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INFLUENCE OF THE INITIAL SPIN DISTRIBUTION ON THE DECAY OF COMPOUND NUCLEI* **

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The competition between fission and n, p and α-particle emission and fusion process is studied. The calculations are performed for ^{160}Yb and ^{126}Ba nuclei at excitation energies from 80 MeV up to about 300 MeV. The nuclear fission is described by a Langevin equation coupled to the Master equation for particle evaporation. A significant influence of the initial spin distribution of the compound nucleus on the prescission particles multiplicities is found.

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1. Model

We describe the fission process in a dynamical model [1] which introduces the evolution of the motion of collective variables by means of a Langevin equation with a friction term. This term takes care of the coupling of the collective with the intrinsic degrees of freedom and includes diffusion through an Einstein relation.

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The emission of light particles (p, n, α) prior to fission is taken into account. At each time step of the classical trajectory followed by the collective coordinate the possible emission of a particle from the nucleus with its actual deformation, excitation and rotational angular momentum is determined through a random procedure. If the answer to the test is positive the type of the particle as well as its energy are fixed by some additional random procedures. The energy is drawn from a distribution constructed from the decay widths obtained in the framework of the Weisskopf theory.

2. Application

We have applied this model to the study of symmetric fission of different isotopes of Gd and Yb at various excitation energies ranging from 150 to 300 MeV and different angular momenta of rotation of the compound nucleus. In order to obtain physical observables like particle multiplicities and energy spectra of light particles, we followed a sizeable set of collective trajectories ($\sim 10^6$) from the compound nucleus (with excitation energies and angular momenta taken from initial distribution which were determined separately [2]) up to a point, where the system has either fissioned or ended up as a evaporation residue. The observables are obtained as averages over the whole set of values obtained from the trajectory calculations.

3. Results

^{160}Yb

Table I shows the multiplicities of light particles obtained for two different excitation energies. In order to calculate α multiplicities one needs to

TABLE I

Multiplicites of the prefission particles emitted by ^{160}Yb at two excitation energies $E^* = 251$ and 293 MeV. The experimental data are taken from Ref. [3].

	E^*=251 MeV		E^* = 293 MeV	
ν	model	exp.	model	exp.
n	5.98	6.10± 1.5	7.80	8.50± 1.6
p	0.94	0.51± 0.07	1.19	0.70± 0.08
α	0.58	0.48± 0.07	0.66	0.75± 0.08

introduce a preformation factor f_α of the α particle inside the nucleus prior to emission. Here this factor was empirically fixed to $f_\alpha = 0.2$.

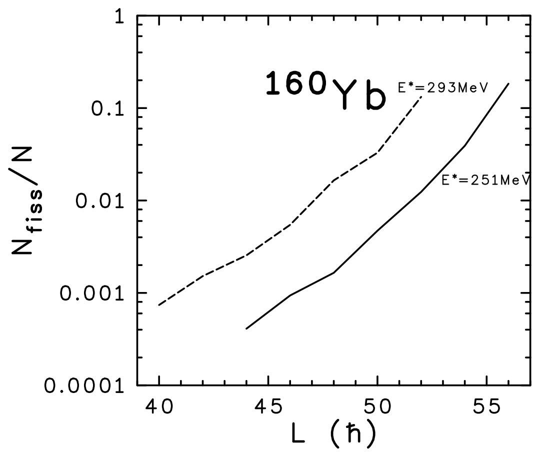

Fig. 1. Fission yield of ^{160}Yb at two excitation energies $E^* = 251$ and 293 MeV as a function of angular momentum L.

Fig. 1 shows the yield of fission events relative to the total number of events which includes particle evaporation from fusion residua. As expected, this yield grows very rapidly with the angular momentum.

^{126}Ba

Table II shows the calculated light particle multiplicities. They should be compared with experimental results which are expected to be available in the near future.

TABLE II

The same data but for ^{126}Ba at different excitation energies studied in Ref. [4].

Reaction	E_{lab} MeV	E^* MeV	M_n -	M_p -	M_α -
	204.0	131.7	2.29	0.03	0.79
^{28}Si + ^{98}Mo	187.2	118.5	1.71	0.00	0.09
	165.8	101.4	1.83	0.00	0.04
	142.8	84.1	0.27	0.04	0.88
^{19}F + ^{107}Ag	147.8	118.5	1.99	0.00	0.16
	128.0	101.5	1.80	0.01	0.06

This nucleus has a very high fission barrier. Fig. 2 shows the fusion and the fission yields in the initial angular momentum distributions which were calculated for two different entrance channels (^{28}Si + ^{98}Mo and ^{19}F + ^{107}Ag) and different bombarding energies. As it can be seen, the fission yields are rather small and located in the tails of the distributions. The energy content of the system if dominated by rotational energy.

