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Entry State Distributions of Discrete Yrast Transitions in Heavy Ion Induced Fusion Reactions

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The compound nucleus formed in a heavy ion induced fusion reaction usually has a large amount of excitation energy (E) and angular momentum (I). The emission of particles proceeds immediately and brings the nuclear excitation energy down to about one neutron binding energy above the yrast line. From there, γ-decay removes the rest of the excitation energy and angular momentum. The point at which γ-ray emission begins is called the entry state and it has a wide distribution both in angular momentum and excitation energy. The γ-rays emitted in the early stages of the decay are from regions of high level density and many decay pathways are possible. Therefore, these transitions appear as a continuum of γ-rays. Eventually, all the decay pathways will feed into a yrast state and subsequently decay along the yrast line. These yrast transitions can be observed as discrete lines when enough intensity is accumulated. The correlation between the entry point and the feeding point is of fundamental interest.

We have studied the nuclei produced in the reactions, $^{150}Sm(^{12}C,Xn)^{158,159}Er$ with 65 MeV ^{12}C beam, $^{100}Mo(^{34}S,4n)$ ^{130}Ce with 144 MeV ^{34}S beam and $^{70}Zn(^{50}Ti,Xn)$ $^{116,117,118}Te$ with ^{170}MeV ^{50}Ti beam. The beams are from the HHIRF tandem accelerator at Oak Ridge National Laboratory. The γ-rays from the compound nuclei were detected using the spin spectrometer, a 4π multi-element γ-ray detector system. In the experiment two of its 70 NaI elements were replaced by high resolution Ge detectors. Coincidence data between either of the Ge detectors and the spin spectrometer were taken.

In the off-line analysis, the total pulse height (H) and coincidence fold (k) were obtained for each event from the pulse height of the individual NaI detectors, after energy and time calibration and the removal of neutron pulses. The two dimensional distribution of (H,k) were then obtained by sorting events in coincidence with discrete transitions.

The entry state distribution states in several nuclei are shown in Fig. 1.

The k and H projections of some of the distributions are shown in Fig. 2. From these distributions the average values of H and k are calculated. Figures 3, 4 and 5 show the results as function of spin of the yrast transition. The average values of ^{130}Ce do not increase with spin but show a sudden increase after the back bending at I=12. This is due to the reduction of low fold component of the distribution, as can be seen from its k-projection. This effect may be due to the difference of the decay pathways feeding the ground state band and the aligned band. On the other hand, the results for Er and Te isotopes increase with spin as expected.

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Figure 1.

