search & discovery

Plutonium result supports theory of shape isomers

Over the past few years evidence has grown for the existence of a double-humped fission barrier in many different nuclei. These nuclei when caught between the two humps would then exist in isomeric states with lifetimes that were very long considering their excitation. The phenomenon goes by the name of "shape isomerism." Now a Munich group has reported (at the European Conference on Nuclear Physics in Aix en Provence, at the end of June) that they have found a rotational band associated with the second minimum in the fission barrier, thus providing strong support for the idea of shape isomerism. The group consists of Hans J. Specht and J. Weber of the University of Munich and E. Konecny and D. Heunemann of the Munich Technical University.

In the old fission picture, when you plotted potential energy as a function of deformation, if the nucleus behaved like a harmonic oscillator the more you deformed it the bigger the restoring forces would be, and the potential would be parabolic. The minimum would not be at zero deformation because the nucleus is prolate to begin with; rather the minimum would be off to the side. When the nucleus fissioned particles would run up the side of the barrier, and spill over the top.

Several years ago G. N. Flerov, S. M. Polikanov and their collaborators at Dubna found that instead of the nucleus fissioning with a lifetime of 10^{-17} to 10^{-18} seconds, some nuclei had spontaneously fissioning isomers with lifetimes measured in nanoseconds. Subsequently Neil Lark and his collaborators at Copenhagen found these isomers way down in the periodic table.

A second piece of experimental information came from studies at Saclay in France and Geel in Belgium. When the energy dependence of the cross section for fission was measured the experimenters found a spectrum with both a fine and an intermediate structure.

The combination of these two kinds of information led many theorists, including Walter Greiner (Frankfurt), Vilen Strutinski (Kurchatov Insti-

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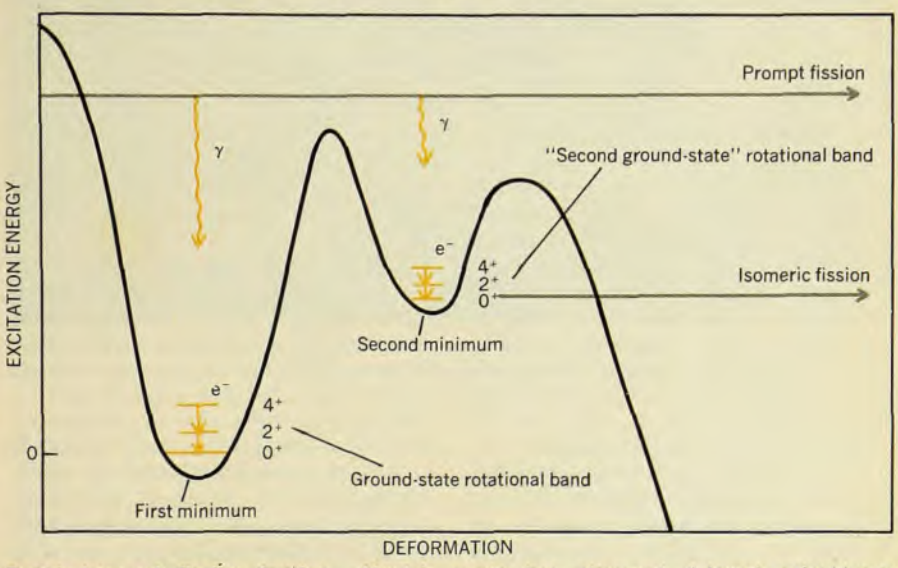


Double-humped fission barrier. Munich group has observed delayed coincidence between conversion electrons and fission fragments. They find that the deformation observed for the fission isomer minimum is much bigger than that of the ground state.

Neoclassicism challenges QED

Some physicists are questioning the necessity of quantum electrodynamics in quantum optics and perhaps elsewhere. A lively discussion on possible alternatives developed during the Third Rochester Conference on Coherence and Quantum Optics at the end of June. The most widely discussed alternative was the neoclassical theory of Edwin Jaynes and his collaborators (Washington University in St. Louis). This theory regards the Maxwell equations as describing the radiation field while the Schrödinger equation is applied to the atoms. The charge and current sources of the Maxwell field are taken to be given by the corresponding probability densities of wave mechanics. Jaynes contends that these nonlinear equations describe physical phenomena better than has been appreciated in earlier times.

