no two periods of five minutes during which it does anything roughly similar."

Wolf has come up with two equations, based on Newton's laws of motion, that describe the toy's behavior. Solving the equations on a computer gives numbers that match the Space Ball's observed motions. "In a sense," says Wolf, "that's a proof that it's chaotic as opposed to being poorly built."

His aim, however, is to quantify the amount of chaos present, not just in the toy but also in any system that may be suspected of exhibiting chaotic behavior. He has developed a computer program, running on a microcomputer, that calculates a quantity called the Lyapunov exponent.

This number provides an estimate of how long the behavior of a system is predictable. For a nonchaotic system, that exponent would be infinite because its future behavior is completely predictable. In chaotic systems, a tiny difference in starting conditions leads to widely divergent and, as a result, unpredictable behavior. The Lyapunov exponent puts a number on how fast this divergence occurs.

"Engineers and scientists have discovered a whole new regime of dynamics," says Francis C. Moon of Cornell University in Ithaca, N.Y., "and we're trying to categorize these different regimes. We want to know when these things occur and what the characteristics of this chaos are. Simple models help us test the criteria."

Another simple but useful model, also presented at this week's meeting, is the work of graduate student Nicholas B. Tufillaro of Bryn Mawr (Pa.) College. His mechanical device consists of a small, vibrating table (constructed from a loudspeaker) and a ball that is constrained to bounce vertically on the table's surface.

As in the case of the Space Ball, a simple set of equations describes the physical system. At the same time, says Tufillaro, "the bouncing-ball system exhibits the whole zoo of nonlinear phenomena shown by far more complex and less comprehensible systems."

In the bouncing-ball apparatus, changing the table's frequency or amplitude alters the ball's motion. At certain frequencies, the ball's motion becomes extremely erratic. Thus, this model allows researchers to study how a physical system shifts into chaos. Moreover, because the ball makes a click every time it hits the table, listeners can actually hear the sound of chaos.

The bouncing-ball system also has educational value, says Tufillaro. Some people still attribute what is often labeled as chaos to factors like background "noise" instead of believing that it results from the nature of the motion itself. Showing these skeptics a simple system that actually works as predicted mathematically can be very convincing. — *I. Peterson*

Quake potential off the San Andreas

The earthquake that laid waste to San Francisco in 1906 brought the San Andreas fault into the seismologic limelight. Now a new study suggests that scientists should also be keeping a watchful eye on the San Gregorio-Hosgri fault system to the west of the San Andreas. According to researchers who presented their findings at the recent Charleston, S.C., meeting of the Seismological Society of America, sections of the San Gregorio-Hosgri fault may be capable of generating earthquakes of magnitude 7 or greater.

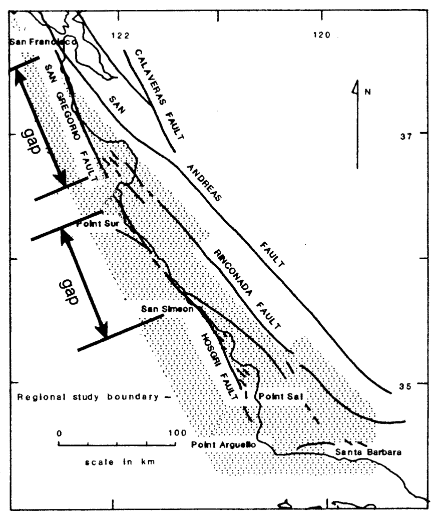
The complete San Gregorio-Hosgri fault zone was first identified and became the focus of controversy several years ago during the planning of the Diablo Canyon (near San Luis Obispo) nuclear power plant, which was originally designed without the knowledge that the Hosgri fault lay a couple of miles offshore. More recently, the fault has attracted the interest of scientists trying to piece together plate motions. Researchers have found that the North American and Pacific plates are slipping past one another at a rate that is much faster than the movement of the San Andreas fault (SN: 12/21 & 28/85, p. 388). Many have considered the San Gregorio-Hosgri fault a likely candidate for taking up some of that excess slip.

Now, looking at the seismic history of the fault, Martitia P. Tuttle at Lamont-Doherty Geological Observatory in Palisades, N.Y., and Karen C. McNally at the University of California at Santa Cruz identify two segments that they suspect are seismic "gaps" — regions of a fault that may be ripe for an earthquake. According to Tuttle, the regions of the fault lying between San Francisco and Santa Cruz and between Monterey and Ragged Point have not experienced magnitude 6 or greater earthquakes since 1880 and possibly since 1800. Based on the length and width of these segments, she estimates that they could rupture with magnitude 7.4 and 7.3 quakes respectively (assuming the fault does not slip "aseismically," or smoothly). In supporting calculations, based on geologic and seismic data for the entire fault, she estimates that a maximum 7.2 quake could occur anywhere along the fault, although it would be most likely to happen at one of the two gaps.

Suggesting yet another possible scenario, Tuttle says the pattern of seismic activity over the last 15 years in the Monterey Bay area is similar to that which preceded magnitude 6 earthquakes in more active spots — possibly indicating that a magnitude 6 earthquake could shake the southern gap in the next 10 years.

One reason relatively little attention has been paid to the San Gregorio-Hosgri fault is that most of it lies offshore, making it extremely difficult to study. And the fault zone, which extends to 1.5 kilometers in width, is made up of many individual strands that, at the surface at least, are not connected. So while there may be movement along the fault at depth, it's not easy to measure or predict.

"I have no doubt that the San Gregorio-Hosgri fault zone is active and capable of future earthquakes," says Kenneth R. Lajoie of the U.S. Geological Survey (USGS) in Menlo Park, Calif. During the last 10 years, he says, he and a co-worker have found ample geologic evidence that the fault has slipped within the last 8,000 years. But the problem, he says, is that the geologic data are not good enough to be used in calculating a quantitative value of slip rate, which is an important ingredient in earthquake and plate motion analysis. And even if scientists could confidently document past movement along one strand, they could not assume that other strands moved at all or moved in the same way.



Tuttle/UCSC

Two "gaps" in the San Gregorio-Hosgri fault zone concern seismologists.

Measurements of ongoing fault movement have also been very limited, because there is no land west of the fault, except in a few spots at the northern end, on which to place geodetic instruments. According to William H. Prescott, also with USGS in Menlo Park, "There's no geodetic evidence that there's much slip occurring along that fault."

In spite of these difficulties, Tuttle and McNally believe the seismic data are compelling enough to call for greater seismic coverage and more intense scientific scrutiny of the fault.

— *S. Weisburd*