Alpha-Decay of Coherent Rotational States (*) (**).

O. Dumitrescu (***)

*International Centre for Theoretical Physics - Trieste, Italy*

L. Fonda

*International Centre for Theoretical Physics - Trieste, Italy*
*Istituto di Fisica Teorica dell'Università - Trieste, Italia*

N. Mankoč-Borštnik (*) (**)

*International Centre for Theoretical Physics - Trieste, Italy*

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**Summary.** — The α-decay of coherent rotational states is discussed for the case in which both the mother and the daughter nuclei have a well-pronounced rational band. By assuming ideal rotational bands, strong pulses appear in the time derivative of the α emission probability.

1. - Introduction.

It has been shown (1) that during heavy-ion collisions the target nucleus can remain in a coherent mixture of rotational states. We call coherent rotational state (CRS) the wave packet \( \psi = \sum_{IM} a_{IM} \phi_{IM} \) with absolute values of

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(***) On leave of absence from Department of Fundamental Physics, Institute of Physics and Nuclear Engineering, Central Institute of Physics, P.O. Box MG6, Bucharest, Romania.

(*) On leave of absence from Faculty of Natural Science and Technology and J. Stefan Institute, University E. Kardelj, Ljubljana, Yugoslavia.

aim peaked around a mean value of \( I \), the phases of \( a_{IM} \) being approximately equidistant and the energies \( E_i \) of the states \( \phi_{IM} \) obeying to a good approximation the rule \( E_i \sim \hbar \omega I(I + 1) \). In the case of the ideal rotational band the coherence of such a state recovers periodically in the time evolution. When the \( \gamma \)-decay of such a state was studied (1), strong pulses appeared in the time derivative of the spontaneous-photon-emission probability. The \( \gamma \) counter was supposed to have a very good time resolution (\( \sim 10^{-18} \) s) rather than a good energy resolution. The purpose of this paper is to find out whether such strong pulses appear also in the time derivative of the \( \alpha \) emission probability when the nuclei with very-well-pronounced rotational structure are taken into consideration. We derive in sect. 2 the formula of the \( \alpha \)-decay probability of the CRS. In sect. 3 a numerical example is discussed. Throughout the paper we shall use natural units \( \hbar = c = 1 \).

2. – Alpha-decay probability.

In this section we derive an approximate expression for the probability of the \( \alpha \)-decay of the CRS for the case in which the detector has a good time resolution (rather than a good energy resolution). In this derivation we use first-order perturbation theory. If we assume that the atomic nuclei are strongly deformed, obeying the rule \( E_i = \omega I(I + 1) \) to a very good approximation, the adiabatic model of Bohr and Mottelson (2) is taken for granted. Let \( \phi_i^{MK}(A + 4) \) and \( \phi_i^{MK}(A) \) denote the wave functions of the members of rotational bands of the mother and the daughter nucleus, respectively. In what follows we shall denote these wave functions by \( \phi_i(A + 4) \) and \( \phi_i(A) \). The subscript \( I \) will then indicate all four quantum numbers: the \( I \)-spin, its projections \( M \) and \( K \) on the laboratory and nuclear \( z \)-axes and the parity \( \pi \). We write the \( \alpha \) channel wave function with definite momentum \( K \) in the following way:

\[
|\phi_{IK}(\alpha, A)\rangle = \frac{1}{\sqrt{m_\alpha \hbar}} \sum_{LM} Y_{LM}^*(K) |\mathcal{S}[X_\alpha, q_L(\epsilon) Y_{LM}(A)]\rangle.
\]

Here \( K^2 = 2m_\alpha \epsilon \), \( m_\alpha = 4mA/(A + 4) \) (with \( m = \) nucleonic mass), \( \mathcal{S} \) is the antisymmetrization operator. The function \( q_L(R, \epsilon) Y_{LM}(R) \) describes the motion of the \( \alpha \)-particle relative to the daughter nucleus with angular momentum \( L \) and kinetic energy \( \epsilon \). \( X_\alpha \) is the \( \alpha \)-particle ground-state wave function. The wave function (2.1) then describes the channel state with one free \( \alpha \)-particle and a nucleus containing \( A \) nucleons.