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FOREIGN TRIP REPORT

ORNL/FTR-3000

DATE: August 17, 1988

SUBJECT: Report of Foreign Assignment of J. Gomez del Campo, Research Staff Member, Physics Division, June 10 - August 2, 1988

TO: Alexander Zucker

FROM: J. Gomez del Campo

PURPOSE: To continue collaboration in heavy-ion nuclear reactions with members of the heavy-ion group of the INFN, Naples, Italy

SITES VISITED:

6/13-7/29/88	INFN, Naples, Italy	F. Terrasi, A. Covello, J. La Rana, A. Uguzzoni
6/26-30/88	Legnaro Accelerator Facility in Padua, Italy	P. Bocaccio

ABSTRACT: The purpose of the assignment to The Istituto Nazionale di Fisica Nucleare (INFN) in Naples was to continue the collaboration with the heavy-ion nuclear physics group. This collaboration included the analysis of experiments done at the French facilities of SARA and GANIL (discussed in reports FTR-2061 and FTR-2672). While in Naples, the traveler was invited to give a seminar at the Laboratori Nazionali di Legnaro, Padua, and to participate with the group of F. Terrasi (Naples) in an experiment. In addition, the traveler was invited to give a 12-lecture course on the statistical model of nuclear reactions for nuclear physics students of the University of Naples and for staff members of the INFN.

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1. Assignment at INFN, Naples, Italy

There were three main projects undertaken during the assignment in Naples: a) Completion of the calculations and analysis needed for the publication of the 37 MeV/nucleon $^{20}Ne+^{60}Ni$ performed at the SARA facility in 1985 (FTR-2061). All the analysis was done and the paper was written. It will be submitted shortly to Physical Review C. This work was greatly simplified because of the excellent computing facilities located at the INFN, Naples, consisting of a large cluster of Vax computers from which one can access the PHYVAX computer of the ORNL Physics Division. b) Continuation of analysis of the experiment: 50 MeV/nucleon $^{20}Ne+^{60}Ni$ performed at GANIL last year (FTR-2672). The main goal of this experiment is to understand the emission of heavy fragments (Z=3 to 10) at backward angles and intermediate energies (10-100 MeV/nucleon). During my stay at Naples, with the collaboration of F. Terrasi, R. Covello, and A. Brondi, we finished the analysis of the radioactivity data. The basic quantity extracted from these data refers to the integrated cross section for production of radioactive nuclei in the range of Z=14 to 38. Similar measurements were done for the 37 MeV/nucleon reaction. An important observation deduced from the GANIL experiment is that the cross section for producing target-like fragments for A>38 at 50 MeV/nucleon decreases by 20% with respect to that at 37 MeV/nucleon. For the 37 MeV/nucleon measurement it was shown that, from the distribution of radioactive nuclei, the total reaction cross section could be deduced; and hence from the result at 50 MeV/nucleon, we conclude that a 20% drop of the total reaction cross section is seen. This result is consistent with other methods used by the Grenoble group (Cox et al.) to extract total reaction cross sections. Additional data exists on γ-ray coincidences with the emitted fragments of Z=3 to 20. We did some analysis of the Li and Be yields, and the cross sections for population of the first excited states of ^{7}Li and ^{7}Be were extracted. The effective temperatures deduced from these ratios are essentially the same as at 37 MeV/nucleon. This result may indicate that the ^{7}Li and ^{7}Be fragments produced in their first excited states are emitted at the end of the deexcitation process. c) Study of deformation effects in the emission of alpha particles and protons from compound nuclei. This topic, which is actively pursued by the group of J. Alexander, M. Kaplan et al., has been continued at INFN, Naples, by J. La Rana since he was a postdoctoral staff member with Kaplan at Carnegie Mellon. What I did on this topic was to modify the Monte-Carlo code LILITA to be able to compute the full decay chain using the angular distributions of the code GANES, which includes deformation effects but is not a multi-step code. J. La Rana will complete this project in Naples, and soon calculations will be done to compare with experimental data. A series of experiments is being planned by J. La Rana et al. to be performed at the accelerator facility of Legnaro, to study in detail the nuclear deformation effects in the emission of light particles. In this regard, this new code could be very helpful in the planning stages.

2. Experiment and visit to Laboratori Nazionali di Legnaro, Padua, Italy

During the week of June 26 I went to the Laboratori Nazionali di Legnaro, in Padua, Italy. The purpose of the visit was to give an invited seminar and to participate in the experiment of F. Terrasi et al. The topic of the seminar was emission of heavy fragments (Z>3). I reviewed some of the main experiments on the topic including those done in collaboration with the Saclay/Naples group and the ones done at HHIRF. I showed some of the data of the 11 MeV/nucleon experiment done at HHIRF, published in the July issue of Physical Review Letters. During my visit to Legnaro, I met with groups from Milano (R. Bonetti) and from Bologna (Ugozzoni et al.) to discuss aspects related to crystal blocking experiments. The group from Bologna, in collaboration with P. Bocaccio, has done a preliminary blocking experiment using the system ^{28}Si (crystal) bombarded by an ^{16}O beam. The main goal is to measure the time decay distribution of the evaporation residues to continue the research that was started at HHIRF in 1981 with the ^{12}C (diamond) + ^{16}O system. They are working on the construction of a remote control goniometer which will enhance their capabilities. They have the necessary detector systems and crystal technology to be able to produce good experiments in the next year. The Milano group is more interested in the analysis of a blocking experiment rather than in performing the measurements. A student of R. Bonnetti (C. Chiesa) has done several calculations to predict the decay time distribution of evaporation residues that result after various assumptions of preequilibrium emission. The calculations were done for the ^{12}C + ^{16}O system, and it turns out that very large effects are predicted. The experiment done at Legnaro was 150 MeV ^{28}Si on ^{60}Ni. Most of my contribution was in the experimental setup, which consisted of two E-DE solid-state detector telescopes placed at ± 25° with respect to the beam and six Ge γ-ray detectors, five placed in the reaction plane and one out of plane. The telescope detected fragments from Z=3 to 18. The main goal of the experiment is the study of the competition between incomplete fusion (or massive transfer) and statistical emission of heavy fragments, like the asymmetric fission emission proposed recently by the ANL group of Sanders et al., for the ^{32}S + ^{24}Mg system. The major focus of our experiment is to study the emission of ^{12}C in coincidence with the γ rays. This setup will give us a unique opportunity to study the cross section for population of the first excited state of ^{12}C (4.4 MeV), which will be very different for the two-reaction mechanisms. In a massive transfer picture, the ^{12}C is produced close to beam velocity by transferring an ^{16}O to the target, and very little population of the 4.4 MeV state is expected. In contrast, a compound nucleus emission should produce twice as much direct population of the 4.4-MeV state than the ground state (compound nucleus temperature of about 3 MeV). The experiment was run for three full days, and enough counting statistics were obtained. In a preliminary analysis of the data, we were able to identify the 4.4-MeV line in ^{12}C.

APPENDIX A

Itinerary

Date	Location	Individuals Contacted	Subjects of Discussion
6/10-12/88	Travel to Naples, Italy via plane and train		
6/13-24	Naples, Italy	F. Terrasi A. Covello J. La Rana and A. Uguzzoni	Assignment at INFN
6/25-30	Travel to Legnaro, Padua via train	P. Bocaccio	Set up experiment
7/1-2	Travel from Legnaro to Naples by car		
7/3-29	Naples, Italy		Assignment at INFN
7/30-8/2	Travel to Oak Ridge via car and plane		