shell strengths of ~0.3-0.5 at this excitation energy). Fig. 2 shows a plot of total kinetic energy release versus fragment mass, again compared with model predictions. Although the data indicate the possibility of some anomalous behavior in the region of $A_H \approx 103$, the best fit to the data is given by the liquid drop calculation with zero shell strength.

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CALCULATIONS OF HIGH-SPIN FISSION FOR A≈200

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One of the long term hopes of heavy-ion studies has been the use of heavy-ion induced fusion-fission processes to extract information on the evolution of fission barriers (B_f) with increasing angular momentum (J). Existing results[1-6] have produced a wide range of conclusions concerning the comparison between values of B_f(J) deduced from experiment and barrier heights obtained from rotating liquid drop model (RLDM) predictions. The differences in conclusions in Refs. 1-6 may reflect in part a real mass-dependence in the validity of the RLDM (specifically in the importance of corrections associated[7] with surface diffuseness and the finite range of the nuclear force), as stressed recently by Blann and Komoto.[5] Nevertheless, nagging discrepancies persist between the conclusions of different workers for selected similar-mass systems, and these cast doubt on the general significance of nuclear properties deduced from fusion-fission studies.

Recently, results have become available for three quite different systems, all leading to compound nuclei (CN) around ^{200}Pb: our own measurements and analysis[6] for ^{6}Li + ^{197}Au,[6] and those of Hinde et al.[8] for ^{19}F + ^{181}Ta and ^{30}Si + ^{170}Er. The data for these different entrance channels provide a useful "case history" in which to probe the origin of discrepancies between different studies. The results for ^{6}Li-induced fusion in the bombarding energy range from 75 to 95 MeV (for ^{181}Ta, ^{194,198}Pt, and ^{208}Pb targets as well as ^{197}Au) were interpreted[6] as completely consistent (to within ~5%) with nuclear structure predictions of the RLDM and noninteracting Fermi gas (NIFG) model; in contrast, Hinde et al.[8] claim that the data for heavier projectiles appear to require ~20% reductions to RLDM fission barrier heights. It should be noted that the corrections to RLDM structure arising from diffuse-surface and finite-range effects are expected[7] to be negligible for A=200.

The differences in conclusions between the two studies[6,8] might arise in principle from a variety of sources: e.g., different experimental techniques for defining the total fusion cross section σ_{fus}; contributions to fission from mechanisms other than complete fusion, which would yield an effective entrance-channel dependence of the extracted nuclear structure parameters; different underlying assumptions and philosophy in the statistical model analysis. In order to explore the latter possibility, we have recently performed statistical model calculations under a variety of assumptions for all three systems above. We have previously urged[9] the comparison of fission results for such widely differing entrance channels to the same compound nucleus, specifically as a test of the treatment described in Ref. 9 for incorporating the fadeout of collective level density enhancements with increasing nuclear temperature.

Our statistical model analysis of the decay of the compound systems ^{200}Pb and ^{203}Pb has been carried out with the code MBEGAT described in detail in Ref. 9. We have used in our calculations several different approaches for the level density as a function of spin and temperature, all of which are described in Ref. 9. These calculations show that differences in the level density treatments cause changes in the calculated σ_{fiss} comparable to those obtained by changing B_f by ~20%.

In Fig. 1 we compare the experimental fission excitation functions[8] for ^{19}F + ^{181}Ta and ^{30}Si + ^{170}Er with those we have calculated using the most complete level density treatment described in Ref. 9, and the same input parameters used in Ref. 6 for the ^{6}Li + ^{197}Au system. Specifically, the fission barrier height and the ratio (a_f/a_ν) of level density parameters for fission vs. particle evaporation have been fixed to RLDM-NIFG predictions. In contrast to the calculations reported in Ref. 6, we have included the predicted variation of a_f/a_ν with spin and with fissioning nuclide along the decay chain (arising from the corresponding variations in RLDM saddle-point shape); the effects of this variation become appreciable for the heavier projectiles because the CN is formed over a substantially broader range of spins than for ^{6}Li + ^{197}Au. We have also incorporated in the calculations shown in Fig. 1 the fadeout of the collective level density enhancement,[9] with the one associated adjustable parameter (governing the deformation at which the collective enhancement is cut off at given temperature) fixed to the value (ζ =1.05) found[6] to give optimum agreement with the ^{6}Li + ^{197}Au data. We have not allowed in the ^{19}F and ^{30}Si calculations for any pre-equilibrium (PE) nucleon emission in the early stages of the decay, since no specific measurements which would constrain such processes are reported in Ref. 8, and general systematics suggest that PE emission becomes unimportant at the bombarding energies (<8 MeV/nucleon) studied for these entrance channels. The initial CN spin distributions for the ^{19}F and ^{30}Si projectiles were calculated following the same prescription as used in Ref. 8, and were constrained to reproduce the measured[8] total fusion cross sections.

