probably less than five other U.S. teams working directly on experimental applications of chaos to devices, and some of those actually are investigating phenomena related to chaos, rather than chaos itself. And it's no coincidence that most of the pioneering work is being done in Navy laboratories: Since 1983 the Office of Naval Research has been the only government agency with a funding program specifically for chaos studies.

There are, however, signs that interest in the field is growing. The Electrical Power Research Institute (EPRI) held a workshop on applications of chaos and complexity theory last November in which researchers from around the world discussed everything from chaos in conveyor belts, to controlling chaos, to chaos in chemical mixing. Since then Jong Kim, a director of exploratory research at EPRI, says he has been besieged by grant requests and proposals, and the organization is considering expanding its funding of chaos research.

Until now, almost all the work done in chaos has been theoretical or computational—especially modeling the complex behavior of the differential equations in which chaos was first discovered. Next October, however, all three Navy teams will host the first ever experimental chaos conference. Forty talks are expected, which suggests that the new results may be spurring a shift toward more experimental study of chaos.

"There's too much good stuff in here" for it not to catch on, Pecora says. "This field is going to be no different than quantum mechanics: Eventually...it's going to have a big [practical] impact." If Pecora has his way, it'll be sooner rather than later...but to ensure that his hopes come to fruition, he may have to find even more sophisticated methods of controlling chaos.

■ ROBERT LANGRETH

A New Ball Game in Nuclear Physics

It's convenient to think of the atomic nucleus as a ball—a little lumpy, to be sure, but basically spherical. Nuclear physicists have known for decades, however, that highly excited or unstable nuclei momentarily stretch or bulge before they decay or settle back into a lower-energy state. And now researchers are exploring the behavior of nuclei that have been deformed more drastically. The quirky ways of these "superdeformed" nuclei are challenging some established ideas about nuclear structure.

The superdeformed nuclei now in the spotlight were discovered in 1986 by Peter Twin and his colleagues at the University of Liverpool. By using particle accelerators to smash together the nuclei of heavy elements, the researchers produced fused "compound" nuclei that sometimes emerged with wildly distorted—and curiously persistent—shapes. The spectrum of the gamma rays emitted by these nuclei in the aftermath of the collisions suggested that some of the nuclei had been flattened into the shape of a discus or stretched like a cigar, the Liverpool researchers reported.

These superdeformed nuclei turned out to be surprisingly long-lived, says nuclear physicist Witold Nazarewicz of the University of Warsaw, who is currently working at the Joint Institute on Heavy Ion Research at the Oak Ridge National Laboratory. Such nuclei might be expected to lose energy rapidly and settle back into a more spherical shape. But some of the distorted nuclei discovered by Twin and his colleagues tend to linger in the superdeformed state.

What keeps these nuclei squashed or stretched, Nazarewicz and his colleagues theorize, is a combination of classical effects such as garden-variety centrifugal force and quantum effects. The unimaginably fast rotation of a superdeformed nucleus—up to 10^{20} revolutions per second, says Nazarewicz—is part of the story, generating forces similar to but enormously greater than those that slightly flatten the spinning earth. Quantum effects, like those that shape the orbitals of electrons, also act to deform the nucleus. In the case of superdeformed nuclei, both types of forces reinforce each other. The stability that results from these two aligned forces gives researchers time to probe the properties of their odd nuclear specimens.

The latest mystery involving superdeformed nuclei came to light last year in an analysis of the signals they give off at the end of their brief lifetimes. Comparing the gamma rays emitted by superdeformed nuclei of different types as they lost energy and relaxed into ground state, a number of teams began seeing some eerie matches in the spectral fingerprints. This was a surprise because the gamma-ray fingerprints of different excited nuclei should be as dissimilar as the fingerprints from different people. Because nuclei emit gamma rays in order to lose rotational energy as they slow down from a fast-spinning excited state, the array of emitted energies should depend on the exact size and shape of the nucleus. Thus each type should emit a characteristic array—a unique signature.

Almost immediately, other nuclear physicists started exploring this new phenomenon, among them Marie-Anne Deleplanque of Lawrence Berkeley Laboratory. "What we've seen is totally unexpected," she says of the phenomenon, which is called band twinning.

Band twinning was first seen in superdeformed dysprosium-152 and terbium-151, which emit nearly identical spectra, but several isotopes of mercury and its nearest neighbors in the periodic table also show the same unexpected matches. "We have no reason to think [these nuclei] should do that," says Deleplanque. "They have different sizes, different moments of inertia....We have no explanation to account for it."

That didn't inhibit Deleplanque and other nuclear physicists from describing their first stabs at solving the puzzle at the American Physical Society (APS) meeting in Washington, D.C., last month. Nazarewicz, a theorist, suggested one possible explanation, based on a postulated quantum-mechanical property called pseudo-spin. Pseudo-spin might lead to correlations in the amount of angular momentum that nuclei of different types could gain or lose at a time. Because these steps determine the spacing between energy levels, and thus the wavelength of emitted gamma rays, pseudo-spin might account for some of the band twinning.

But pseudo-spin can't fully explain the striking energy matches observed, says Nazarewicz. The size of a nucleus—its actual diameter—as well as its angular momentum should affect its gamma spectrum. A difference of only one proton or neutron should be more than enough to distinguish the gamma emissions of two nuclei.

Nazarewicz told the APS gathering that he expects more twists to the story. He thinks the pairs of otherwise disparate deformed nuclei that show band twinning may be alike in some unsuspected way. "Band twinning shows there may be a new symmetry we don't know about," he says, a kind of symmetry hidden in ordinary nuclei.

■ FAYE FLAM