MODIFIED QUASI-DEUTERON MODEL

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Saclay measurements of the photon absorption cross section by lead can be fitted from 35 to 106 MeV by my 12 year old modified quasi-deuteron model, with a damping factor D of 60 MeV.

Recent Saclay experiments [1] using monochromatic photons from positron annihilation, provide data on the absorption cross section for the nuclear photoeffect in lead, from 25 to 106 MeV photon energy. They find an empirical fit to their results above 35 MeV: the absorption cross section is a linear function of the photon energy, the line going through 20 mb at 35 MeV and 12 mb at 110 MeV. The data and linear fit (dotted line) are shown in fig. 1. The cross section is far above the line at 25 MeV, presumably due to the tail of the giant dipole resonance.

I presented [2] a preliminary theoretical model 12 years ago, designed to apply to this energy region, which I called the modified quasi-deuteron (mqd) model. This model was not in disagreement with preliminary Rensselaer measurements [3] in this energy region. It is desirable to compare the mqd with the Saclay data.

Schoch [4] has recently made a *different* modification of the quasi-deuteron model, designed to fit data on the *differential* cross section for photon absorption by oxygen above 60 MeV, leading to emission of a single nucleon leaving the residual nucleus in its *ground state.* I hope that a complete theory will be worked out which would include my mqd and Schoch's version (or improvements on my work and/or his) as special cases. For the time being, I shall discuss my mqd with no further reference to Schoch's work.

In the original quasi-deuteron (qd) model I argued [5] that two-nucleon correlations in a nucleus will be similar to those in a deuteron, and hence that the cross section for absorption of high-energy photons will be similar to the absorption cross section σ_d for a deuteron. I found the nuclear cross section σ_{qd} to be

$$\sigma_{qd} = 8(NZ/A)\sigma_d \,. \tag{1}$$

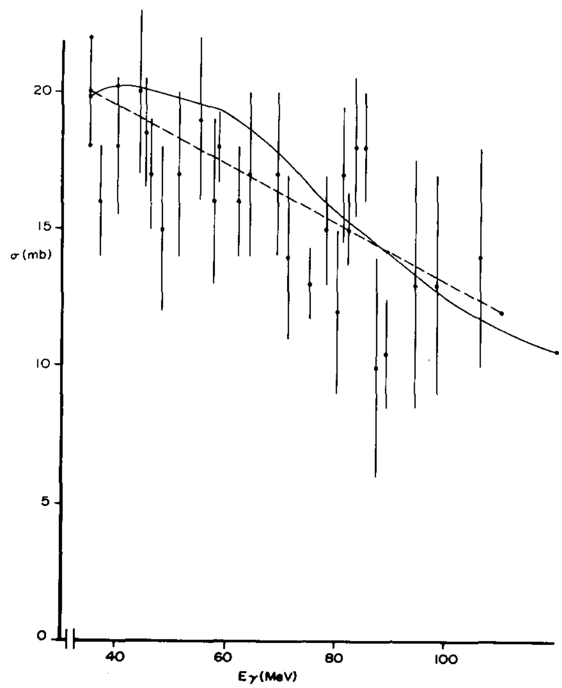

Fig. 1. Absorption cross section for lead in mb versus photon energy in MeV. The points with error bars show Saclay data [1]; the dashed line is the Saclay empirical fit; the solid curve is the modified quasi-deuteron model, namely eq. (2) with damping parameter D set at 60 MeV.

The factor NZ comes from the number of neutron–proton pairs. The coefficient 8 is not well determined: e.g., Lepetre [1] uses 4.6 instead of 8.

In presenting the mqd I argued [2] that at photon energies comparable to the Fermi energy in the nucleus, there would be strong damping of the cross section σ_{qd} due to Pauli blocking of final states for the neutron and/or proton emitted from the quasi-deuteron. I introduced a one-parameter function, $\exp(-D/E_\gamma)$ to simulate this blocking, so that the mqd cross section, σ_{mqd}, is

$$\sigma_{\mathrm{mqd}} = 8(NZ/A)\exp(-D/E_\gamma)\sigma_{\mathrm{d}} \,. \qquad (2)$$

I determined the value of the parameter D as roughly 30 MeV, from the requirement that the integrated cross section for σ_{mqd} should be 1.2 times the Thomas–Reiche–Kuhn nuclear cross section.

Evaluation of eq. (2) for D = 30 MeV gives a cross section that is far from a linear function of photon energy, and is far above the data shown in fig. 1. (My results are 130% above the line at 35 MeV, and 30% above at 110 MeV.) I can now determine the value of D by fitting the Saclay data, instead of fitting the integrated cross section. I find that using D = 60 MeV gives the curve shown in fig. 1, which fits both the data and the Saclay linear fit remarkably well. The curve and line generally agree within 1 mb, i.e., well within current experimental errors.

The success of eq. (2), with D = 60 MeV, encourages me to believe that my modified quasi-deuteron model has some merit. Of course, the form used for the damping in eq. (2) is ad hoc, and it would be good to derive the damping from a bona fide model. In any case, eq. (2) is better grounded in theory than the linear fit which I would like it to replace.

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References

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