neutrons emitted per (^{6}Li,xn) reaction.

The quality of agreement found in Figs. 2-4 suggests that at the present level of reliability of the statistical model it is not necessary to include microscopic (shell and/or pairing) corrections or other modifications to the NIFG-RLDM structure in order to understand the overall decay properties of hot, high-spin nuclei. This conclusion conflicts with recent suggestions made on the basis of less complete programs of measurement and analysis.[9] In order to enhance sensitivity to such structure corrections, one needs to devise more selective measurements (we have suggested examples in Ref. 4) and to address other ambiguities in the statistical model treatment.

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IMPROVEMENTS TO THE STATISTICAL MODEL TREATMENT OF HIGH-SPIN COMPOUND NUCLEI

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In our attempts to constrain nuclear structure parameters at high spin by studying the decay modes of fusion products, it has become clear that one needs not only more careful and systematic measurements of the decay properties, but also expanded and improved versions of the standard statistical model analysis codes. We have already implemented one major improvement to the code MB-II (Ref. 1), incorporating the capability to calculate the fission-fragment angular distribution $W(\theta)$. As we have described in a recent publication[2], this feature represents an important addition to the code, since it does not require introducing any significant new assumptions, while $W(\theta)$ does provide significant new constraints on the spin distribution of the compound nucleus (CN) and on the "chance" distribution of the observed fission. (The chance distribution refers to the relative contributions of fission directly from the CN vs. fission following the emission of one, two, three, etc., neutrons from the CN.) The calculation is based on the model of Halpern and Strutinski,[3] according to which $W(\theta)$, for a given total angular momentum (J) of the fissioning nucleus, depends on the statistical distribution of angular momentum projection values (K, $0 \leq K \leq J$) along the nuclear symmetry axis at the saddle-point deformation. Details concerning the calculation can be found in Refs. 2 and 4.

In Fig. 1 we present calculations for four different sets of parameters (all without any particular physical significance) which are intended to illustrate the sensitivity of $W(\theta)$ [as characterized by the ani-

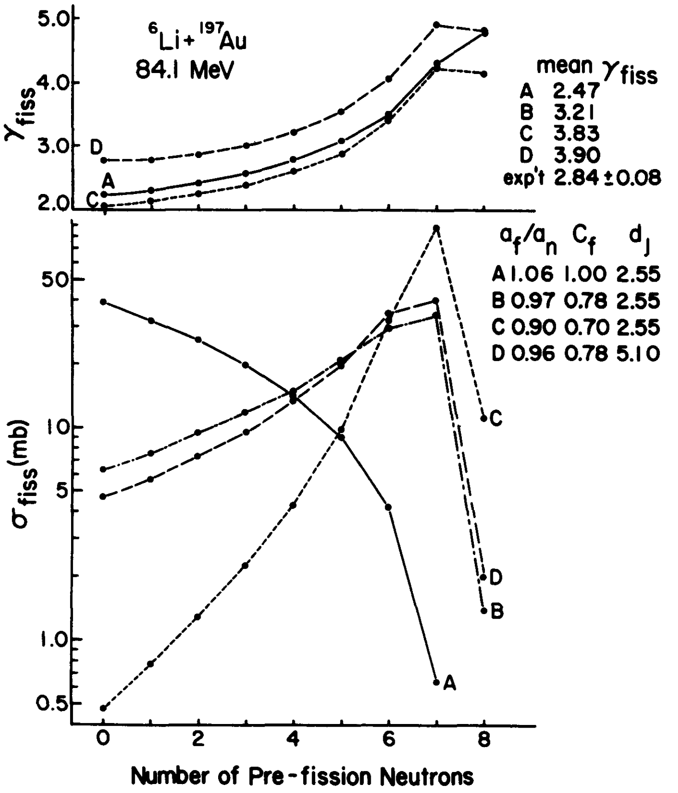

Figure 1. Statistical model calculations illustrating the variation of the fission anisotropy and cross section with chance for four different parameter sets, each reproducing the measured total fusion and fission cross sections. The mean γ_{fiss} values listed refer to W(θ) summed over all chances. The γ_{fiss} curve for parameter set B (not shown) falls between those for A and C.

sotropy $\gamma_{fiss} \equiv W(170°)/W(90°)$] to the spin and chance distributions. The initial CN spin distribution is changed via the parameter d_J, which specifies the diffuseness of the high-spin fall-off (increasing d_J yields increasing fission contributions from high spins). The chance distribution (shown for the four parameter sets in the lower half of the figure) has been varied by scaling fission barrier heights from rotating-liquid-drop predictions by the adjustable factor C_f, and by changing the ratio a_f/a_n of level density parameters relevant at the saddle-point (a_f) and yrast (a_n) deformations. It is the mean calculated γ_{fiss} values, weighted by the chance distribution, which should be compared with the experimental result. Calculations using the same parameter sets for other cases than that treated in Fig. 1 indicate that the competing sensitivities of γ_{fiss} to the spin and chance distributions can be distinguished by measurements of the target and energy dependences of σ_{fiss} and γ_{fiss}.