Marlan Scully and Murray Sargent (University of Arizona) have pointed out (PHYSICS TODAY, March 1972, page 38) that if one takes the neoclassical theory literally such fundamental aspects of quantum mechanics as the uncertainty principle are no longer preserved even for matter. It is therefore clear that this neoclassical theory (if taken as completely correct) would involve a rethinking of all aspects of quantum mechanics. However, in view of the successes of semiclassical theory in many quantum-optical contexts, Jaynes has embarked on a program to ascertain the limits of validity of the semi- or neoclassical theory. As Jaynes put it in the last Rochester Conference (1966), "Physics goes forward on the shoulders of doubters, not believers, and I doubt that quantum electrodynamics is necessary."

This position continues to attract attention and in fact was challenged (at that time) by Peter Franken (University of Michigan) with what is now a celebrated $50 bet. The terms of the bet were that Jaynes calculate either the Lamb shift or the anomalous electron moment by the neoclassical theory within a ten-year period. Neither claims a victory as yet, and Willis Lamb (Yale University) still holds the purse.

One difference between the neoclassi-

If the copper sulfate gel becomes exposed to the air it dries out and the experimenters see no x rays. Even with the proper amount of water the experiment is not reproducible; they see x rays only about 10% of the time.

Assuming the Utah group is seeing the copper Kα line at 8 keV, Michel Duguay of Bell Labs (who has been devoting considerable time to x-ray laser considerations) calculates that they would need a pumping power of about 10^{15} watts; the Utah group has only 1.5 gigawatts of pumping power, a million times too small. Kepros told us this is inaccurate. On focusing the intensity is 300 gigawatts/cm^2, he said.

Kepros, at the Rochester conference, proposed that a population inversion may be produced by a shielding effect whereby the oxygen K-absorption edge protects the copper L shell from depopulation by slow electrons. Fast electrons would not be significantly affected by the oxygen and could then remove the copper K-shell electrons, thus allowing the necessary population inversion.

Another possible explanation has been offered by Ray Elton of the Naval Research Laboratory, who has been observing intense x-ray emission coming from a small region in a plasma pinch. Elton and the Utah group feel that the mechanism for the anomalous, highly localized heating observed in the pinch may be similar to the mechanism that produces the high electron energy needed to cause the Utah laser to lase. Elton qualifies this suggestion, however, by noting that the Utah system is a liquid and it is not known whether or not the same kind of plasma conditions are formed when the gelatine system blows up as Elton gets in a two-electrode discharge. —GBL

Bell Labs experiments with auto-exhaust catalysts

In an attempt to understand the mechanism of catalysis a Bell Labs group has found a class of compounds that are good catalysts for the oxidation of carbon monoxide. The Bell group, Rudie Voorhoeve, Joseph Remeika, Paul Freeland and Bernd Matthias (also at the University of California, La Jolla), says[1] that the compounds are promising substitutes for platinum in devices for catalytically treating automobile exhaust.

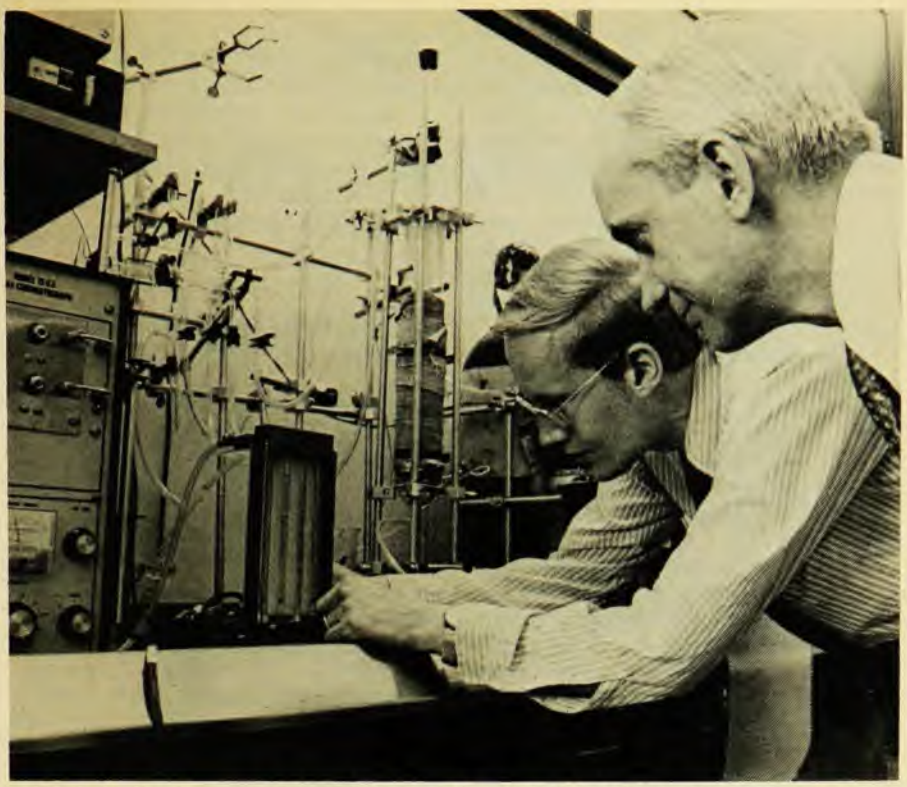
Matthias became interested in catalysis after talking with Willard Libby (UCLA), who suggested[2] that lanthanum cobaltite might be a good auto-exhaust catalyst. This is the same compound that D. B. Meadowcraft (Central Electricity Research Laboratory, Leatherhead, England) had earlier proposed[3] could be used in batteries.

