Evaluation of Fe neutron cross sections and photon production data

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Within the framework of a general study of neutron induced reactions on structural materials, an evaluation of neutron cross sections for stable iron isotopes, namely of ^{54}Fe (5.8%), ^{56}Fe (91.72%), ^{57}Fe (2.2%) and ^{58}Fe (0.28%), is presently in progress at ENEA, Bologna. This evaluation covers the incident neutron energy range from 1 MeV, when the continuum region starts above the resonance domain, up to 20 MeV. In particular, the gamma-ray production cross sections and spectra are calculated for the following processes: radiative capture, inelastic scattering, (n,2n), (n,p) and (n,α).

The evaluation makes use of techniques and computing codes already tested in the calculations performed for chromium isotopes. Preliminary results for ^{56}Fe have been presented at the previous technical meeting of the JEF working groups in April 1988.
In particular, we have considered neutron induced reaction on ^{56}Fe and used standard optical model and GR parameters for this mass region. The level density parameters have been determined on the basis of experimental information and microscopic BCS calculations.

The adopted formula for nuclear level densities can reproduce satisfactorily all kind of experimental information such as cumulative numbers of levels of both parities at low energy, s-and p-wave average level spacings at the neutron binding energy, by means of four adjustable parameters. Moreover, our formula reproduces the theoretical parity distribution of excited levels, estimated within a Nilsson plus BCS model. Inclusion of parity effects in level density formalism has a great influence on statistical calculations of neutron capture cross sections (of the order of 30-50% over the whole energy range up to several MeV e.g. for Chomium isotopes, increasing the average radiative widths, which are roughly proportional to the total neutron capture rate).

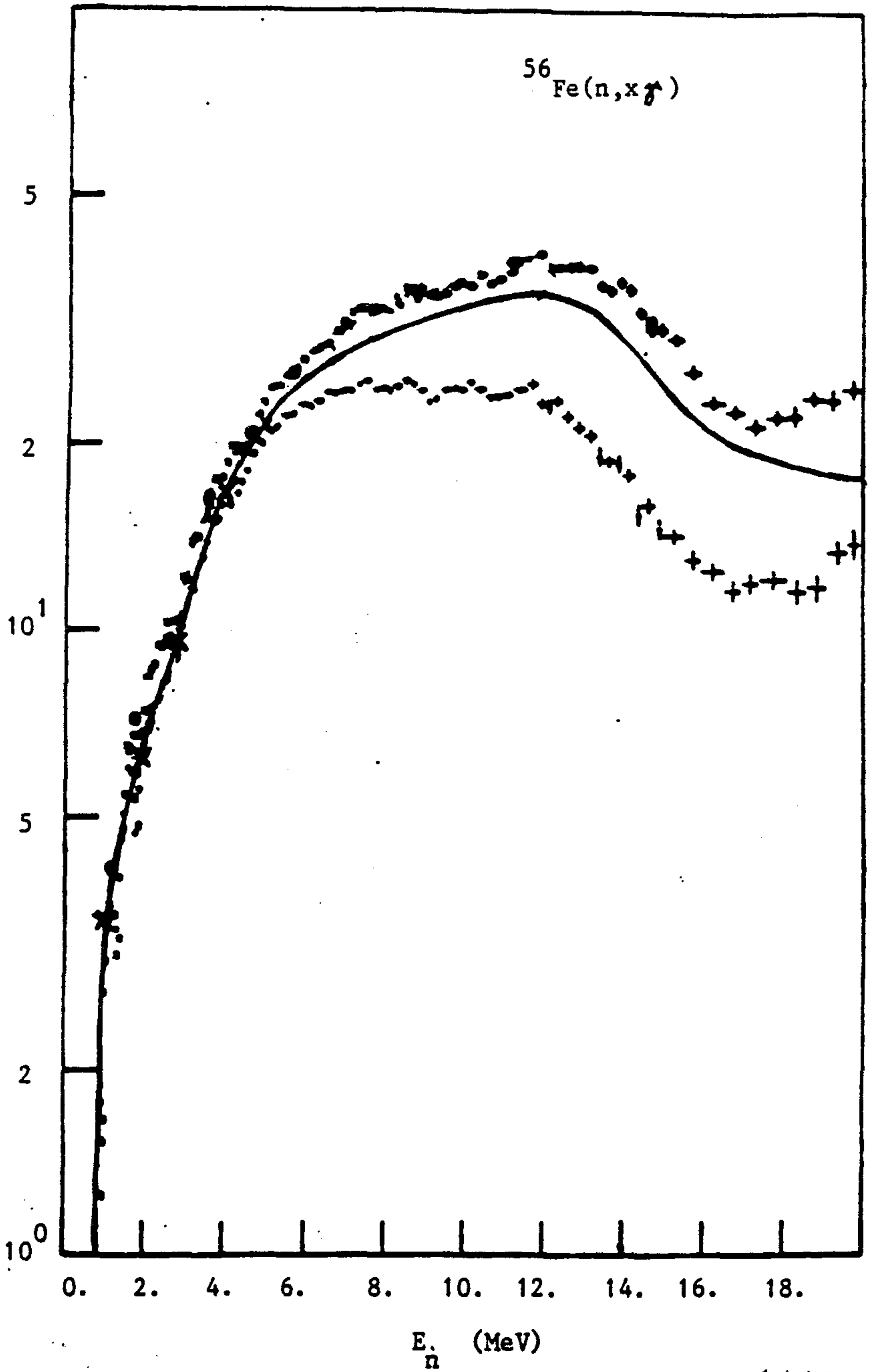
In this way, we have performed calculations of neutron cross sections and photon production data for ^{56}Fe in the incident neutron energy range, 1 MeV $\leqslant E_n \leqslant$ 20 MeV.
Neutron inelastic scattering, (n,2n), (n,p) and (n,α) cross sections, so obtained, compare well with the corresponding experimental data.
Figs. 1 and 2 show, respectively, the ^{56}Fe photon production cross section as a function of incident-neutron energy and the total gamma-ray spectrum, following 14.1 MeV neutron reactions.

