMER**

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MASTER

INSTITUT LAUE-LANGEVIN,
GRENOBLE, FRANCE

The purpose of the trip was a neutron scattering study of the high-energy ($E > 30$ meV) magnetic excitations of the itinerant antiferromagnet $\text{Mn}_{90}\text{Cu}_{10}$. The study of the magnetic excitations in itinerant magnets is of current scientific interest, and in recent years, various experiments on Fe and Ni have resulted in important contributions to the understanding of these ferromagnetic systems. Comparable efforts in the understanding of itinerant antiferromagnets, on the other hand, have always been hampered by the lack of high-quality crystals, as well as by experimental difficulties. The study performed during this trip is a continuation of a project started by R. Nicklow (ORNL, Solid State Division) and Y. Tsunoda (Osaka University, Osaka, Japan) in 1986. As part of this project, Tsunoda grew a high-quality single-crystal specimen of MnCu at Osaka. This crystal was specially strained at growth so it has a monodomain structure below its magnetic ordering temperature. An inelastic neutron scattering experiment performed on this crystal at the High Flux Isotope Reactor (HFIR) by Nicklow and Tsunoda showed that, because of the steep stiffness and severe damping of the spin waves in this system, data with energy transfer greater than 30 meV were necessary in order to understand the spin dynamics of this system. Experiments in this range of neutron energy transfers can be performed at instruments at hot-neutron sources, as well as at spallation sources. With this in mind, a team was formed to present a proposal to perform an experiment at the IN1 hot-neutron triple-axis spectrometer at the ILL. This team consisted of Nicklow, Tsunoda, M. Hagen (University of Keele, Keele, England), and J. Fernandez-Baca (ORNL). This proposal was accepted on its scientific merit, and 14 days of neutron beam time were allocated for this experiment. Hagen and Fernandez-Baca traveled to the ILL in Grenoble to perform this experiment.

The ILL is a multinational laboratory aimed at providing the scientific community (of its affiliated countries) with a unique neutron-beam facility applicable in fields such as condensed matter, chemistry, biology, nuclear physics, and materials science. Until 1986, the members of the ILL were

France, Germany, and Great Britain. In recent years, the ILL has created a new class of membership (scientific membership) that allows Spain, Switzerland, and Austria to have access to the ILL facilities, with each contribution limited to 1.5% of the total operating budget. Recently, Italy has also shown interest in joining the ILL, and it would not be surprising if this country becomes another scientific member of this prestigious institute, with full access to its excellent facilities. The commitment of the ILL to neutron scattering research is impressive. The ILL facilities for neutron scattering include the world's largest variety of instruments in the cold-, thermal-, and hot-neutron energy ranges. In addition to this, the ILL has recently announced a modernization program of renewal and improvement of neutron sources and instruments, as well as enhancement of the institute's infrastructure, to be carried out in this decade.

The IN1 instrument, utilized in the experiment, is the only triple-axis spectrometer in the world that is located at a hot-neutron source. This instrument is designed for measuring high-energy transfers in combination with small-momentum transfers in single crystals. This instrument offers the choice of three different monochromators [Cu(200), Cu(220), and Cu(331)] that can be vertically focused to optimize the intensity at the sample position. The changes of monochromator and curvature are completely controlled by a computer. Three different vertically focusing analyzers [PG(002), Cu(200), and Cu(220)] can be used to optimize the intensity and resolution in an individual experiment. Remotely controlled diaphragms and a motorized sample goniometer allow the experimenter to mask and orient the sample. This instrument has been used in the past to measure the high-energy magnetic excitations in Fe and, more recently, in the lanthanide cuprates. Our local contact, S. Hayden, was very experienced in the use of this instrument, and his assistance and advice were invaluable to us. The adequate choice of monochromator, analyzer, collimators, and incident energy values was crucial in our measurements of the spin waves in $\text{Mn}_{90}\text{Cu}_{10}$. Once the optimum experimental conditions were found, we could measure relatively well-defined excitations up to 60–70 meV. In this system the magnetic form factor decreases rapidly with the increase of wave vector, and our measurements were constrained to the vicinity of the (110)