We are currently making another major modification to MB-II, this time in the treatment of nuclear level densities. A number of the statistical model codes (including MB-II) most commonly used in treatments of heavy-ion induced fission evaluate the spin-dependence of the level density in a manner which implicitly assumes spherical symmetry at some point in the calculation. Such a treatment is not valid for the actual yrast and saddle-point shapes of interest. In determining a more appropriate procedure for deformed nuclei, one must decide whether or not to include collective degrees of freedom explicitly, and if so, whether to include them in similar manner at the strongly deformed saddle point and at the often mildly deformed yrast shapes.

In our approach we have been guided by theoretical studies in Refs. 5 and 6. At the nuclear temperatures of interest ($t \lesssim 2$ MeV) it seems proper to include collective levels explicitly in counting states, since the intrinsic configurations which contribute to the collective states would, in the absence of the collectivity, not contribute significantly to the low-temperature state density. (By the same token, the intrinsic state density would have to be appropriately depleted at higher temperatures to avoid double-counting.) As in Refs. 5 and 6 we consider explicitly only rotational collective levels, and these we include at both saddle-point and yrast deformations. The total level density at excitation energy E^* and total angular momentum J, including the rotational bands based upon each intrinsic state (characterized by symmetry-axis spin projection K), is then given by:

$$\rho(E^*,J) = \sum_{K=0}^{J} \rho_{\text{intrinsic}}[E^*-E_{\text{rot}}(J,K),K]$$

$$= \frac{\hbar}{(2\pi \mathcal{J}_{\parallel} t)^{1/2}} \tag{1}$$

$$\times \sum_{K=0}^{J} \rho_{\text{intrinsic}}\Big[E^* - \frac{\hbar^2-\{J(J+1)-K^2\}}{2\mathcal{J}_{\perp}} - \frac{\hbar^2 K^2}{2\mathcal{J}_{\parallel}}\Big]$$

here, $\rho_{\text{intrinsic}}(U) \propto \exp(2\sqrt{aU})/U^{5/4}$; $\mathcal{J}_{\parallel}$ is strictly a statistical characteristic of the intrinsic configurations generating the projection K, but it can be identified as an "effective" classical moment of inertia for rotations about the symmetry axis. The collective rotations occur only about axes orthogonal to the symmetry axis, and are associated with the moment of inertia $\mathcal{J}_{\perp}$.

In the code the level densities relevant to fission (ρ_f) and to particle emission (ρ_n) will be evaluated via approximations to Eq. (1), involving replacement of the K-summation by an integral. Different approximations will be used to evaluate the integrals for ρ_f and ρ_n, corresponding to our different assumptions for the shapes of the yrast (mildly deformed oblate, with spin parallel to symmetry axis) and saddle-point (strongly deformed prolate, with spin perpendicular to symmetry axis) nuclei. The resulting formulae are:

$$\rho_f(E^*,J) \propto (2\pi)^{1/2} (\mathcal{J}_{\parallel})_{sp}^{-1/2} (K_o)_{sp}$$

$$\times \operatorname{erf}\Big\{\frac{(J+1/2)}{\sqrt{2}(K_o)_{sp}}\Big\} \frac{\exp\{2(a_f U_{sp})^{1/2}}{U_{sp}^{3/2}} \quad ; \tag{2}$$

$$\rho_n(E^*,J) \propto (2J+1)(\mathcal{J}_{\parallel})_{\text{yrast}}^{-1/2}$$

$$\times \exp\Big\{-\frac{J(J+1)}{3(K_o)^2_{\text{yrast}}}\Big\} \frac{\exp\{2(a_n U_{\text{yrast}})^{1/2}\}}{U_{\text{yrast}}^{3/2}} .$$

Here, U_{sp} and U_{yrast} represent the excitation energy E^* decremented by the rotational energies associated, respectively, with the saddle-point and with the yrast deformations at spin J; $K_o^2 = \mathcal{J}_{\perp} \mathcal{J}_{\parallel} t/\hbar^2 |\mathcal{J}_{\perp} - \mathcal{J}_{\parallel}|$ for each deformation; and

$$\operatorname{erf}(x) = 2\pi^{-1/2} \int_o^x e^{-t^2}\, dt.$$

We expect that use of Eq. (2) in place of the present MB-II level-density evaluation will reduce the calculated values of σ_{fiss} and γ_{fiss}, by amounts comparable to the present calculational uncertainties arising from uncertainties in the measured total fusion cross sections and initial CN spin distributions.

Further improvements to MB-II are planned for the near future. We harbor no illusions that these improvements can remove all ambiguities from the statistical model treatment of CN decay; significant uncertainties will remain, e.g., from the effects of pre-equilibrium particle emission, and of the untreated dilution of collectivity in the level-density evaluation at moderate-to-high nuclear temperatures. Nonetheless, these improvements should substantially enhance the significance of comparisons between calculations and measurements.

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*NSF Undergraduate Research Participation Fellow, Summer, 1978.

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