Evaluation of Cr neutron cross sections and photon production data

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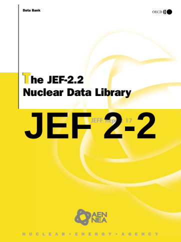
Natural Chromium is a mixture of four stable isotopes: ^{50}Cr (4.35%), ^{52}Cr (83.79%), ^{53}Cr (9.50%) and ^{54}CR (2.36%). In this work, neutron cross sections and gamma-ray spectra are evaluated for each isotope in the incident neutron energy range 1 keV-20 MeV then suitably added, weighted on the percentage abundance, to obtain cross sections and spectra for the natural element too.

In the considered energy interval, an optical model involving spherical equilibrium shapes, and statistical calculations - in the framework of the Hauser - Feshbach formalism with statistical fluctuations taken into account in the neutron and gamma channels below 3 MeV - are performed.

For Chromium isotopes the resolved resonance region extends up to about 600 keV; below this energy optical and statistical models must be applied with some caution, giving only the average trends of neutron cross sections. Moreover, a still debatable subject concerns the amount of non-statistical effects in gamma-ray spectra induced by neutron capture in the incident energy range below 1 MeV, where valence and doorway capture mechanisms may be important in explaining the strengths of some enhanced transitions.

At neutron energies higher than 10 MeV, non-statistical contributions to neutron cross sections and spectra become important; in particular, direct-semidirect capture mechanism in the radiative capture channel is outstanding in comparison with statistical terms and affects widely the subsequent gamma-ray cascade, too. These contributions have been neglected in the present evaluation.

The following reactions are considered: elastic and inelastic scattering (both in discrete and continuum regions), radiative capture, (n,p), (n,α) and (n,2n).



The photon production data, according to the structure of the Evaluated Nuclear Data File (ENDF) with which our evaluated results are arranged, include multiplicities and transition probabilities (file 12), photon production cross sections (file 13) and angular distributions (file 14).

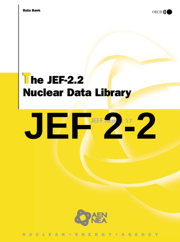
For the most part gamma-ray emission proceeds, in the considered energy range, after neutron capture and inelastic scattering. Other less important contributions arise from (n,2n) and particle emission reactions.
The total and shape elastic cross sections are obtained by means of spherical optical model (OM) calculations performed with the POLIFEMO code.

For statistical model calculations which concern neutron inelastic and compound elastic scattering, (n,2n), (n,p), (n,α) and radiative capture reactions, nuclear structure information is requested as input data, namely discrete level schemes, level density parameters and giant resonance shapes, which has been deduced from both experimental data and theoretical model calculations.

We have then calculated photon production cross sections and spectra following neutron-induced reactions in the energy range from 1 keV to 8 MeV by means of a modified version of the PENELOPE code. In this energy interval, the main sources of emitted gamma-rays are neutron radiative capture and inelastic scattering processes. The latter is predominant in the MeV region, just above the threshold energy. Gamma-ray cascades originating from (n,γ) and (n,n'γ) reactions are then described in the framework of the statistical model, allowing up to seven successive photon decays, sufficient in the considered energy range.

For ease of application, for instance in reactor physics and shielding calculations, the evaluted neutron cross sections and photon production data have been set up in a standard way, according to ENDF/B rules and formats.

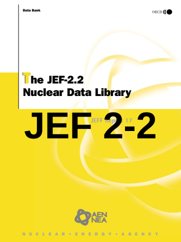
To this end, an original chain of codes has been developed, both for single isotopes and the natural element (which is a weighted mixture of them).



To sum up, an evaluated data file in ENDF/B format has been obtained with photon production data ranging from 1 keV to 20 MeV of incident neutron energy.

This data file has been checked by means of ENDF utility codes, CHECKR, FIZCON and PHYCHE and no mistake has been found.

The mentional POLIFEMO and PENELOPE codes have been developed at ENEA-Nuclear Data and Codes Laboratory (Department TIB) by F. Fabbri and G. Reffo.



References

1) A. Mengoni, F. Fabbri, G. Maino, "Evaluation of gamma-ray production cross sections and spectra for neutron induced reactions on chromium", ENEA report RT/TIB/85/38, Rome, December 1985.

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3) A. Mengoni, F. Fabbri, G. Maino, "Gamma-ray production cross sections following ^{52}Cr (n,n'γ) reaction", Institute of Physics Conference Series 88, 664 (1988).