

Lifetime of Compound Nucleus Is Measured by Crystal Blocking

In a time-of-flight experiment where the flight path is less than 0.01 nanometer and the time is 10^{-16} sec, the lifetime of a compound nucleus has been directly measured (probably for the first time). Combining solid-state physics with nuclear physics, Karl Ove Nielsen (Aarhus University, Denmark) and Walter M. Gibson (Bell Telephone Laboratories) determined the lifetime by measuring blocking patterns from single crystals. They reported their results at the Washington meeting of the American Physical Society.

Blocking occurs when a charged particle formed on a lattice site is prevented from leaving the crystal exactly along the crystal axes, and to a smaller extent, along the crystal planes. If you examine the angular distribution of particles, it shows a pattern of dips, which corresponds to the major crystal axes and planes. But, if the charged particle originates beyond the lattice site, the blocking disappears and you see no pattern.

Nielsen and Gibson bombarded crystals of uranium dioxide with protons of about 10 MeV. When you hit U^{238} with 10-MeV protons, the compound nucleus formed will recoil out of a lattice site with a velocity of about 10^7 cm/sec. If the compound nucleus lasts about 10^{-17} sec before fissioning it will have recoiled far enough to decrease the amount of blocking. So by examining the blocking pattern, you should be able to determine the lifetime of the compound nucleus.

The detectors, made of cellulose acetate, are sensitive to highly ionizing particles (such as fission fragments), but not to protons. By counting fission fragments as a function of position, you get an angular distribution.

Earlier blocking experiments, by Fred Brown, Donald Marsden and R. D. Werner (*Phys. Rev. Letters* **20**, 1449, 1968) of Chalk River Nuclear Laboratories, had set an upper limit on the lifetime for fast fission of U^{238} bombarded with 12-MeV protons; the limit was 2×10^{-17} sec.

Because the lifetime of the excited nucleus varies inversely as the difference between the excitation energy

and the fission-threshold energy, if you hit the target with too much energy the compound nucleus decays too quickly to observe. Yet you must give the target enough energy to make the recoiling compound system move away from the atomic row, Gibson explains. The compound nucleus formed from 10-MeV protons has too high an excitation energy; it promptly decays either by fission or by neutron emission to Np^{238} . The new compound nucleus, Np^{238} , has just the right lifetime to be observable.

Knowing the velocity of the recoiling nucleus accurately and the distance it moves, Gibson and Nielsen can calculate the total lifetime of Np^{238} . They also did a control experiment to correct for multiple scattering in the crystal or at its surface. For 10-MeV proton fission of U^{238} they measure a lifetime of $(0.48 \pm 0.15) \times 10^{-16}$ sec; this corresponds to a partial fission lifetime of $(2.0 \pm 0.7) \times 10^{-16}$ sec for the excited Np^{238} nucleus at approximately 7.3 MeV average excitation. Calculating the Np^{238} life-

time from fission widths, you get $(2.4 \pm 1) \times 10^{-16}$ sec, in good agreement with the blocking results.

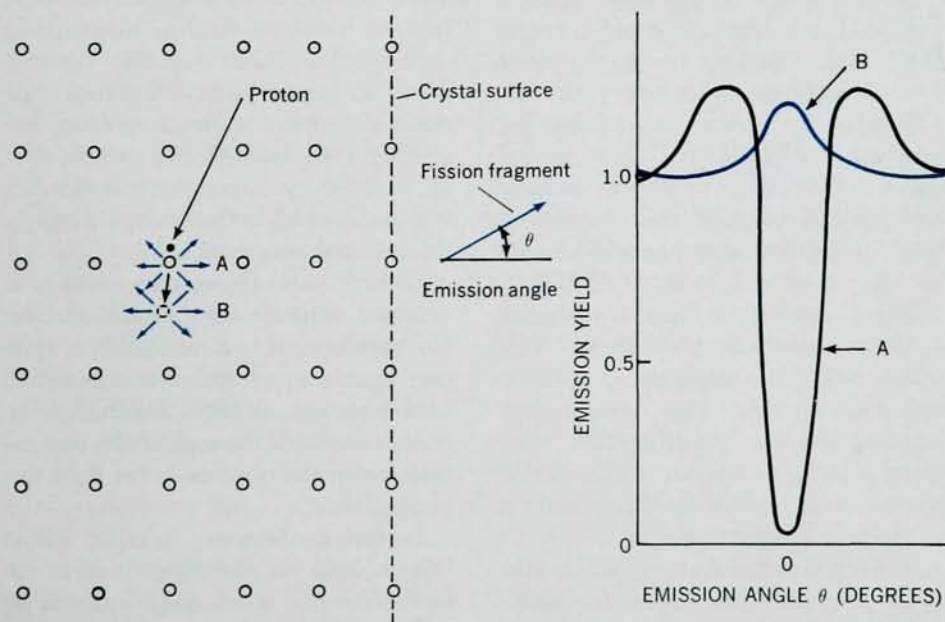
Now the experimenters are trying monoenergetic neutrons, which should enable them to define the excitation energy of the compound system somewhat better.

—GBL

US Fusion Experimenters Want to Try Tokomaks Now

The recent visit of Lev Artsimovich to the US, in which he reported significant plasma confinement at thermonuclear temperatures in the Tokomak T-3 (*PHYSICS TODAY*, June, page 54), has generated a wave of US proposals to build Tokomaks or Tokomak-like devices. Among the laboratories proposing Tokomak experiments are Princeton, Oak Ridge, MIT, University of Texas and Gulf General Atomic.

Meanwhile, at the Kurchatov Institute, Moscow, plans for a much larger Tokomak are already well advanced. The new device is expected to produce ion temperatures of 3 keV and



FISSION LIFETIME MEASUREMENT. Proton strikes uranium nucleus (left), which recoils from lattice site. Idealized curves (right) show emission yield vs. emission angle. Black curve corresponds to emission from a lattice site (blocking). Colored curve corresponds to emission from a position between the lattice sites (no blocking). In a real measurement the emission distribution will be intermediate between the two cases. The emission yield at $\theta = 0$ can be related to the average distance that the recoil nucleus has moved before decaying.