dramatic in the last two columns of Tables I and II. Here for 142-MeV initial excitation it appears that the probability for charged-particle emission greatly exceeds that for the survival of the compound-nucleus residue.

An understanding of reactions between heavy nuclei is clearly dependent on our factual knowledge of fissionability at high energy and spin.[5,6] Recently several calculations have been presented[1,4] in an attempt to approach a systematic parametrization of fission barriers and level densities. This Letter dramatizes a most important aspect of this problem: the competition between fission and light-charged-particle evaporation. Meaningful description of the fission-evaporation competition requires a more careful calibration of the associated level densities and transmission coefficients at high energies and spins.[1,4] Cross sections and energy spectra from this work will be compared to statistical-model calculations in a later paper.

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Breakup of ^{9}Be in the Coulomb Field of Heavy Nuclei

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Measured cross sections for the breakup of ^{9}Be ions in the Coulomb field are found to be in disagreement with calculations based on a model which describes well the Coulomb breakup of deuterons. A possible explanation for this discrepancy in terms of Coulomb excitation of the projectile is suggested.

The breakup of different particles in the field of nuclei for energies well below the Coulomb barrier can be calculated with a semiclassical model.[1] In the case of the breakup of the deuteron, the results of this approximation are in excellent agreement with quantal (distorted-wave Born approximation, DWBA) calculations and with measured cross sections.[2] The assumption for the semiclassical approximations are even better fulfilled in the case of heavy ions. In order to check the models for another system, we measured the Coulomb breakup of ^{9}Be into ^{8}Be

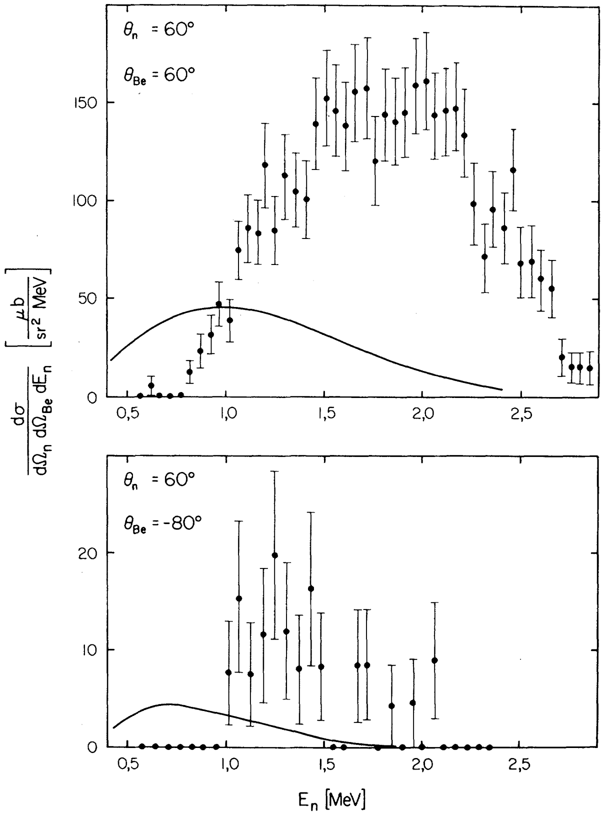

FIG. 1. Measured and calculated triple-differential cross sections for the breakup of ^{9}Be in the Coulomb field of silver at 20 MeV.

and a neutron. ^{9}Be seems to be a suitable nucleus for this purpose because due to its low binding energy the cross sections are quite high.

