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FISSION FRAGMENT ANGULAR DISTRIBUTIONS

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Many recent papers have found that calculations with the standard angular distribution formula for fission fragments from compound nuclei do not reproduce the strong anisotropies observed in the decay of high spin systems. They conclude that a non-compound nuclear process must exist for some partial waves and postulate an ad-hoc angular distribution for this process in order to reproduce the strong anisotropies. It is the purpose of this contribution to demonstrate that much of the data are, in fact, consistent with compound nucleus formation and to emphasize that the standard model is not a generally valid way to calculate fission fragment angular distributions from a compound nucleus.

Since the late 1950's fission fragment angular distributions have been calculated using a postulated distribution of the K quantum number at the saddle point, $e^{-K^2/2K_0^2}$, where $1/K_0^2 = 1/\mathcal{J}_{\parallel}T - 1/\mathcal{J}_{\perp}T$ [1]. The moments of inertia, $\mathcal{J}$, are taken for saddle point shapes from the rotating liquid drop model[2] and T is the nuclear temperature. While this specific form is one which is plausible for low spin systems, it is not a condition which need be satisfied for compound nucleus formation. For example, if the same assumption were made for light particle emission from spherical nuclei, all resulting *angular distributions would be isotropic.* As was pointed out in ref. 3 the general compound nucleus angular distribution formula arises from treating the exit channel explicitly and leads in the cases of <u>high spin</u> compound nuclei to the approximate formula

$$W(\theta) = \sum_{J,K}(2J+1)T_J\,\frac{2J+1}{2}\,\left|D^J_{0K}(\theta)\right|^2\,\frac{e^{-K^2/2\sigma_{\parallel}^2}}{\sum_K e^{-K^2/2\sigma_{\parallel}^2}} \qquad (1)$$

In eq. 1, J is the spin of the compound nucleus and K is the projection of J on the emission axis. The only difference between this formula and the standard one is the width of the K distribution. Here $\sigma_{\parallel}^2 = \mathcal{J}_{\parallel_1}T_1 + \mathcal{J}_{\parallel_2}T_2$ where $\mathcal{J}_{\parallel}T$ is the product of the moment of inertia parallel to the symmetry axis and T the temperature of the fission fragment 1. The value of $\sigma_{\parallel}^2$ is also roughly equal to $\mathcal{J}_{\parallel}T$ where both of these quantities are evaluated at the saddle point of the compound nucleus. For high spin systems $1/\sin\theta$ distributions result from eq. 1 independent of the saddle point shape whereas the standard model tends toward isotropy.

As examples of the dramatic consequences of eq. 1, we choose the cases shown in ref. 4. The parameters chosen to do the calculation for these cases are $\mathcal{J}_{\parallel_1} + \mathcal{J}_{\parallel_2} = .47\mathcal{J}_0$ where $\mathcal{J}_0$ is the moment of inertia of a spherical compound nucleus and $T_1 = T_2 = \sqrt{8(E_{cm}+Q-E_k)}$. Equal mass fission fragments have been assumed for the calculation of Q and E_k comes from the systematics of fission fragment kinetic energies. Because of space restrictions only one set of data from ref. 4 is shown in fig. 1. The agreement of the calculations with data for the other cases is equally satisfactory and demonstrates that the data are consistent with compound nucleus formation, i.e. there is no need to postulate another process. Of course, these results do not prove compound nucleus formation but to experimentally demonstrate otherwise requires the observation of an asymmetry around 90 degrees for a specific mass.

Finally, the predictions of eq. 1 are consistent with the assumption used in the rotating liquid drop model that J is oriented approximately perpendicular to the symmetry axis of the compound nucleus (R⊥J) and that the K <u>mode</u> of the deformed compound nucleus is statistically populated at the saddle point. As is correctly pointed out by the authors of ref. 4, as well as by others, the high spin data are certainly not consistent with the standard assumption that both R and K are statistically populated. However, *this is not a condition of compound nucleus formation* and is in conflict with a basic assumption of the rotating liquid drop model.

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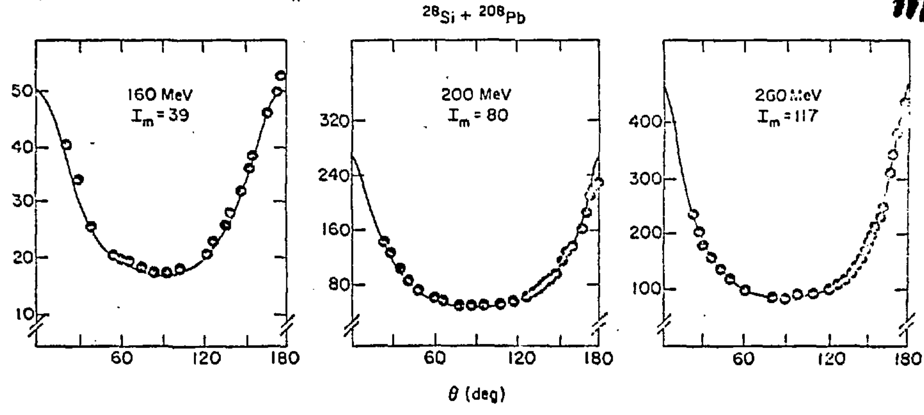

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