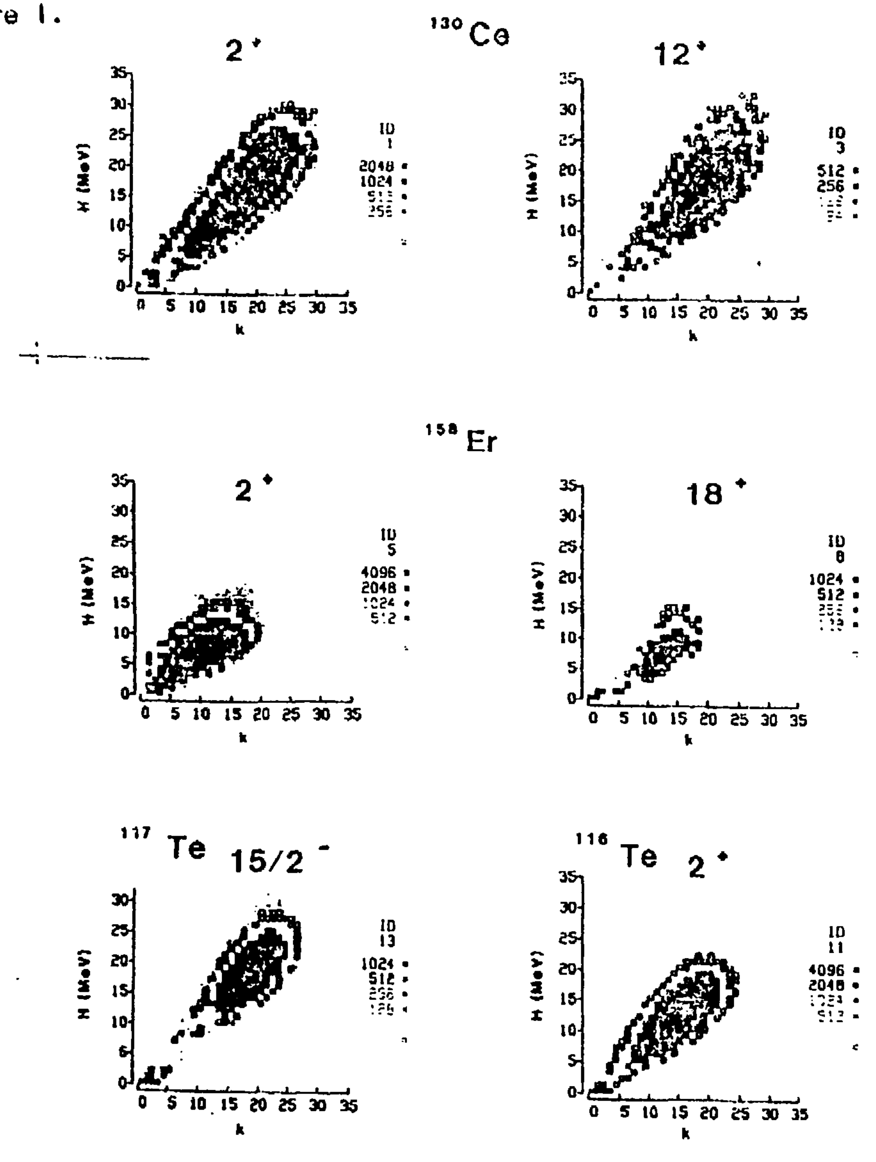

Fig. 1 Entry state (H,k) distributions of yrast state of ^{130}Ce, ^{158}Er and ^{116,117}Te

Figure 2.

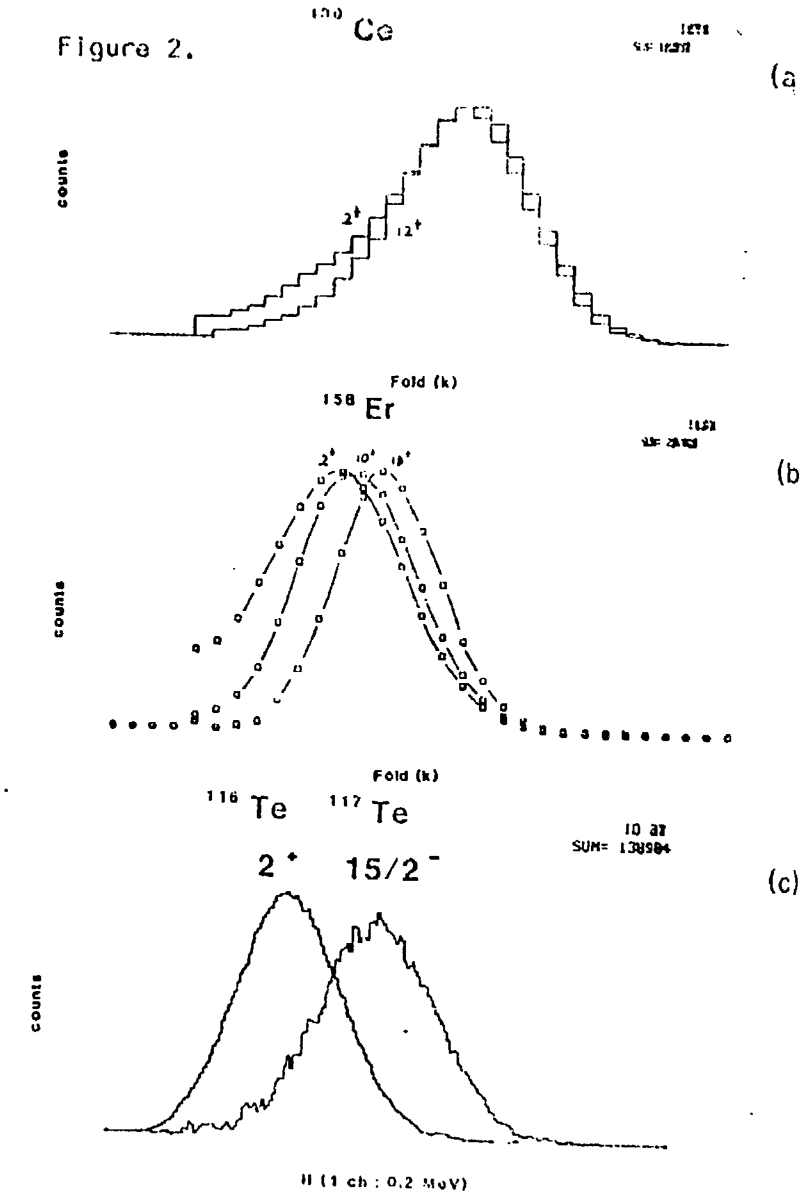

Fig. 2 (a) Fold (k) distribution of the 2^+ and 12^+ states of ^{130}Ce, (b) k distribution of 2^+, 10^+, and 18^+ states of ^{158}Er, (c) H – distribution of 2^+ state of ^{116}Te and $15/2^-$ state of ^{117}Te

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Figure 3.