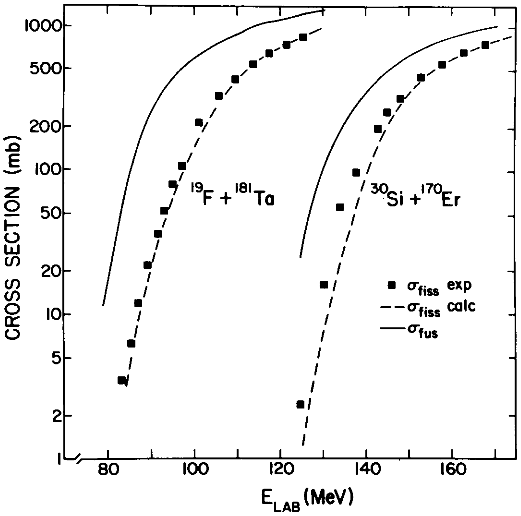

Figure 1. Comparison of the calculated and measured energy dependences for σ_{fiss} for two different entrance channels to the same compound nucleus (^{200}Pb). The σ_{fiss} measurements and the curves drawn through σ_{fus} measurements are taken from Ref. 8. The calculations, described in the text, employ fission barrier heights and a level density parameter ratio predicted by the rotating liquid drop and non-interacting Fermi-gas models, and they simultaneously reproduce a wide variety of measurements for ^{6}Li-induced fusion in the same mass range (see Ref. 6).

The agreement in Fig. 1 between the calculated and experimental absolute values of σ_{fiss}, although not as good as the best fits obtained by the authors of Ref. 8, is very satisfactory considering the absence of any adjusted parameters in our calculations. If one were to set $B_f=0.83B_f^{RLDM}$ and $a_f/a_v=1.00$, as suggested in Ref. 8, but using our more sophisticated level density treatment, the calculated σ_{fiss} would substantially exceed the measured values at all bombarding energies for all three systems, and the fission-fragment anisotropies measured for ^{6}Li + ^{197}Au would be overpredicted by ~25%.

We conclude that the differing claims in Refs. 6 and 8 concerning high-spin fission barrier heights for A≈200 can be largely attributed to differences in the underlying assumptions and philosophy of the statistical model analyses, although certainly differences in experimental technique and in contributions from competing reaction mechanisms may further cloud the comparison. Our calculations adequately explain the measurements for three widely differing entrance channels to A≈200 CN, reinforcing our earlier conclusion[6] that there is no evidence, at the present level of sophistication of the statistical treatment for an inadequacy of the RLDM-NIFG structure predictions at high spin and excitation in this mass range.

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190 MeV PROTON-INDUCED SYMMETRIC AND ASYMMETRIC FISSION*

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Proton-induced fission (E_p = 190 MeV) has been studied for uranium and several selected nuclei with A between 140 and 210. Fission fragments were detected in the 163 cm diameter scattering chamber using solid-state detectors. Typically a single 300 mm^2 Si detector (<100μm) was placed on one detector arm (θ≈90°) about 15 cm from the target. A three-detector array (600 mm^2 Si; <100 μm) was located about 30 cm away on an opposing detector arm (θ < -90°), with the target set at 45° with respect to the incident beam. Energy signals, and timing signals relative to the cyclotron r.f. and between detectors were used for fragment identification, with energy and relative mass spectra calibrated using a thin ^{252}Cf fission source. The time-of-flight resolution of 0.7 to 1.5 ns (FWHM) was sufficient to separate fission fragments from most of the energetic light ions emitted and provide an approximate mass identification (±10 amu) (see Fig. 1).

The targets consisted of self-supporting rolled metal foils, about 500 μg/cm^2, or in the case of U, Eu,