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Suppression of Neutron Emission in Heavy Ion Induced Fusion Reactions: Entrance Channel Effect and/or Superdeformed Shapes?

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In the 233-MeV $^{64}Ni + ^{92}Zr$ reaction the emission of two neutrons constitutes the strongest decay channel, in contrast to statistical model calculations which predict the emission of three neutrons to be the strongest by more than one order of magnitude.[1)] Possible explanations for the apparent neutron suppression in terms of unusually large gamma-decay width, anomalously energetic neutrons or an unknown yrast line have been ruled out. Here we report on a series of experiments aimed at a better understanding of this suppression.

The neutron multiplicity M_n has been obtained for the 55-75 MeV $^{12}C + ^{144}Sm$ and the 225-290 MeV $^{64}Ni + ^{92}Zr$ reactions leading to the same compound nucleus

^{156}Er. Figure 1 compares M_n as a function of the compound nucleus excitation energy with the calculations obtained from the code CASCADE.[2] It can be seen that the data are well reproduced in the case of the ^{12}C induced reactions, whereas on the average the neutron multiplicity is overpredicted by 0.5 neutrons in the more symmetric reaction. This result not only illustrates the ability of the calculations to reproduce the properties of the compound nucleus decay in the ^{12}C-case but it also illustrates that the suppression persists over a wide energy range for the Ni induced reaction.

It has been suggested that the explanation may lie in a tail to very high ℓ-values arising from, for instance, zero-point fluctuations or coupled-channel effects in the near-barrier ^{64}Ni-induced reaction.[3] This question can be addressed by measuring directly the fusion cross-sections and the ℓ-distributions. The evaporation-residues cross-sections for the two reactions were measured using a technique described in ref. 4. The measured values are compared with those calculated using the empirical model by Kailas and Gupta[5] in figs. 2 and 3. While good agreement is achieved in the ^{12}C-case (hereby increasing our confidence in the ℓ-values used in the statistical model calculations), enhancement of the fusion cross section below the barrier is evident in the Ni induced reaction (at the highest beam energies part of the fusion cross section results in fission which is not detected, hence the calculation exceeds the measured cross section).

Experiments performed with the Darmstadt-Heidelberg crystal ball allow extraction of the ℓ-distributions in the above reactions. The measured distributions have been corrected for the response of the ball and converted to ℓ-distributions before gamma-emission. It is found that with 225-MeV ^{64}Ni (fig. 4) at the barrier, there is a significantly larger yield at higher ℓ-values than predicted in the empirical model of ref. 5. This observation is consistent with the enhancement of sub-barrier fusion. In contrast, at 236 MeV (fig. 5) ℓ_{max} = 37 is close to the Kailas-Gupta value and no tail to unexpectedly high-ℓ values is observed, ruling out this possibility as an explanation for the neutron suppression. The ℓ-distributions for the ^{12}C-induced reactions (not shown) are rather similar to the expected empirical ones.

Several of the more obvious explanations for the observed neutron suppression can now be ruled out. Thus, our original speculation of trapping in a superdeformed minimum (ref. 1) still qualifies for further examination.

References

1. W. Kühn et al., Phys. Rev. Lett. 51 (1983) 1858.
2. F. Pühlhofer, Nucl. Phys. A280 (1977) 267.
3. S. Landowne and C. M. Dasso, Phys. Lett. 138B (1984) 32.
4. W. S. Freeman et al., Phys. Rev. Lett. 50 (1983) 1563.
5. S. Kailas and S. K. Gupta, Z. Phys. A 302 (1981) 355.

