Progress Report

April 1, 1991 - March 31, 1992

"On-Line Nuclear Orientation"
Grant number DE-FG06-87ER40345

submitted to

U.S. Department of Energy

by

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1. Introduction

This report describes progress made during the year April 1, 1991 to March 31, 1992 in work supported by our U. S. Department of Energy grant DE-FG06-87ER40345. This work is carried out primarily at the UNISOR (University Isotope Separator at Oak Ridge) facility of the Holifield Heavy-Ion Accelerator Facility of the Oak Ridge National Laboratory. The primary mission of this work is the study of the structure and properties of nuclei far from stability through on-line nuclear orientation using the UNISOR Nuclear Orientation Facility, a helium dilution refrigerator coupled on-line to the mass separator. Our group was one of the original proposers of this facility and played a central role in its design, construction, and development.

The structure of nuclei far from stability is in general poorly known. Knowledge from heavy-ion reactions is generally limited to states on or near the yrast line, and thus a great deal of the low-energy structure, especially that at low spin, is often missed in such studies. The large beta-decay energies, on the other hand, result in the population of a multitude of states which often give a reasonably complete picture of the complex structure of these nuclei. The goal of this work is to use the nuclear orientation facility in conjunction with other UNISOR capabilities to examine and to understand the structure of these nuclei.

2. Shape coexistence in ^{184}Pt

Coexistence of bands corresponding to different shapes in the even-even Pt isotopes has been previously studied at UNISOR. The nucleus ^{184}Pt is close to the center of this region, where the more deformed band has become the ground state. The structure of this nucleus is poorly known, and the band structure has not been worked out in detail at low spin.

Coexisting bands often show E0 transitions¹, and we believe that the systematic study of these E0 transitions can provide a sensitive test of the mixing of the coexisting configurations. Internal conversion studies of transitions connecting states of the same spin-parity may show transitions with anomalously large conversion coefficients, but the E0 amplitudes cannot be deduced unless the relative amounts of E2 and M1 are known. For this purpose, it is necessary to study angular distributions from low-temperature oriented nuclei, in this case ^{184}Au . Because the orientation data cannot be unambiguously analyzed without detailed information on the decay spectroscopy, we have also undertaken a complete set of spectroscopic studies, involving electron and gamma singles and coincidence measurements.

A preliminary report on these results has been given at a meeting of the Division of Nuclear Physics of the American Physical Society². An invited talk describing these results in more detail has been given at a nuclear structure symposium of the American Chemical Society, and another paper has been presented at the Second International Conference on

On-Line Nuclear Orientation and Related Topics³. A short manuscript describing this work has been prepared for publication⁴ and is appended to this report. A more detailed manuscript describing the entire decay scheme is being prepared for publication. This work has been carried out in collaboration with investigators from Georgia Tech (J. L. Wood), Louisiana State University (E. F. Zganjar), and UNISOR (H. K. Carter). Our group is the leader of this project. These experiments will serve as the basis of the Ph.D. thesis of Mr. Yue-shu Xu, whose degree is expected in late 1991 or early 1992.

3. Nuclear Structure of ^{187}Ir

The odd-mass Ir isotopes lie in a region where the nuclear shapes are in transition. There is a gradual change in the structure with decreasing A from A = 193 to A = 187. However, between A = 187 and A = 185 the structure changes rapidly, with a new configuration dropping rapidly down to form the ground state and the quadrupole moment increasing by more than 50%. We have previously studied the structure in this region through nuclear orientation experiments on the decays of ^{193}Os to ^{193}Ir and ^{191}Pt to ^{191}Ir . Subsequently at UNISOR we have taken data on the gamma-ray angular distributions in the decays of ^{187}Pt to ^{187}Ir and ^{189}Pt to ^{189}Ir , as well as on the A = 185 decay chain. As was the case for ^{184}Au , attempts to analyze the orientation data showed the spectroscopy data to be inadequate, so we have taken additional spectroscopic data on these decays (gamma and electron singles and coincidences).

The analysis of the raw data has been completed for mass 187, and a new decay

scheme has been constructed. We are currently in the final stages of analyzing the electron conversion coefficients and correlating the resulting multipolarity information with the angular distribution results. This analysis should be completed in December 1991. Preliminary analyses have been started on the $A = 189$ and 185 decays; we expect that these decay schemes will be completed by the spring of 1992.

A preliminary report on this work was presented at the Second International Conference on On-Line Nuclear Orientation and Related Topics. A copy of the manuscript to be published⁵ in the proceedings of that Conference is appended to this report.

