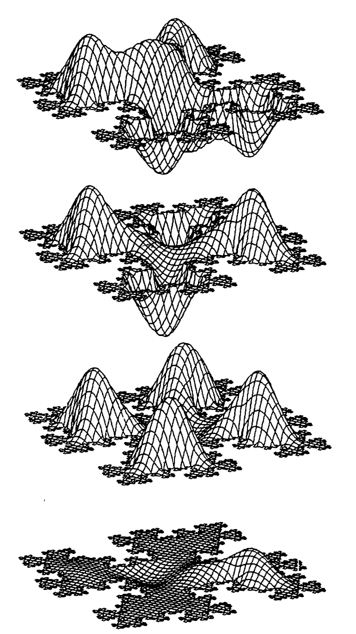
Beating a Fractal Drum

When Bernard Sapoval and his colleagues at the Ecole Polytechnique in Paris beat a drum, their neighbors don't complain about noise. There isn't much. What muffles the drum, Sapoval thinks, is the shape of its perimeter. Instead of being round like that of an ordinary drum, it is fractal, resembling a jagged-edged snowflake.

Sapoval's work, published in the November 18 *Physical Review Letters*, won't lead to a better drum. But he and some other fractal experts think it may help answer a question that has perplexed researchers since the consummately irregular shapes called fractals were discovered in the early 1980s: Why does nature love fractals? Researchers have discerned fractal shapes in coastlines, galaxies, and the branching of human blood vessels, to name just a few examples. If fractals are better than other shapes at damping vibrations, as Sapoval's result suggests, they might also be more robust. And that special sturdiness could explain why in nature, the rule is survival of the fractal.



SAPOVAL, PHYS. REV. LETT.

Fractal embrace. *Some vibration modes of the fractal drum are trapped within its arms.*

Sapoval already knew that jagged, bumpy contours don't support resonant vibrations as well as curves and lines do—which is why the designers of ordinary drums and other musical instruments emphasize smooth contours. Fractals, in contrast, are shapes that look rough on every scale: When you zoom in on them, you might expect the bulges and dips to smooth out, but instead you see smaller bulges and dips that look exactly like the larger ones. Sapoval reasoned that fractals, as paragons of irregularity, might represent the ultimate in damping ability.

To test the idea, Sapoval cut his fractal shape out of a piece of metal and stretched a transparent membrane over it to make a drum. He then sprinkled the surface with a fine powder that would act as a tracer of the vibrations and "beat" the drum using a loudspeaker. By photographing the ripples and furrows in the powder, he could study the frequencies and amplitudes of the membrane's vibrations.

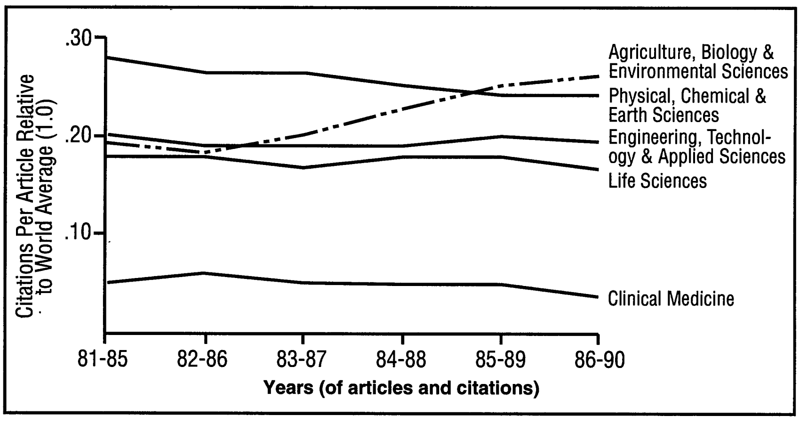
The powder didn't trace the damping directly, but it revealed a dramatic and telling effect—localized vibration. Wherever you strike an ordinary drum, the vibration spreads out to affect the entire surface. Not so on the fractal drum. "The membrane moves in one place and not in others," Sapoval explains. On the snowflake-like surface, vibrations sometimes shook only one branch. "It would be as if you had a water wave in only one part of a basin." That means, he says, that the vibrations were getting damped out even faster than they could spread.

Could that same damping ability explain why, say, a surf-pounded coastline tends to have a fractal outline? Sapoval thinks it might. Even in the branching channels of the blood system, he says, fractals may lend robustness. "The heart is a very violent pump, and if there were any resonance in the blood circulation, you would die."

Sapoval even thinks his results could open up a new route to understanding and controlling the properties of materials such as ordinary glasses. The interfaces between the different microscopic components of glass are fractal, he says. "I think of glass as a collection of fractal drums." The drumbeats that die out at the interfaces are the thermal vibrations that propagate through the atomic structure of the material. By understanding the relation between the shape of the interfaces and the thermal properties of a glass, he thinks, materials scientists might gain new control over these properties.

Sapoval's work on fractal damping is also striking a chord among other fractal experts. "I find it a very exciting development," says Benoit Mandelbrot, the IBM mathematician credited with the discovery of fractals. He notes that other scientists have been studying how vibrations are damped within aerogels, foamy chunks of silica whose structure makes a solid fractal, but Sapoval and his colleagues are the first to look at shapes bounded by a fractal perimeter. "By next year's physics conferences we will hear much more discussion of the work," Mandelbrot adds.

Ultimately, Mandelbrot hopes, work like that of Sapoval's group may yield a unified explanation for the myriad fractal forms in nature. "It is a source of longing to many scientists to have an explanation for fractals," he says. ■ FAYE FLAM



Soviet slide. "The state of Soviet science is startlingly weak and weakening," concludes the Institute for Scientific Information from recent analyses of publication and citation data. During the past decade Soviet research reports published in international journals were cited only 20% to 25% as often as those from other nations. It did not even make a list of the top 30 nations during the '80s, being bested by its own satellites Hungary and East Germany, among others. The physical sciences—the Soviets' strongest suit—slipped by 11.1% in relative citation impact during the decade. The only areas showing improvement were agriculture and environmental sciences, where citations climbed by 44.4%. Citation impact is derived by dividing the number of citations by the number of papers published. ■ C.H.