Triple-differential cross sections $d\sigma/d\Omega_{Be}d\Omega_n dE_{Be}$ were measured with a silver target of about 100 μg/cm^2 thickness. The two α particles from the decay of the ground state of ^{8}Be were registered with two rectangular surface-barrier semiconductor detectors in coincidence,[3] whereas the neutrons were detected by a neutron counter consisting of a NE213 liquid scintillator and a XP1040 photomultiplier. For each event, four parameters were recorded on the disk of the data-acquisition computer, viz., the energies of both α particles, their difference in time of flight, and the time difference between one of the α particles and the neutron. The cross sections belonging to different ^{8}Be energies were obtained from the number of counts along the "kinematical curve" in the two-dimensional spectrum of the sum of α energies versus the neutron time of flight. The measurements were carried out at the angles $\theta_{Be} = 60°$ and $\theta_{Be} = -80°$, whereas the angle of the neutron detector was fixed at 60° to the beam axis. The minus sign in θ_{Be} indicates that the ^{8}Be and neutron detectors were on opposite sides of the beamline. The energy of the ^{9}Be ions was 20 MeV. The results of these measurements are shown in Fig. 1.

With the same arrangement for the detection of ^{8}Be, but without use of the neutron detector, also the double-differential cross section $d\sigma/d\Omega_{Be}dE_{Be}$ could be determined. In this case, a gold target of about 100 μg/cm^2 thickness was used. The ^{8}Be detector was set at an angle of 140° for beam energies of 18, 20, 23, and 26 MeV. Additionally, for an energy of 20 MeV an angular distribution was measured from 60° to 160° in steps of 20°. Examples of these data are given in Fig. 2, whereas in Table I all cross sections (after integration over the ^{8}Be energy) are presented.

Figures 1 and 2 and Table I give also the semiclassical cross sections, calculated with a spectroscopic factor of ^{9}B equal to 1. The disagreement between the experiment and the calculation

TABLE I. Comparison of measured and calculated cross sections for the breakup of ^{9}Be in the Coulomb field of ^{197}Au. $\sigma(^9\text{Be}^*)$, the cross section for Coulomb excitation, is not included in the theoretical values $d\sigma/d\Omega$ (theor).

Energy [MeV]	Angle [deg]	$d\sigma/d\Omega$ (expt) [μb/sr]	$d\sigma/d\Omega$ (theor) [μb/sr]	$\frac{d\sigma/d\Omega\ (\text{expt})}{d\sigma/d\Omega\ (\text{theor})}$	$\sigma(^9\text{Be}^*)$ [μb/sr]
18	140	(15.6 ± 10)%	5.3	2.95	10.5
20	140	(53.0 ± 4.3)%	22.0	2.41	50.1
23	140	(215.2 ± 9)%	106.0	2.03	274.1
26	140	(614.6 ± 9)%	312.0	1.97	1022.7
20	160	(51.3 ± 7)%	22.1	2.32	42.4
20	120	(52.9 ± 5.3)%	21.5	2.46	62.4
20	100	(49.8 ± 4.2)%	19.5	2.55	76.1
20	80	(37.8 ± 4)%	15.7	2.41	81.2
20	60	(23.4 ± 7)%	8.3	2.81	60.0