This work was carried out in collaboration with researchers from Louisiana State University (E. F. Zganjar) and UNISOR (H. K. Carter and P. F. Mantica) and with students from LSU, Georgia Tech, and the University of Maryland. The Oregon State University group is the leader of this project. These experiments will serve as the basis of the Ph.D. thesis of Mr. Mark Gummin, who expects to complete his degree in the late spring or summer of 1992.

4. g-factors of excited states

It is also possible to use the UNISOR NOF as a facility for studying the g-factors of excited states. In these experiments, the refrigerator would not be used, but the superconducting magnet of the NOF would provide an external field for perturbed angular correlation (PAC) measurements on samples mass-separated at UNISOR and deposited in a Fe target at the refrigerator. If these experiments could be realized, it would be possible

to measure g-factors of excited states of nuclei far from stability, which has previously not been possible except for a few special cases of high-spin states following heavy-ion reactions.

To test the feasibility of these experiments, we have constructed and tested an off-line apparatus in our laboratories at Oregon State University. It consists of 2 Ge detectors on opposite sides of the sample and 4 NaI detectors at the 45° positions. Each Ge is placed in coincidence with the 4 NaI, and so 8 simultaneous PAC measurements are done. A magnet that produces a field at the sample of 0.1 T has been built and its field profile mapped with a Hall-effect probe. The 8 coincidence signals are routed through a computer and stored. The counting system has been built and tested, and a new computer interface has been designed, built, and tested.

For a prototype experiment, we have chosen ^{180}Hf , in which the decay of the 5-hr isomer populates the $I = 2, 4, 6$, and 8 states of the ground-state band. Despite the short lifetimes of these states, we expect to be able to measure the g-factors of the $I = 4$ and $I = 6$ members of this band. Determination of g-factors of a series of states in a rotational band provides a sensitive test of the degree to which the parameters of the band remain constant with increasing excitation (and increasing rotational angular momentum). Owing to the short half-life of ^{180}Hf , we have chosen to carry out preliminary tests with ^{181}Hf , which has a known g-factor. We have obtained samples of the cubic ferromagnet ZrFe_2 doped with about 0.1 atomic per cent Hf. These samples have been prepared for us by Teledyne Wah Chang, Inc. The samples were activated in the OSU reactor and measured in our system.

Preliminary tests showed the system to be completely functional and to be capable

of measuring g-factors down to the desired level of precision. However, during final tests the liquid nitrogen was unfortunately allowed to run dry in the Ge detectors. One detector is being returned to the manufacturer for repair. The other detector was performing marginally during the preliminary experiments and will be replaced. We expect the apparatus to be back in operation in early 1992.

These experiments are being carried out by Mr. Prasanna Samarawickrama for his M.S. thesis. Mr. Samarawickrama has already accepted a position with Microsoft Corporation, but he will return to OSU when the apparatus is operational to complete the experiments. His thesis is nearing completion.

5. OLNO-2

We were the organizers of the Second International Conference on On-Line Nuclear Orientation and Related Topics, held at the Joint Institute for Heavy Ion Research at Oak Ridge from October 16-19, 1991. The Conference was attended by 75 scientists from throughout the world. There were 52 papers presented; a copy of the program is appended to this report. We are also editing the proceedings of the conference, which will be published in early 1992.

6. Refrigerator development

Researchers from Oregon State University played a fundamental and essential role

in the acquisition of the UNISOR dilution refrigerator, in its design, and in its testing and use. We continue to support this facility through work on the NMR system, which was added to the refrigerator and tested in the summer of 1991. Although this addition to the facility is not yet fully operational, we expect to continue to contribute to its development during this contract year and the next.

7. References

1. E. F. Zganjar and J. L. Wood, Nucl. Phys. A520, 427c (1990).
2. Y.-S. Xu et al., Bull. Am. Phys. Soc. 35, 1657 (1990).
3. Y.-S. Xu et al., Hyperfine Interactions, to be published.
4. Y. S. Xu et al., Phys. Rev. Lett. (submitted).
5. M. A. Gummin et al., to be published.

8. Personnel

Principal investigator: Kenneth S. Krane

Graduate students: Mark Gummin (Ph.D. expected 1992)
Prasanna Samarawickrama (M.S. expected 1992)
Yue-Shu Xu (Ph.D. expected 1991-92)
Susan Klein

Undergraduate student: Anupama Bhat

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