Irregularity in the behavior of the radiative force function in ^{238}U

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It is shown that the irregularity in the behavior of the radiative force function in the reaction $^{238}U(\gamma, n)^{237}U$ is connected with an increase of the density of the two-quasiparticle states with $I^{\pi} = 1^{-}$, which have large matrix elements for $E1$ transitions from the ground state of ^{238}U.

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The semimicroscopic method of calculating the density of the nuclear states, which consists in a direct counting of the number of states with given I^{π} in a definite energy interval, makes it possible to reveal fluctuations in the behavior of the level density. The density fluctuations can lead to a nonstatistical behavior of a number of characteristics of the highly-excited states. The investigations carried out in[1] have shown that in the energy dependence of the density $\rho(E)$ of levels with fixed I^{π}, in some spherical nuclei, there are large fluctuations up to the neutron binding energy B_n. In deformed nuclei, as a rule, the fluctuations of the total density are small at $\mathcal{E} \geq B_n$, but the density of states with a fixed number of quasiparticles can fluctuate strongly. We present in this article the results of calculation of the level densities and radiative widths in ^{238}U, for the purpose of explaining the substructure in the behavior of the radiative force function in the reaction $^{238}U(\gamma, n)^{237}U$.

A peak of approximate width 300 keV was observed[2] in the cross section of

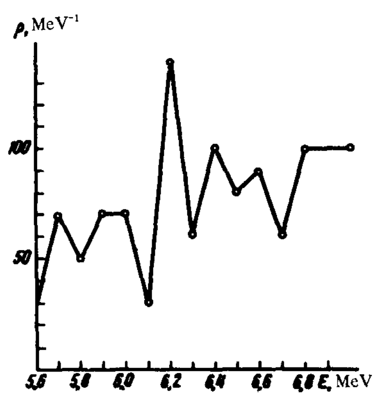

FIG. 1. Density of two-quasiparticle states with $I^{\pi} = 1^{-}$ with ^{238}U; the averaging interval is 0.1 MeV.

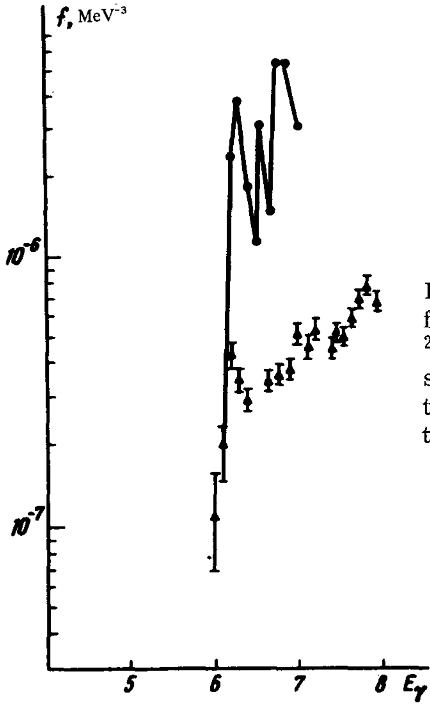

FIG. 2. Radiative force function for $E1$ transitions in the reaction $^{238}U(\gamma,n)$; the points joined by the solid lines are our calculations; the triangles are the experimental points from[2].

the reaction $^{238}U(\gamma,n)^{237}U$ at an excitation energy 6.2 MeV. It is assumed that this peak is connected with $E1$ transitions. According to the quasiparticle selection rules, $E1$ transitions from the ground state of ^{238}U should go to two-quasiparticle components of states with $I^\pi = 1^-$. The radiative force function for $E1$ transitions from an $I^\pi = 1^-$ state with energy E_λ is defined as

$$f^{I}_{o\lambda}(E_\gamma) = \frac{1}{E_\gamma^3}\,\bar{\Gamma}^{I}_{\gamma o\lambda}\,\rho_I(E_\lambda), \qquad (1)$$

where $E_\gamma = E_\lambda$, $\rho_I(E_\lambda)$ is the density of levels with spin I, and $\bar{\Gamma}$ is the average radiative width.

The calculated density of the two-quasiparticle states with $I^\pi = 1^-$ in ^{238}U is shown in Fig. 1. It is seen from the figure that the density of the I^- states changes significantly in the interval 5.6—7.0 MeV and has a maximum at 6.2 MeV. We have calculated the average radiative widths for the $E1$ transitions with wave functions of a Saxon-Woods Potential[3] and effective charges $e_n = -Z/A$ for the neutrons and $e_p = N/A$ for the protons. The calculated radiative widths have a peak at $E = 6.3$ MeV. The calculated radiative force function shown in Fig. 2 has a number of maxima and minima. Maxima at 6.2 MeV are obtained in the measured and experimental radiative force functions. In our calculations we did not take into account the fragmentation (force distribution) of the two-quasiparticle states. The fragmentation of two-quasiparticle states over many nuclear levels leads to a decrease of the absolute value of the radiative force function and to a certain smoothing of the fluctuations. It can be assumed that the overall picture remains unchanged.

Our investigations allow us to conclude that the substructure observed experimentally at 6.2 MeV in the $E1$ force function in ^{238}U is connected with the arrangement and structure of the two-quasiparticle states. We note that the large value of the $E1$ force function at 6.2 MeV coincides also with the peak in the photofission of ^{238}U.[4] One can hope that the description of the absolute values of the radiative force functions can be obtained within the framework of the model of[5], where account is taken of the fragmentation of the quasiparticle states.

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