High-Spin Isomeric States of Iridium and Gold

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Iridium (^{191,193}Ir) and Gold (^{197}Au) isotopes served as radiochemical detectors during nuclear tests at the Nevada Test Site. A precise knowledge of the neutron-induced cross sections for the detector nuclei is crucial for extracting the energy components of the neutron fluence as well as yield information. Complete experimental data is not available for all relevant reactions and evaluated cross sections must be used. A vital component of modern reaction models is a detailed knowledge of the nuclear structure of the reaction nuclei. However, there was little known about the long-lived isomeric states of ^{191,193}Ir and ^{197}Au until recent experimental results from GEANIE/LANSCE. Figure 1 shows the details of the isomer states as well as the states that gamma transition to them. Experimental data for the production of these high-spin isomer states provide a unique opportunity to test and improve modern reaction models.

GNASH calculations [1], which utilize the Hauser-Feshbach (HF) compound nucleus theory, were performed to obtain gamma-ray production cross sections for the four dominant reactions feeding the $11/2^-$ isomer of ^{191,193}Ir and ^{197}Au. In HF, a projectile incident on a target produces a compound nucleus (CN) that is long-lived enough to have reached equilibrium. From equilibrium, the CN decays via a series of gamma and particle emissions. GNASH calculates detailed level populations for each nuclear state at each step of the CN decay. As these populations determine all relevant gamma-ray and particle emission cross sections, accurate nuclear structure information is vital.

Figure 2 shows gamma-ray production cross sections for the states feeding the isomer of ^{197}Au. There is reasonable agreement between experiment (triangles) and theory (solid line). The cross sections from "high-spin" excited states, (594.4 keV and 358 keV transitions) are very well reproduced. The pre-equilibrium model used by GNASH significantly effects these transitions. By implementing the quantum mechanical theory of Feshbach-Kerman-Koonin, GNASH better predicts these high-spin transitions. The production cross sections from "low-spin" excited state, (174.8 keV and 538.6 keV) are often underestimated for incident neutron energies between 2–7 MeV. It is unclear if these discrepancies are primarily due to model deficiencies or assumptions made in the data analysis.

The improvements to evaluated neutron cross sections is discussed in another report, "Iridium Cross-Section Evaluations" [2].

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[1] Proceedings of the Workshop: "Nuclear Reaction Data and Nuclear Reactors - Physics, Design, and Safety, Vol. 1," International Centre for Theoretical Physics, Trieste, Italy, 15 April – 17 May, 1996, Ed. A. Gandini and G. Reffo (World Scientific, Singapore, 1999) pp. 227–404.
[2] P. Talou, et al., "Iridium Cross-Section Evaluations," in this volume on p. 146.

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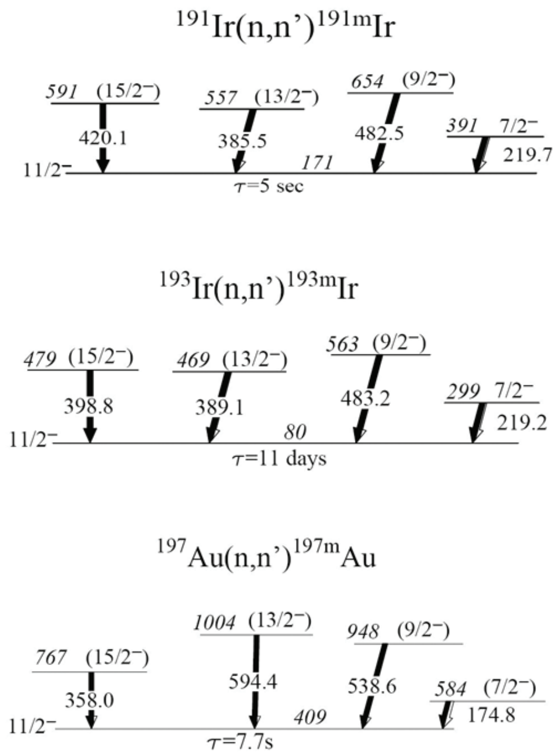

Fig. 1.
The details of the high-spin isomer states as well as the states that gamma transition to them. Experimental data for the production of these isomer states provide a unique opportunity to test and improve modern reaction models.

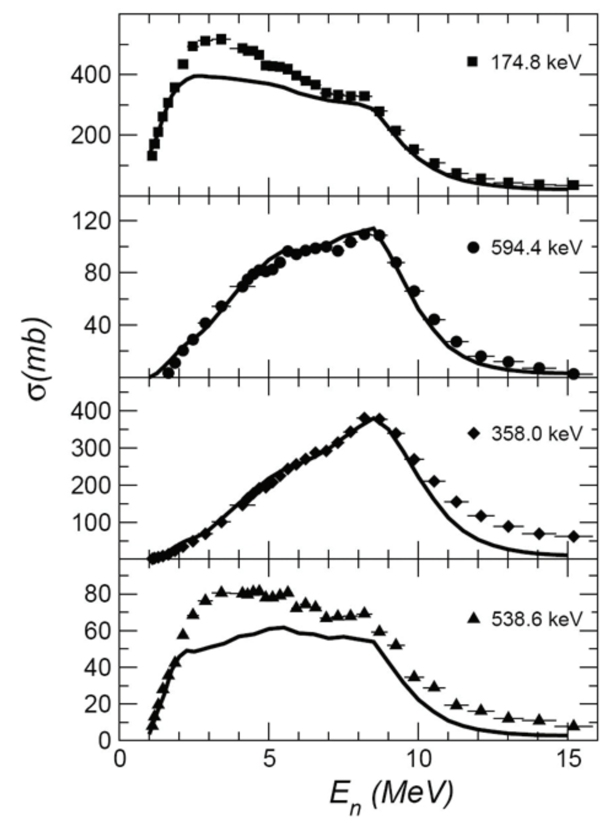

Fig. 2.
Gamma-ray production cross sections for the states feeding the isomer of ^{197}Au.