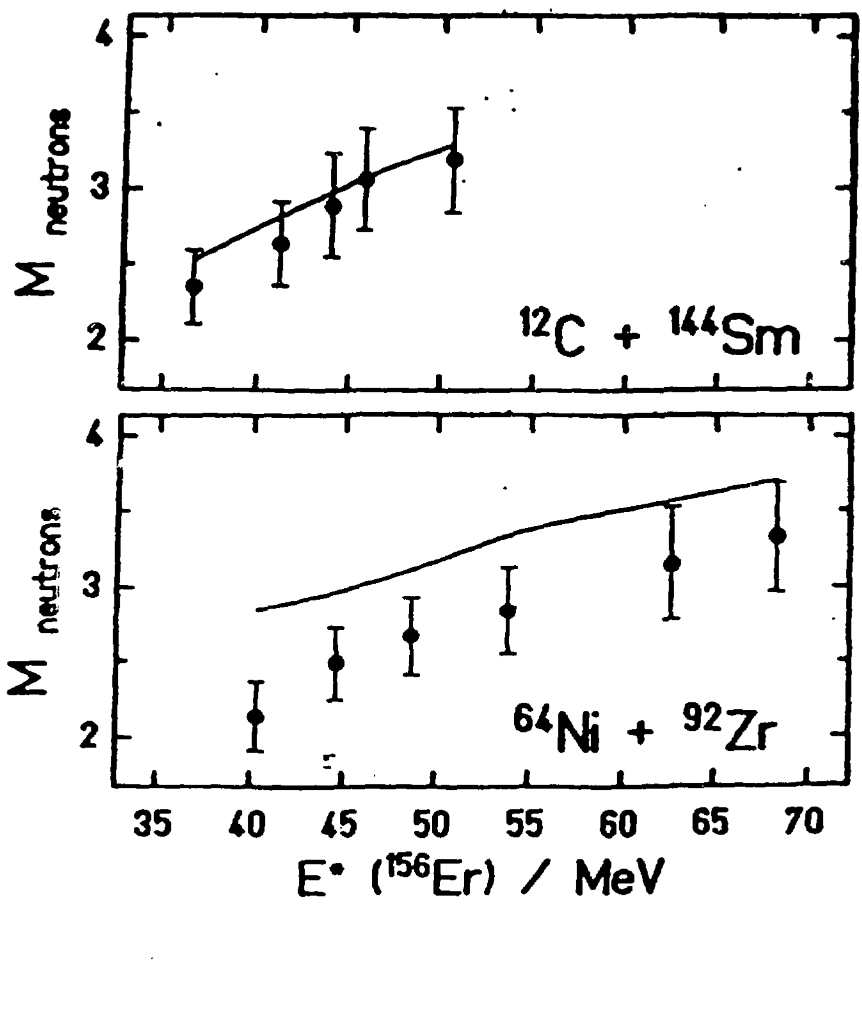

4
3
2
$M_{neutrons}$
$^{12}C + ^{144}Sm$
4
3
2
$M_{neutrons}$
$^{64}Ni + ^{92}Zr$
35 40 45 50 55 60 65 70
E^* (^{156}Er) / MeV