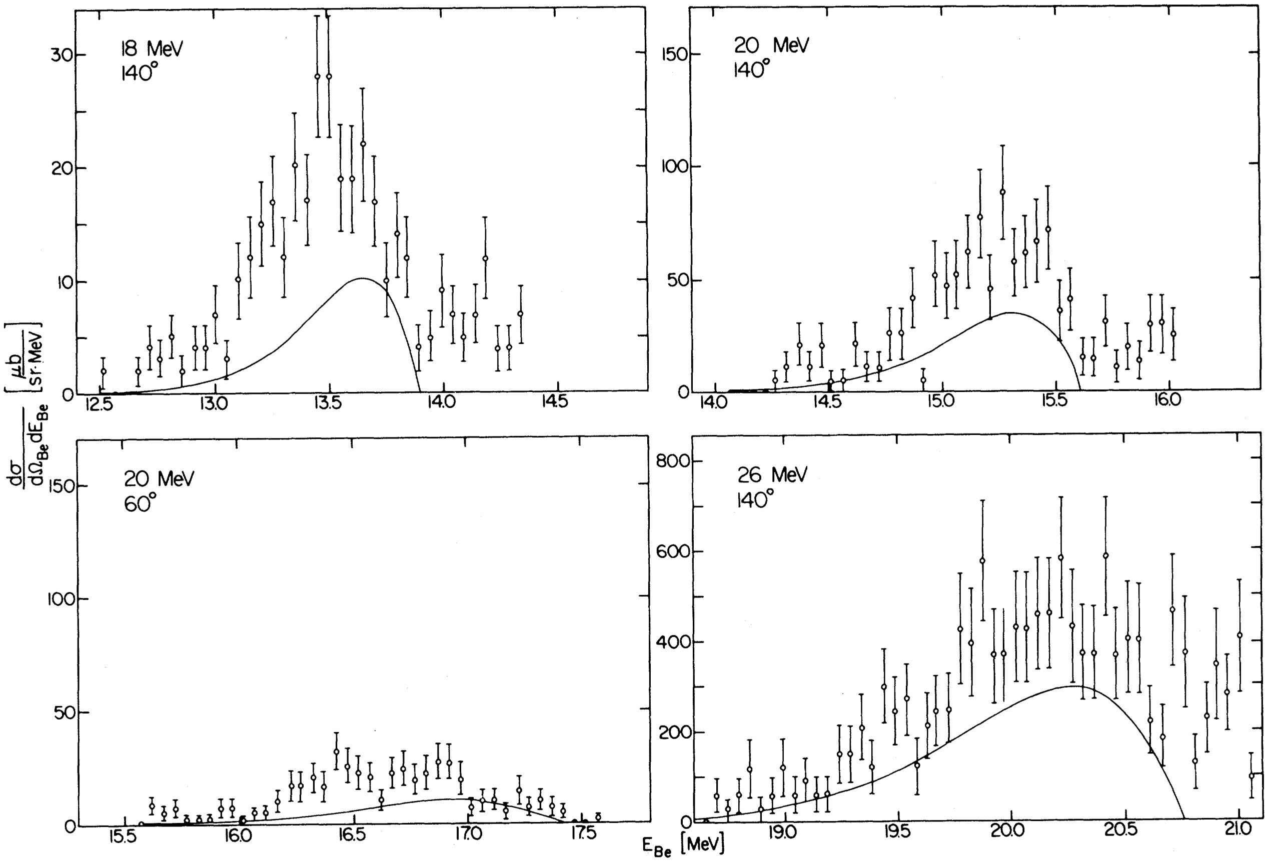

FIG. 2. Double-differential cross sections for the breakup of ^{9}Be in the field of ^{197}Au at different energies and angles.

is obvious, even without introducing a more realistic spectroscopic factor of approximately 0.5.[4]

Since for these energies the semiclassical model and a usual DWBA calculation give practically the same results, another reaction mechanism must be responsible for the large discrepancy. This might be the Coulomb excitation of ^{9}Be. This process can quite well lead to a notable increase of the breakup cross section since for ^{9}Be all excited states are particle unstable. Most probable are $E1$ transitions to the 1.68-MeV ($\frac{1}{2}^+$) level with a reduced matrix element of 2.42×10^{-3} $e^2 \cdot$b.[5] Because of the short-live time of the excited level ($\Gamma = 210$ keV) these contributions cannot be distinguished energetically from the direct breakup and should be coherently combined with the amplitude for this process. They are listed in the last column of Table I. Since the deuteron has no excited state, this mechanism does not influence the cross section for deuteron breakup and therefore in this case no discrepancy between theoretical and experimental values could be observed. In the case of the breakup of ^{6}Li, on the other hand, Coulomb excitation is the predominant process;[6] since the width of the relevant state is rather small, the two steps—excitation and decay—are well separated and this mechanism does not interfere with the rather unimportant direct breakup.

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