As for fig. 1, it has to be outlined that the difference between the two sets of measurements can be partly removed as due to an error in the flux measurement (1); however, uncertainties on the absolute values of the cross section still remain and only the spectral shape (well reproduced by our calculations up to E_n=18MeV) is clearly determined. Moreover, it is worth noting that experimental data (1) refer to natural iron.

References

1) G.T. Chapman, G.L. Morgan, F.G. Perey, report ORNL/TM-5416 (1976);
J.K. DicKens, G.L. Morgan, F.G. Perey, Nucl. Sci. and Engineering 50, 311 (1973).

2) F. Fabbri, G. Maino, E. Menapace, A. Mengoni, "Gamma-ray production data and related nuclear structure calculations", to be published in Proceed. of Int. Conf. on Nuclear Data for Science and Technology, Mito (Japan), May 30 - June 3 (1988).


^{56}Fe(n,xγ)
Cross section (b/sr)
10^0
2
5
10^1
2
5
0.
2.
4.
6.
8.
10.
12.
14.
16.
18.
E_n (MeV)

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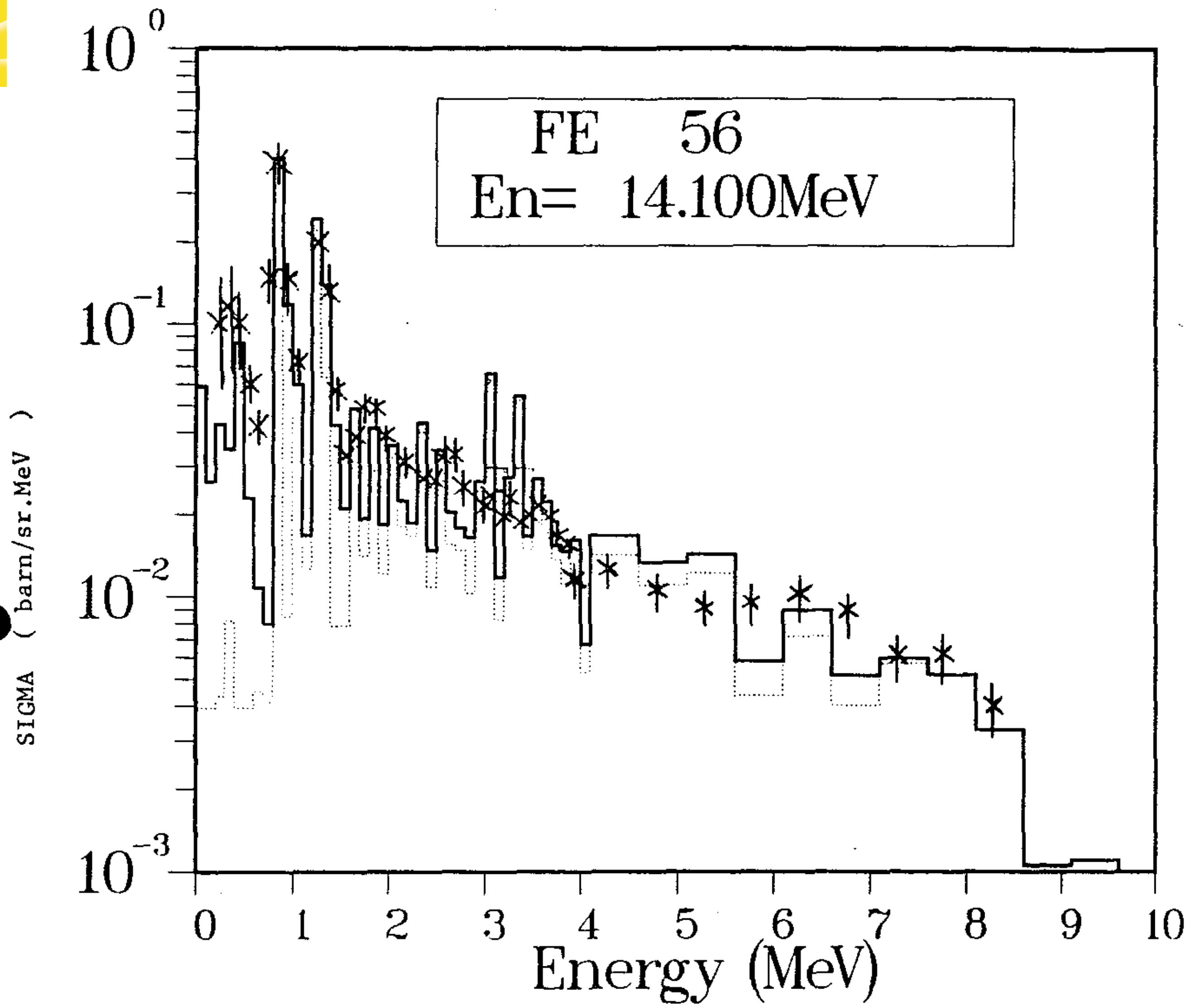

Gamma-ray emission spectrum from $^{56}Fe(n,x\gamma)$ reactions at $\vartheta = 90°$ for 14.1 MeV incident neutrons. Experimental data are taken from : D.M.Drake, E.D.Arthur and M.G.Silbert, Nucl.Sci. Eng. 65, 49 (1978). Solid line : present calculations for total gamma-ray emission spectrum, namely $(n,n'\gamma)$, (n,γ), $(n,2n\gamma)$, $(n,p\gamma)$, $(n,np\gamma)$ and $(n,\alpha\gamma)$. Dotted line : present calculations for $(n,n'\gamma)$ channel only.

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