Fig. 1

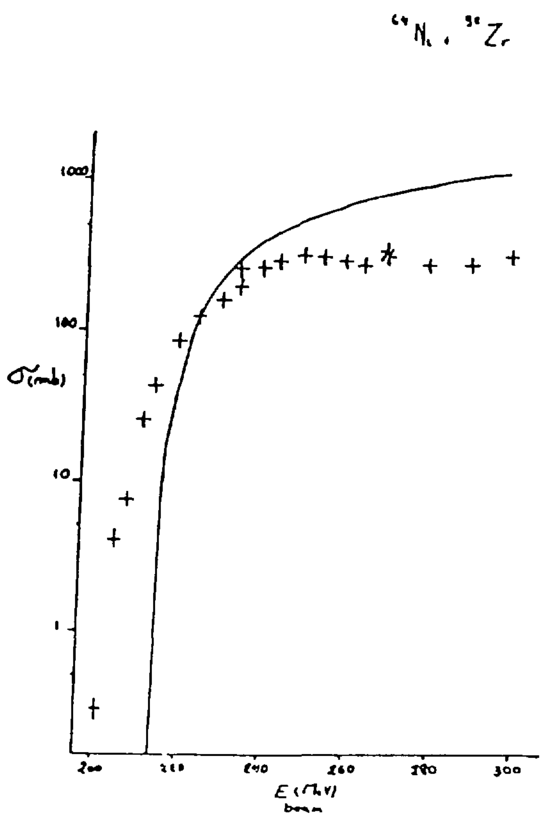

1000
100
10
1
σ(mb)
200
240
260
280
300
E (MeV)
beam

Fig. 2

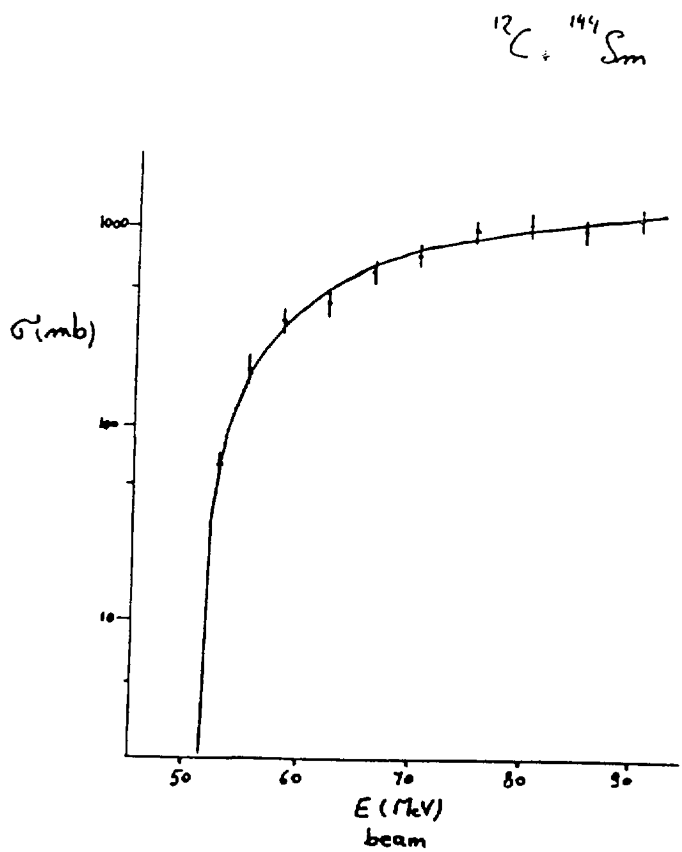
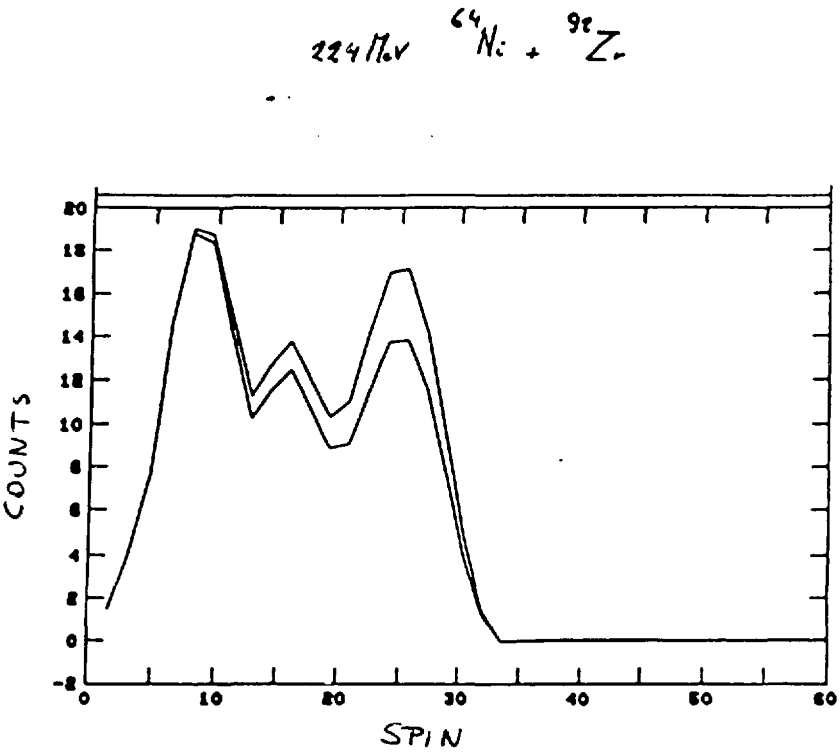
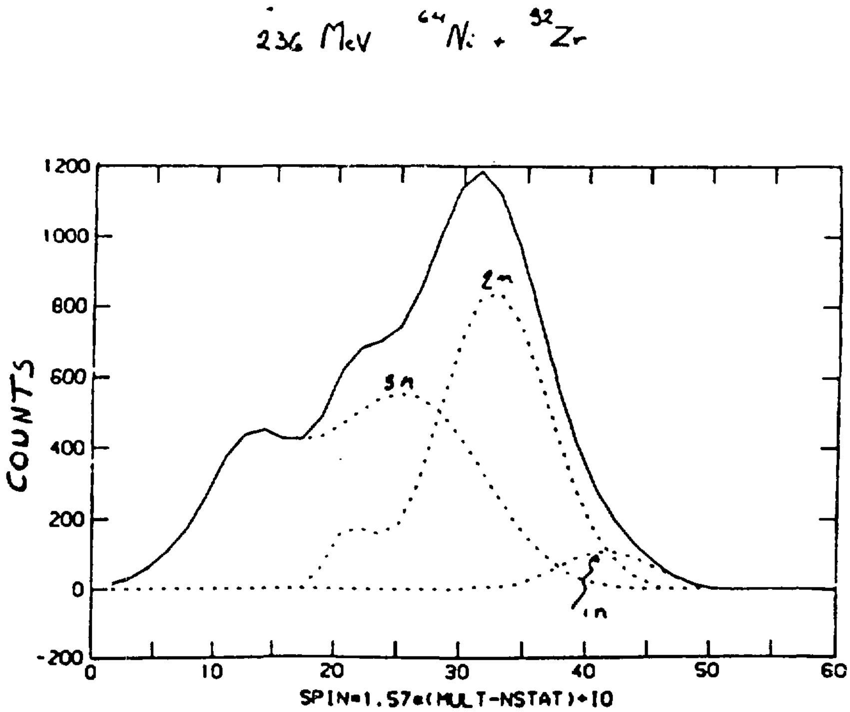

1000
σ(mb)
10
50
60
70
80
90
E (MeV)
beam

Fig. 3



224 MeV ^{64}Ni + ^{92}Zr
COUNTS
SPIN

Fig. 4



236 MeV ^{64}Ni + ^{92}Zr
COUNTS
SPIN=1.57*(MULT-NSTAT)+10

Fig. 5