The Bell group studied the perovskite-like compounds of $RE_{1-x}Pb_xMnO_3$ and $RECoO_3$, where RE stands for the rare earths lanthanum, praseodymium or neodymium. These inorganic oxides are made at high temperatures of about 1200 deg C so that chemically they are quite stable. The experimenters measured the oxidation of carbon monoxide (to produce carbon dioxide) by applying a continuous flow of CO and O_2 to a sample of about 2 cm^2 of catalyst, measuring the oxidation as a function of temperature and a function of time.

They compared their catalysts with a commercial one, the PTX catalyst marketed by Engelhard Minerals and Chemicals Corp; this is a fixed-bed catalyst that consists of about 0.5% (by weight) platinum on silicon dioxide–aluminum oxide arranged in a ceramic honeycomb structure. The experimenters crushed the Engelhard catalyst into pellets and compared it with crushed single crystals of their catalysts. They reported that neodymium lead manganite and praseodymium cobaltite were more active than the PTX catalyst and that the other manganites and cobaltites were about as active as the PTX catalyst. Furthermore they said that the activities of the manganites deteriorate much more slowly than that of the platinum.

Shortly after the Bell announcement, Engelhard's president, Milton F. Rosenthal, issued a statement criticizing the Bell report. He said the Bell results "were based solely on laboratory experiments and that no experiments have taken place with automobiles or with a simulated automobile exhaust-gas environment." He complained that the Bell method was to crush the PTX catalyst, but that Engelhard catalysts were specially fabricated with carefully controlled and dispersed quantities of platinum. In addition he said the flow rates that the Bell group used were too low for practical automotive use.

An Engelhard spokesman told us that the firm has a commitment from the Ford Motor Company to supply 60% of Ford requirements for exhaust catalysts in 1975 and to license them for the other 40% of their needs in that year. —GBL



Rudie J. H. Voorhoeve and Joseph P. Remeika of Bell Telephone Laboratories test new catalytic materials that may be useful for removing pollutants from automobile exhaust.

References

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2. W. F. Libby, Science **171**, 499 (1971).
3. D. B. Meadowcraft, Nature **226**, 847 (1970).

Shape isomers

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tute), James Nix (Los Alamos) and Wladyslaw Swiatecki (Berkeley) to reason that instead of having a smooth barrier there were actually two parabolas—a deep one where the nucleus normally sits and just to the right of it, on the falling outside wall of the potential, a second, shallower potential. Because the second minimum is higher in energy than the first, the spacing of its energy levels is much larger than the spacing at the same energy in the inside well. When you put neutrons in at different

energies, you postulate that the various quantum states of the inside well give the fine structure. The intermediate structure comes from energy structure in the outer well. And the spontaneous fission is from particles trapped in the lowest level in the outer well that can't get out easily. The theorists have shown, using the model of Sven-Gosta Nilsson (University of Lund), that the shell model predicts the double-humped well.

So the picture has been one of states that are at quite high excitation, about 3 MeV, which are nevertheless highly stable against gamma-ray emission—not because they have high spins but because of the large change of shape that they need to undergo to get back to the normal state.

Although there has been a great deal of activity on shape isomers, there has been no direct demonstration that the fission isomers were states of very high deformation, as they would need to be if the model were correct. If indeed the fission isomers were highly deformed nuclei, they should be capable of showing rotational states based on the second minimum. (The normal rotational sequence is based on the ground state, and it lies in the ordinary first minimum.) Because the deformation is expected to be much bigger in the fission isomer minimum, the states should be correspondingly closer together than they are in the ground-state band.