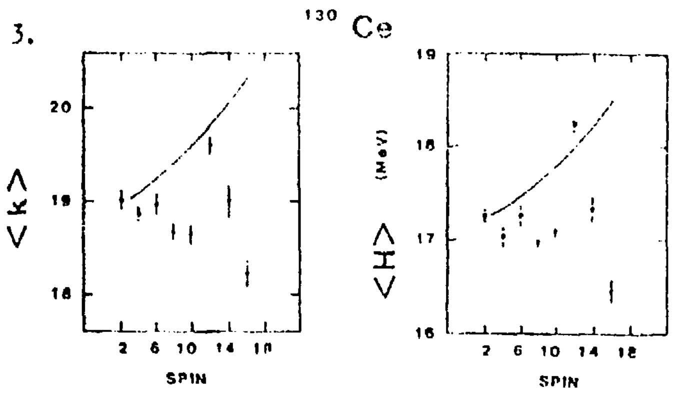

Fig. 3 Average k and H values of yrast state in ^{130}Ce

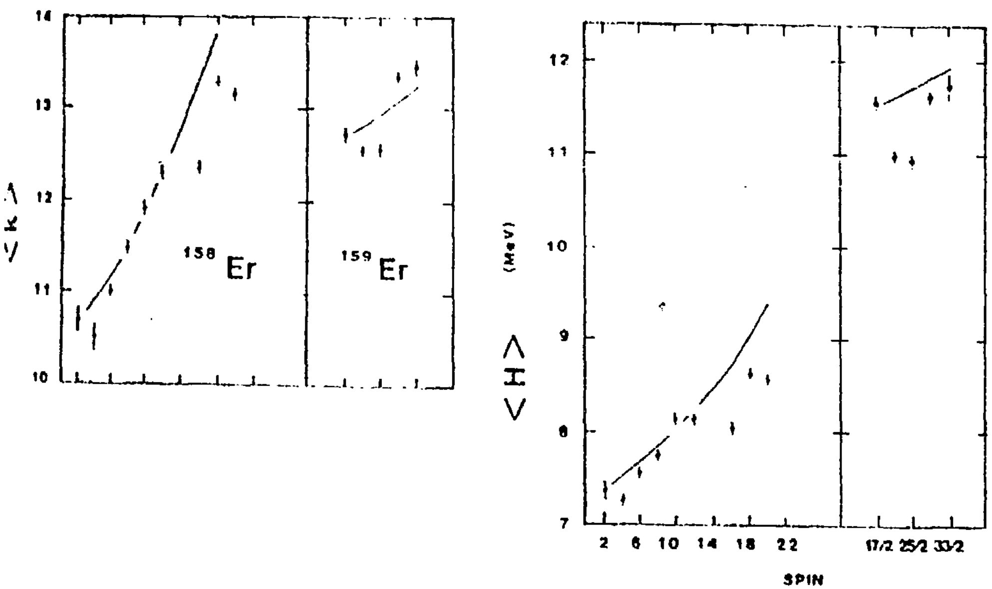

Fig. 4 Average k and H values of yrast state in ^{158,159}Er

Figure 5.

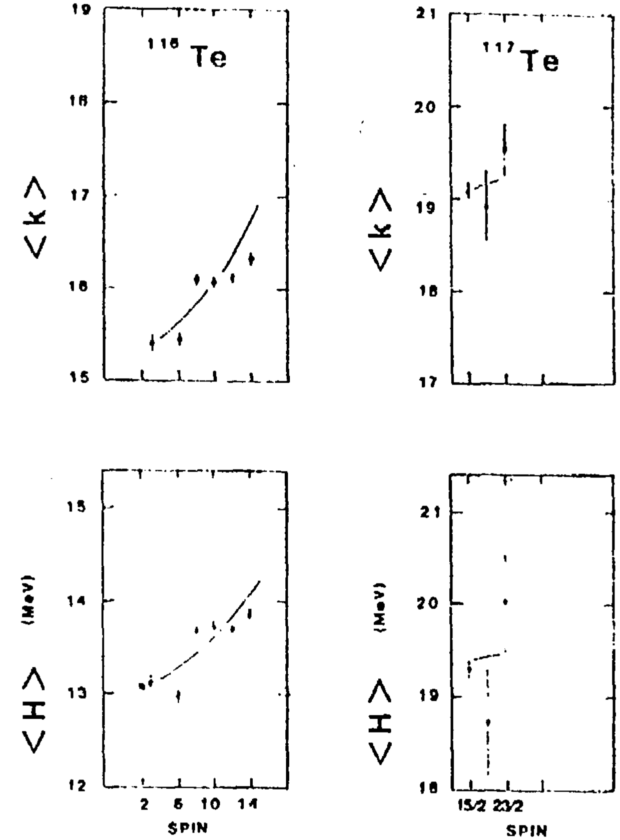

Fig. 5 Average k and H values of yrast state in ^{116,117}Te