Iridium Cross-Section Evaluations

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A suite of activation detectors, also known as radiochemical detectors, was used during nuclear tests at the Nevada Test Site. Strategically loaded, these detectors permitted integral performance diagnostics including energy profiles of the neutron fluence as well as yields. The Iridium isotopes (^{191,193}Ir) constitute a set of such detectors.

The usefulness of activation detectors as probes depends sensitively on accurate cross sections of neutron-induced reactions, (n,xn). A vital component of modern reaction models is a detailed knowledge of the nuclear structure of detector nuclei. Until recently, there was little known about the nuclear excited states of Ir isotopes and precise cross-section evaluations were not possible. Recent experimental results, including those from GEANIE/LANSCE, have significantly improved our understanding of the Ir nuclear structure (see [1]). These improvements, together with recent advances in reaction models, afforded the opportunity to re-evaluate the relevant (n,xn) Ir cross sections.

Utilizing GNASH [2], a nuclear reaction code based on the Hauser-Feshbach theory of compound nuclei, new Ir (n,xn) cross sections have been obtained and incorporated into the ENDF libraries. Figure 1 gives an example of the new evaluations and compares the ^{191}Ir(n,2n)^{190}Ir cross section to previous evaluations and experiment [3–6]. By comparing the 1999 calculation (red) by Chadwick and Hayes [7] with the modern evaluation (black), it is clear that the current model better represents the high-energy data obtained by Bayhurst [3]. Though the improved nuclear structure is a vital component, the high-energy cross section is most affected by recent improvements in modeling of the pre-equilibrium nucleus.

Though experimental data is well reproduced, it is important for many applications to understand the uncertainties associated with model evaluations. GNASH incorporates several models, and detailing the uncertainties is difficult; methods are still under development. Currently, error estimates are obtained based on model parameter uncertainties and experimental data. An example is shown in Fig. 2 using the ^{191}Ir(n,2n)^{190}Ir cross section (black). One-sigma “high” and “low” uncertainty quantifications (blue) are shown and in general agree with available experimental data.

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[1] P. Talou, et al., “High-Spin Isomer states of Iridium and Gold” in this volume on p. 148
[2] 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.
[3] B.P. Bayhurst, et al., *Phys. Rev. C* **12**, 451 (1975).
[4] M. Herman, et al., *Nuc. Phys. A* **430**, 69 (1984).
[5] S.M. Qaim, Nuc. *Phys. A* **185**, 614 (1972).
[6] J.K. Temperley and D.E. Barnes, BRL-1491 (1970).
[7] M.B. Chadwick and A.C. Hayes “Iridium as a Radiochemical Detector for Neutron Spectrometry,” Los Alamos National Laboratory report LACP-99-226 (1999).

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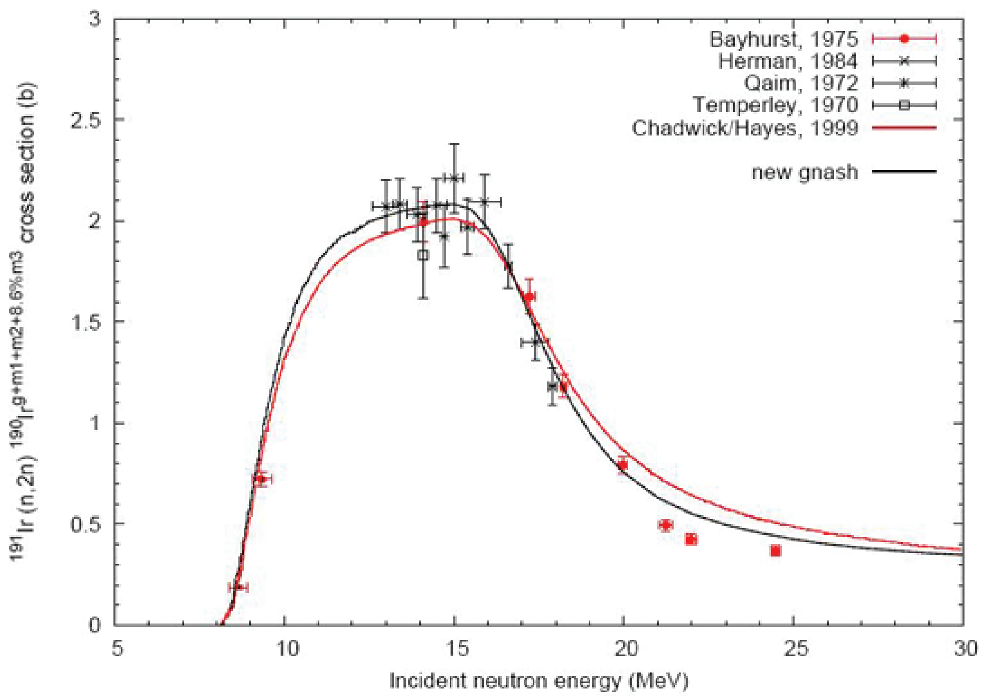

Fig. 1.
An example of the new evaluations and comparison of the $^{191}Ir(n,2n)^{190}Ir$ cross section to previous evaluations and experiment [3–6].

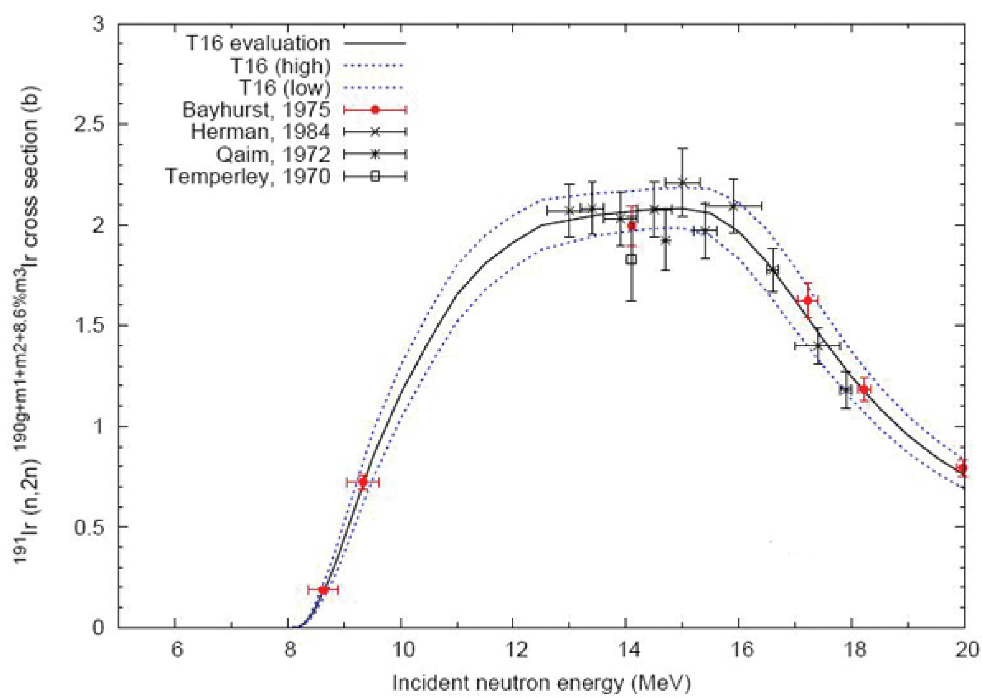

Fig. 2.
An example using the $^{191}Ir(n,2n)^{190}Ir$ cross section (black). One-sigma "high" and "low" uncertainty quantifications (blue) are shown and in general agree with available experimental data.