The Munich experimenters studied the 4-nanosec isomer of Pu^{240}, produced by bombarding U^{238} with 25-MeV alpha particles from the Munich MP Tandem accelerator. Following a nuclear reaction, any population of the secondary minimum would lead to electromagnetic transitions that precede isomeric fission. In an even–even nucleus the final decay will go by E2 transitions within the rotational band built on the isomeric level, the experimenters say. The states should have lifetimes very much shorter than 0.1 nanosec, that is, small compared to the spontaneous fission lifetime. So to identify the band experimentally, rather than observing the gamma rays that link the fission isomer states, they measure delayed coincidences between conversion electrons and fission fragments.

The experimenters find a set of conversion electrons that they associate with transitions between states in a rotational sequence. Furthermore they check this out with the expected relationship between the level spacings. They find that indeed the deformation of the fission isomer minimum is much bigger than the ground state. In fact they report what they believe is the biggest nuclear deformation ever observed.

Thus the Munich group has demonstrated that Pu^{240} can exist in essentially two different states of quasiequilibrium deformation, one that represents the normal ground state, on which the normal rotational band is based, and another of considerably greater deformation on which the "second ground-state" rotational band is based. The ground state of that second rotational band is a fission isomer. —GBL

Cornell synchrotron energy increased from 10 to 12 GeV

The energy of the 10-GeV electrons at Cornell's Wilson Synchrotron Laboratory has been increased to 12 GeV, and the experimental hall housing the synchrotron is being enlarged.

The synchrotron energy has been increased by adding a new bank of rf cavities in one of the straight sections of the synchrotron. A new cavity design with high impedance and an 80-kV klystron provides the 20% increase in energy. The cavities run at the same frequency they did before the modification: 714 MHz. Modifications to the synchrotron began in late 1970.

Construction of the 120 × 70 foot addition to the 100 × 100 foot experimental hall was done at the end of the summer. The addition will give Cornell and visiting physicists greater flexibility in scheduling experiments that will take advantage of the increased energy of the synchrotron. It should also help to alleviate some of the crowding that was felt earlier.

Funds for the building expansion totalling $975 000 have been granted by the National Science Foundation. Cornell received $200 000 from NSF for upgrading the synchrotron.

Cave drawing is evidence of Crab nebula supernova

What appears to be the fourth independent record of the Crab nebula supernova in 1054 was discovered in a cave in northern California, according to Stephen Maran of NASA's Goddard Space Flight Center. The American Indian petroglyph consists of a drawing of a sphere and a crescent; the sphere is thought to represent the supernova and the crescent, the moon. The findings were reported at the Michigan State Meeting of the American Astronomical Society in August.

Maran told PHYSICS TODAY that the drawing came to light through the persistent efforts of Muriel Kennedy, the wife of the superintendent of Lava Beds National Monument, where the cave is located. Kennedy found the painting in July 1964 and after some research decided that it probably represented the supernova event. She told Maran that she had been trying to interest scientists and science magazines in her find ever since then, but no one was interested.

When she saw an article in *Time* on an appeal by Maran and his colleagues, John C. Brandt and Theodore P. Steckher, for records of the Vela X supernova event, she wrote the magazine a letter that was forwarded to Maran. "A week later we were out there," he told us.

According to Maran, the probability is high that the picture does indeed represent the supernova. On the morning of 5 July 1054 in California the moon was in a crescent phase and only about 3 deg away from the supernova. This was confirmed by Robert Harrington of the Naval Observatory in Washington, who calculated the relative positions of the moon and the supernova to an accuracy of about one hour.

Another fact supporting the hypothesis that the picture represents a supernova is that crescents are extremely rare designs in American Indian petroglyphs. According to Maran, almost the only ones found after a search through thousands of records of wall paintings are two in Arizona that were discovered by William Miller of Hale Observatories and are also thought to represent the supernova event. Japanese and Chinese annals also contain records of the event. —SMH

NBS to base legal volt on the Josephson effect

The National Bureau of Standards has adopted a new procedure for maintaining the US legal volt based on the determination of the ratio of $2e/h$ using the ac Josephson effect. Recent work at the University of Pennsylvania and NBS has shown that $2e/h$ can be determined in terms of a particular unit of voltage to 1 part in 10 million or better.

In the past, the US legal volt has been determined as the mean emf of a large reference group of standard saturated cells kept at constant temperature, but this quantity may vary as much as several parts in 10 million per year.

Using the ac Josephson effect (in which the frequency of an ac current between two weakly coupled superconductors is governed by the relation $\nu = (2e/h)V$) and a special 100:1 fixed ratio potentiometer, it is possible to compare directly the standard-cell voltage (approximately 1.018 V) with the 10.18 mV of an appropriately tuned Josephson junction. This can be done to an uncertainty of only a few parts in 10^8. □