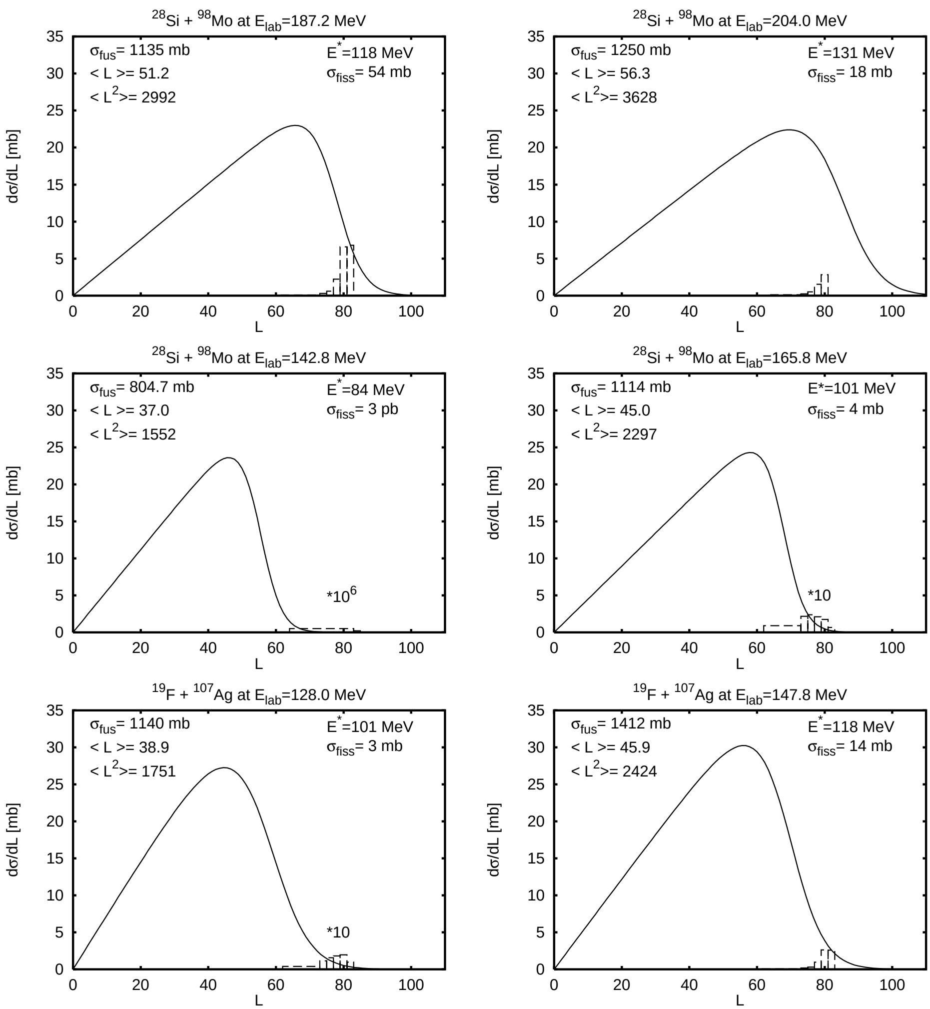

Fig. 2. The differential fusion (solid lines) and fission (bars) cross sections for the compound nucleus ^{126}Ba for different entrance channel reactions.

4. Conclusions

In the case of ^{160}Yb we find a nice agreement between the results of our model calculations and the experimental results. The agreement should be confirmed by a more microscopic determination of the α particle preformation factor.

The calculations show a strong influence of the nuclear deformation on light particle evaporation from excited nuclei. This influence plays also an important role in the competition between fission and light particle emission from fusion residua. The knowledge of the relative fission yield could give us some information about the friction force.

The fission probability depends also very sensitively on the angular momentum. This shows that a precise knowledge of the angular momentum distribution of the initial compound nucleus is needed.

Finally one may also mention that for ^{160}Yb we find that particles in coincidence with fission are, on the average, emitted at larger deformations than those emitted by evaporation residua. It would be nice to check this point by means of the experimental angular distributions of these particles.

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