That's not quite as good as the $1/e$ result for multivariate integration, but Wozniakowski has shown it's the best result possible. Moreover, notes collaborator Joe Traub, also of Columbia, Wozniakowski's algorithm has no theoretical competitor, since for approximation, Monte Carlo methods don't help.

Wozniakowski and Traub hope to break the curse of dimensionality for more problems, including problems in optimization and differential equations. Their ultimate goal is to define the group of problems that are computationally "tractable" in the average-case setting. At the same time, they would like to make Wozniakowski's theoretical breakthroughs more practical. Right now the results are only asymptotic, meaning that the proportionality to $1/e$ (for integration) and $1/e^2$ (for approximation) holds only for small values of e. "We want to get non-asymptotic results," says Wozniakowski. "They'll be much more important for applications."

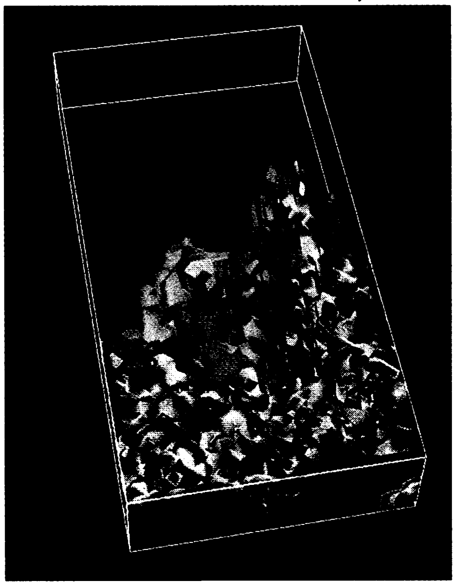
Microbial Math

The contamination of groundwater aquifers by toxic chemicals is widely recognized as a major problem in the United States. An example: At the Hanford Site in south central Washington state, underground disposal of carbon tetrachloride over 18 years has left a 5-square-kilometer plume of contaminated groundwater that may cost $60 billion to clean up. And that's only one case: Toxic chemicals routinely leak from landfills and rusted storage tanks everywhere.

But in many cases, the gray cloud of toxic waste has an unanticipated microbial silver lining: organisms already present in the environment are capable of cleaning things up, or at least containing the damage. Indeed, in recent years the use of microbes as toxic scavengers—in situ biorestoration as this approach is called—has emerged as a promising treatment technology.

Yet there's a big if: The microorganisms must be triggered properly by the introduction of dissolved oxygen or other nutrients into the system, and providing just the right nutrient triggers for this weapon isn't simple. The process is physically and chemically complex, involving transport and interaction of substrate, dissolved oxygen, and microorganisms, as well as the movement of water within the aquifer. To help unravel some of these complexities, researchers at Rice University are turning to mathematical models. Although the models are in the early stages now, Mary Wheeler and her colleagues hope that ultimately they will enable environmental scientists to characterize contaminant migration, aid in making regulatory decisions, and predict and evaluate the performance of restoration projects.

Mary F. Wheeler



Odor eaters. *The distribution of microbial mass in a model of in situ biorestoration, as modeled by Mary Wheeler of Rice University and her colleagues. The lowest concentration is in blue, the highest in yellow.*

In an invited address at the Washington meeting, Wheeler described the groundwater model, which consists of a system of nonlinear partial differential equations. There's no hope of finding their exact solutions—only numerical approximations. One thing that makes the problem "very hard," Wheeler notes, is the fact that things in the model happen on different time scales: Chemical reactions are very fast, the flow of fluids is slower, and the model needs to consider even longer-term effects—that may extend over hundreds of years.

There are "lots of computational questions to be settled," Wheeler says, adding that two things may help her in that effort. New computer architectures for parallel computation should make it possible to create more realistic, three-dimensional models. At the same time, interactive graphics and other computer visualization tools should help investigators see more directly what the models are trying to show them.

The effort could be well worth it, Wheeler argued, because models have one great virtue: They could prevent those directing cleanup efforts from making expensive mistakes in real time. Field studies and experiments cost millions of dollars, Wheeler notes, "and if you make a mistake, it can be even more costly. Doing it on the computer is very cheap." ■ BARRY CIPRA

A Most Improbable Planet

If you were looking for a planet circling some distant star, about the last place you'd expect to find one would be in the harsh environs of an ultradense neutron star. But a group from the Nuffield Radio Astronomy Laboratories at Jodrell Bank, in England, believes it has stumbled upon a planet in just such an improbable place.

Their report in this week's *Nature* could be the first solid evidence of a planet outside our own solar system. Caution is in order, however, for there have been many putative glimpses of extrasolar planets in the past, and most have not stood up to further scrutiny.

"We weren't looking for anything like this," says Andrew Lyne, who was monitoring the radio signals from some 40 pulsars—rapidly spinning neutron stars—with his coworkers Matthew Bailes and Setnam Shemar when they found the key evidence. Pulsars, like all neutron stars, are thought to form when massive progenitor stars explode as supernovae. Even if the star had a solar system, Lyne says with some understatement, "people had assumed that any planets would have a hard time surviving."

Still, Lyne and his colleagues think that a planet might be the cause of puzzling oscillations they observed in the signal from one pulsar 30,000 light-years from Earth. Ordinarily, pulsars give off an uncannily regular, clocklike sequence of radio pulses. But in this case, he says, "we couldn't make sense of the arrival times we were seeing." Finally a pattern emerged: Over a 6-month cycle the interval between pulses—roughly a third of a second—got gradually shorter by 8 milliseconds, then longer again.

The explanation they favor: an unseen mass orbiting the neutron star every 6 months, pulling it to and fro by a distance of 8 light-milliseconds. The workers calculate that a planet about 10 times as massive as Earth, orbiting at about the same distance as Venus, would do the job.

If its existence is confirmed—and David Black, director of the Lunar and Planetary Science Institute in Houston, told *Science* the claim is "going to warrant confirming"—that still leaves the problem of explaining how it got there. Maybe, Black suggests, the pulsar formed in "a kinder, gentler supernova." Or maybe the explosion destroyed the star's original planets but left debris that condensed to form new ones. Either way, Black says, the astronomers may have found "a true celestial freak." ■ TIM APPENZELLER