magnetic Bragg peak. With this constraint the background increases considerably at high-energy transfers, and the measurement of excitations higher than 60–70 meV was not possible. Analysis of the data is in progress. This analysis involves least-square fitting to the convolution of a model cross section with the resolution function of the instrument. As a result of this analysis, values of the spin-wave energy and damping will be obtained that can be compared with theoretical predictions. From a preliminary analysis we can conclude that the stiffness constant is of the order of 200–300 meV Å and that the spin-wave damping increases rapidly with the wave vector transfer. All measurements were performed at room temperature. A study of the feasibility of another experiment to measure the temperature dependence of these magnetic excitations is also in progress.

While at the ILL, there is always the opportunity to hold scientific discussions with members of the institute's scientific staff, as well as with visiting scientists. This interaction with other scientists is of great value. Of particular interest are the discussions that were held with A. Hewat (ILL) and R. Cowley (Oxford University, Oxford, Great Britain). Hewat is the instrument scientist of D2B, a high-resolution multidetector powder spectrometer at the ILL. The traveler and Hewat discussed the state of HB4, the most recent addition to the HFIR at ORNL, which is an instrument conceptually designed to resemble D2B. This discussion was very productive, and Hewat gave me some advice on how to improve the calibration and performance of HB4. Further discussion with Cowley was centered upon his recent polarized neutron experiments on amorphous alloys. Cowley has performed an extensive study on a variety of iron-based amorphous alloys, and he has concluded that many of these systems that were always assumed to be (collinear) ferromagnets are in fact systems that exhibit various degrees of spin canting. This is of considerable interest because it would imply the existence of longitudinal fluctuations, even at low temperatures, which would explain the discrepancy between the spin-wave stiffness constants deduced from magnetization and from neutron scattering measurements. This well-known discrepancy has been a mystery for more than 20 years. The traveler would also like to mention that Hewat

and Cowley, as well as other scientists that were contacted during the trip, expressed great interest in the recent restart of HFIR.

SUMMARY

The ILL is currently the best institute in the world for neutron scattering. Their continuing commitment to maintain this leadership is evident from the present state of their facilities and their modernization plans for the 1990's. While occasionally experiments from the U. S. are performed in these facilities (if they are part of a collaboration with institutions of countries that are ILL members), it is obvious that they aim to meet the needs of their member countries. While the condensed matter physics and materials science communities of these countries benefit from the excellent facilities at the ILL, the U. S. keeps falling behind Europe in neutron scattering research. Neutron scattering instruments in the U. S. are often antiquated, and some types of instruments (like the one used in our experiment) are unavailable. To regain the leadership in neutron scattering research will require the successful completion of the Advanced Neutron Source. The traveler's experiment was carried out at IN1, which is the only inelastic scattering instrument in the world located at a reactor's hot source. In this experiment, the spin-wave excitations in $\text{Mn}_{90}\text{Cu}_{10}$ were measured up to 70 meV at room temperature. In addition, productive discussions were held with scientists at the ILL.

APPENDICES

A. ITINERARY

B. LITERATURE ACQUIRED DURING FOREIGN TRAVEL

APPENDIX A ITINERARY

Dates	Location	Individuals Contacted	Subject of Discussion
9/24-25/90	Travel from Knoxville, Tennessee, to Grenoble, France, via plane		
9/26-10/10/90	Institut Laue-Langevin, Grenoble, France	S. Hayden A. Hewat R. Cowley	To perform neutron scattering research.
10/10-11/90	Travel from Grenoble, France, to Knoxville, Tennessee, via plane		

APPENDIX B**LITERATURE ACQUIRED DURING FOREIGN TRAVEL**

1. *General Information and Regulations*, ILL, Grenoble, France, September 1990.
2. *General Regulations on Safety and Radioprotection*, ILL, Grenoble, France.
3. *Experimental Reports and Theory College Activities 1989*, ILL, Grenoble, France, 1989.

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