The Spurious Effects of the Dispersion in the Number of Particles on $\beta$-Transitions.

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Summary. — A general method is presented for eliminating, in the theoretical values of the first-forbidden beta-transitions, the unphysical effects due to the particle number fluctuation allowed by the usual BCS wave functions. Analytical expressions are given for the pertinent pairing correlation reduction factors, calculated with both BCS and strict particle-number-projected BCS wave functions. Our treatment allows for the fact that parent and daughter nuclei do not have, generally, the same axial deformation. Furthermore, the blocking effect has been exactly and systematically taken into account. Numerical calculations were performed with a wrought newly adopted Nilsson model, and compared to a computation of experimental data on odd-mass nuclei from the rare-earth region. In the majority of the beta-decays studied the elimination of the unphysical components in the wave functions improves the theoretical half-lives. The influence of the Coriolis interaction has been studied in the first-order perturbation theory, and it has been found that in general it worsens the $f_I$ values.

1. — Introduction.

It has been known for a long time that the residual two-body interactions must have a pairing character. Generally, the pairing effect is taken into account in a semi-phenomenological manner, by using the BCS wave functions. The BCS theory, by inducing a considerable mixing among shell model configurations, sensibly modifies the quasi-total of the predictions of the independent-particle model, in particular those concerning the beta- and gamma-ray spectroscopy. This modification not always being an improvement, the pure Nilsson estimates for electromagnetic transitions being for example often nearer
the experimental measures than the BCS transition rates, several corrections have been made to the BCS model, concerning the $\gamma$-transitions as well as the $\beta$-transitions. Concerning the $\beta$-transitions between spheroidal-shaped nuclei, we mention particularly:

i) The Kotani corrective term $\log \frac{f_{\alpha}}{f_{\beta}}$, which however is usually too small to improve noticeably the theoretical results \(^{(1,2)}\).

ii) The derivation of the fractional occupation parameters $u$ and $v$ from the experimental data, by the use of simple theoretical formulae \(^{(3)}\); this approach cannot explain the absolute magnitude of the $ft$ values.

iii) The addition of a quadrupole force to the pairing force \(^{(4)}\), and the treatment of quasi-particles and phonon excitations.

iv) The correction induced by three quasi-particle states \(^{(5)}\).

v) The nuclear finite-size effects \(^{(6)}\).

vi) The QRPA approach with separable residual interactions \(^{(7)}\).

vii) The centrifugal and spin-spin polarization effects \(^{(8)}\) which may improve some first-forbidden transitions.

One of the most important corrections, which may easily be taken into account, seems to be

viii) the Coriolis interaction effect. To our knowledge, the only studies of nuclear $\beta$-decay processes which consider the Coriolis mixture are those of Bogdan \textit{et al.} \(^{(9,10)}\).

In previous treatments nonconservation of mass number must induce some error \(^{(10)}\). To the best of our knowledge the only attempt made to study the influence on $\beta$-decay rates by number-projected BCS wave functions is the calculation of Miranda and Preston \(^{(11)}\). The study some reduction factors for allowed and first-forbidden $\beta$-decays in the rare-earth region, and thus bring

\(^{(2)}\) D. Bogdan: \textit{Nucl. Phys.}, 61, 241 (1965).