Summary. — The rate and angular distribution of knock-on neutrons in polarized-muon capture by spinless nuclei is calculated in a simple statistical model, and compared with experimental data and other calculations.

1. Introduction.

Muon capture by nuclei is often accompanied by neutron emission:

\[(A, Z) + \mu^- \rightarrow (A, Z-1) + \nu \rightarrow (A-1, Z-1) + n + \nu.\]

For spinless nuclei and polarized muons the neutron angular distribution with respect to the \(\mu\) polarization direction has been investigated, both theoretically and experimentally, since the time of the parity violation discovery \(^{(1)}\). The emission rate has the form

\[
\frac{dA}{d(\cos \Theta) dT} = \frac{\nu}{2} (1 + \alpha \cos \Theta),
\]

where \(T\) is the neutron kinetic energy and \(\Theta\) is the angle between the neutron momentum \(n\) and the muon polarization. The asymmetry coefficient \(\alpha(T)\) may

\(^{(1)}\) To speed up publication, the author of this paper has agreed to not receive the proofs for correction.

be a function of $T$. Experimental measurements of $\alpha$ have yielded different results in various laboratories (3) ranging from $-1$ to $-1$. The measurements of the Carnegie group with $^{40}$Ca, $^{32}$S and $^{28}$Si, still with poor energy resolution, suggest a strong variation of $\alpha$ with $T$ (3).

Slow neutrons are reasonably assumed to come from a compound nucleus by "evaporation", as suggested by the two-step transition of eq. (1). Parity conservation in the second step requires then $\alpha = 0$, since the memory of the first stage has been lost. On the contrary, energetic neutrons are knocked out directly in a "single particle" interaction $p + \mu \rightarrow n + v$.

For the latter case, and in particular for closed-shell nuclei, a simplified relativistic calculation is presented in this paper where the elementary-process feature is emphasized over the conventional nuclear-physics approach.

In Sect. 2 the assumptions of our approach are clearly stated. In Sect. 3 the calculations are developed and the results compared with experimental data and other calculations. The relation between momentum and energy for the initial and final nucleon turns out to have great influences on the results, and Sect. 4 comments on other alternative relations. Conventions on notation and some lengthy formulae are relegated to the Appendices.

2. - Assumptions.

A completely relativistic calculation of the matrix element is made. The reason is that the directly emitted neutrons have a very high momentum inside the nucleus and come from high-momentum protons. The squared matrix element has many terms, and many of them have absolute values much greater than the total sum.

We suppose the muon at rest in the nucleus centre-of-mass system.

The initial proton is described by its momentum distribution amplitude obtained as the Fourier transform of the single-particle wave function. Harmonic-oscillator wave functions were mostly used, but also a Hartree-Fock function was tested.

The neutron within the nucleus is described by a plane wave, thus neglecting any distortion produced by the nuclear potential. However, a higher momentum $n$ is assigned to the neutron inside the nucleus than outside it by adding a potential energy $-U$ to its energylike component of the four-momentum. Thus the neutron energy outside the nucleus is

$$M + T = \sqrt{M^2 + n^2} - U.$$ 