until each spot of the surface has been touched by the disinfectant at least once?" he says.

Now, the mathematical results are stimulating new efforts to measure the persistence exponents in other systems. Following a talk by Majumdar at Lucent Technology's Bell Labs in New Jersey, two experimentalists, Bernie Yurke and Andrew Pargellis, reanalyzed videotaped results of a past experiment in which liquid crystal molecules held between two plates could twist either clockwise or anticlockwise, resulting in light and dark patches when viewed in polarized light. Light and dark regions coalesced and grew in time, but some fraction of the original area between the planes never flipped, yielding a value of theta. "It turns out to be 0.19, very close to the diffusion approximation," says Majumdar.

Zeitak, meanwhile, has been collaborating with Joel Stavans of the Weizmann Institute in Rehovot, Israel, and Wing-Yim Tam of Hong Kong University of Science and Technology on the collapse of foams. This effect, known to drinkers and brewers the world over, is the coalescence of small bubbles in a foam to make larger bubbles. Their results, currently being written up, indicate that the original small bubbles demonstrate persistence obeying a power law similar to that in diffusion models.

Now Majumdar's team is beginning to apply the concept of persistence to attack different types of problem. One example is so-called critical phenomena, in which systems undergo abrupt and dramatic changes in their properties—the sudden magnetization of a lump of heated iron once its temperature falls below a critical value, for example. In the 28 October issue of *Physical Review Letters*, Majumdar has shown that a persistence power law can give a probability that, at the critical temperature, the system still has not flipped its magnetic direction after a certain length of time—results backed up by Stauffer in the October issue of *International Journal of Modern Physics C*.

The real power of persistence, and its application in real physical situations such as industrial reactions and biological systems, will have to wait for experimenters to come up with definitive ways of measuring the new exponents. Yurke, meanwhile, wonders what other surprises are lurking in effects that physicists thought they understood. "It makes me wonder about what else we might be overlooking in these systems," he says.

–Andrew Watson

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ASTRONOMY

Do Comets Get a Nudge From the Galaxy?

For decades, astronomers have known that most of the comets in the solar system are just rare visitors. Their true home is the Oort cloud, a vast spherical halo of icy objects that extends from beyond Pluto outward for more than a light-year. But what sends distant comets on their wanderings has been controversial. Now two astronomers at the University of Southwestern Louisiana, John Matese and Daniel Whitmire, offer a new candidate: the mass of the Milky Way as a whole, all the way to its distant core.

Matese and Whitmire, who present their idea in the 20 November *Astrophysical Journal*, say the galaxy's influence is unmistakable: Their calculations of how the Milky Way would stir the Oort cloud mesh neatly with an analysis of comet orbits. But the idea that the feeble gravitational pull of the distant galaxy could be influencing the solar system is hard for some other astronomers to swallow. "I don't mean to say that they're wrong," said Brian Marsden of the Harvard-Smithsonian Center for Astrophysics. "But I've played around with the [comet] data for years—and you can see some very funny things."

The roots of the puzzle go back to 1950, when the Dutch astronomer J. H. Oort calculated that the comets passing near Earth were shaken loose from a distant cloud. Oort's idea, says Matese, was that "a star came by and really shook them up" or some other "quasi-violent" event took place, kicking a few comets into elongated orbits that take them into the inner solar system every few hundred or thousand years.

But in the past decade, many astronomers, pointing to the lack of evidence for the sporadic "comet showers" that violent disruptions of the Oort cloud should unleash, have concluded that such events are responsible for only one-fifth or so of the comets we see. The most widely accepted explanation for the other four-fifths, says Matese, is that they are kneaded out of the Oort cloud by what he calls "gentle galactic tugging." But the mechanism of that tugging is poorly understood.

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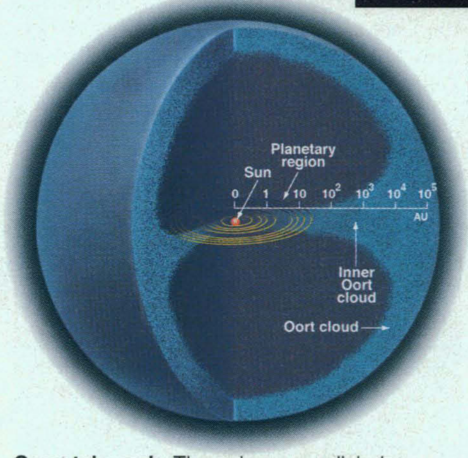

K. SUTLIFF

Comets' perch. The galaxy may dislodge occasional visitors like comet Hyakutake *(top)*.

It has to come from some galactic tidal force that pulls on the orbiting comets, sapping their angular momentum so that they can plunge toward the sun. One possibility is the so-called z-tide, which comes from nearby stars and matter and pulls in a direction perpendicular to the plane of the galaxy. The other, 16 times weaker, is the so-called radial tide—the combined gravitational pull of the matter in the galactic interior, including all the stars and dark matter in its very core—that pulls toward the center of the galaxy. Since the gravitational attraction of nearby matter is so much larger, many astronomers think the z-tide is the main effect pulling comets from the Oort cloud.

Not necessarily, say Matese and Whitmire. The two astronomers claim that the weaker radial tide has a disproportionately strong effect on some comets—strong enough to account for fully one-third of all long-period comets. The reason: It can act on comets that are untouched by the z-tide. The z-tide's orientation perpendicular to the galaxy means it can only reduce the angular momentum of Oort cloud comets whose orbits are tilted relative to the galaxy. The radial tide, on the other hand, can affect the motion of comets moving in the plane of the galaxy. For those comets, Matese says, the radial tide "is the only game in town."

An analysis of comet tracks bears out the calculations, he and Whitmire say. Because the two galactic tides act in different directions, the paths of the comets they dislodge should be different. The analysis showed the influence of the radial tide in one-third of the tracks, as predicted. And with more than 80 comets in their database, says Whitmire, the statistical strength of their conclusion is "unheard of" in astronomy.

But Marsden thinks the comet data just aren't good enough to support Matese's and Whitmire's analysis. "I have no problem with [their] theoretical analysis," he says, "but it's a miserable, crummy set of data ... I say that having provided a lot of that data myself." With better data or a different analysis, Marsden says, the effect might disappear—and another way for the galaxy to pluck comets from the Oort cloud might emerge.

–Charles Seife

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