ОБЪЕДИНЕННЫЙ
ИНСТИТУТ
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ
ДУБНА

E4 - 11626

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1978

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Submitted to "Письма в ЖЭТФ"

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О форме и парциальных ширинах распадов нейтронных резонансов

Для экспериментальной проверки общепринятых положений предлагается измерить форму изолированного резонанса, проверить, имеются ли отклонения от экспоненциального закона распада для полной вероятности и для парциальных переходов, и выяснить, меняются ли соотношения между вероятностями парциальных переходов при продвижении по энергии внутри резонанса от его нижней части к максимальному и далее к верхней части. Объектами изучения могут быть достаточно широкие изолированные нейтронные резонансы в атомных ядрах.

Работа выполнена в Лаборатории теоретической физики ОИЯИ.

Препринт Объединенного института ядерных исследований. Дубна 1978

Soloviev V.G. E4 - 11626

On the Form and Partial Widths of Neutron Resonance

For the experimental check of general assumptions we propose to measure the form of the isolated resonance, to verify whether there are deviations from the exponential decay law for the total probability and partial transitions and to analyze the relations between the orobabilities of partial transitions with changing energy inside the resonance from its lower part to the peak and upper part. Rather wide isolated neutron resonances in atomic nuclei are a convenient tool for these investigations.

The investigation has been performed at the Laboratory of Theoretical Physics, JINR.

Preprint of the Joint Institute for Nuclear Research. Dubna 1978

After publishing the paper of N.S.Krylov and V.A.Fock [1] the energy distributions of decaying nuclear states have been accepted to be of the Breit-Wigner form. It has been shown [1] that the decay of a state depends only on the function of energy distribution in this state. A general assumption on the meromorphic nature of the energy distribution function is sufficient for obtaining a usual exponential form of the decay. The study of the decay of quasistationary states is connected with the time-energy uncertainty relation [1-4]. This relation is usually discussed (see, for instance, refs. [5-7]) under the assumption that the energy resolution ΔE of incident particles is much larger than the width of the resonance Γ. The fulfillment of the condition $\Delta E \ll \Gamma$ is necessary for the study of the form of resonances and specific features of their decay. It is convenient to study the form of resonances and the branching ratio of their decay with the help of rather wide quasistationary states of atomic nuclei lying near the neutron binding energy B_n.

It is known that the generally accepted assumptions are to be justified experimentally. The aim of the present paper is to show the necessity of measuring accurately the form of isolated resonances. These measurements are also useful because the Breit-Wigner form of the resonance is considered in the decomposition of complex curves which are a superposition of several states for the assignment of the resonance energy and its relative strength.

Let us formulate the problems which should be answered by relevant experiments. They are:

1) What is the form of an isolated resonance in the case of one and many decay channels? What is the form of a resonance for each decay channel in the case of several opened channels? Are there deviations from the Breit-Wigner form?

2) Are there deviations from the exponential law for the total and partial decay probability?

3) Whether the relation between the partial transition probabilities changes inside a certain isolated resonance, i.e., when the energy changes from the lower part of the resonance to its maximal value and with further increasing energy.

It should be noted that a large number of opened and closed decay channels of a certain state is due to the multicomponent character of the wave function of this state. In ref.[8], for instance, the wave function of a highly excited state is given as a series over the states with different number of quasiparticles and phonons. The decay in a certain channel is determined by certain components of the wave function. Since only one definite state is considered, the maxima of energy distributions are thought to coincide in different channels. However, this assumption should be verified experimentally. The relations between different decay channels of one resonance when passing from the lower to the upper part of the resonance change if the coefficients of the wave functions expansion over the quasiparticle and phonon operators change with energy inside the resonance.

The above questions can be answered by studying experimentally wide isolated neutron resonances. These resonances exist in nuclei lying in the region $30<A<70$. To this end one can use the following resonances: in ^{46}Sc (compound nucleus) with energy 4.27 *keV* above B_n with the width $\Gamma = 0.25$ *keV;* in ^{49}Ti with energy 17.6 *keV* and $\Gamma = 8.71$ *keV;* in ^{50}Ti with energy 3.83 *keV* and $\Gamma = 0.225$ *keV;* in ^{52}V with energy 4.163 *keV*, $\Gamma = 0.565$ *keV* and with energy 6.80 *keV*, $\Gamma = 1.14$ *keV;* in ^{54}Cr with energy 4.185 *keV*, $\Gamma = 1.14$ *keV* and with energy 8.18 *keV*, $\Gamma = 1.23$ *keV;* in ^{63}Ni with energy 4.54 *keV* and $\Gamma = 1.6$ *keV*. Certainly, the analysis of the experimental data will allow one to find other resonances convenient for the experimental investigation. The form of resonances and the ratio between the partial transitions can be studied by the precise measurements of γ-rays from the lower part, peak and upper part of the resonance. There may be another possibility: To select from some nuclei γ-rays from (n,γ) reactions on narrow resonances so that they could excite different energy intervals of the wide resonance under consideration.

It should be noted that the form, decay and the ratios between partial transitions should be studied in the isolated quasistationary states. Such investigations are useless for the giant dipole resonances. Though the form of the giant dipole resonance in spherical nuclei is well described by the Breit-Wigner formula[9], the giant dipole resonance is an envelope of many levels. For the giant multipole resonance, especially "new" ones, monopole, quadrupole and octupole, the resonance width is arbitrary chosen, and one should better define the location of the resonance. Certainly, with increasing energy resolution, there will appear the fine structure of giant multipole resonances.

Perhaps, the "true" elementary nonstable particles differ from the resonances since their characteristics inside their widths can not be questined at all.

In conclusion the author is grateful to N.N.Bogolubov, D.I.Blokhintsev, A.I.Baz, S.M.Bilenky, L.A.Malov, S.Mughabghab, B.M.Pontecorvo, Ju.P.Popov and D.V.Shirkov for interesting discussions.

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Received by Publishing Department
on May 23 1978.