BRIEF

A DARK UNIVERSE LIKE OUR OWN

By Pam Frost Gorder

As scientists confront an increasingly mysterious universe of mostly dark matter and dark energy, there's comfort in the discovery that the dark matter, at least, moves in ways that are already familiar (see Figure 1).

A new theory by Chung-Pei Ma and Edmund Bertschinger suggests that dark matter doesn't hover around galaxies in formless halos as once thought; rather, it clumps together in ways that mirror normal matter. In fact, dark matter might move according to a 90-year-old equation (developed by Albert Einstein in 1905 and named after Robert Brown, who first observed it in 1827), which describes the path of pollen granules floating in water.

This *Brownian motion* could help scientists overcome barriers that currently limit dark-matter models. For example, the many-body (or *N*-body) technique for modeling particles' gravitational interaction has been the dark-matter simulation cornerstone for more than 20 years. But the problem is too large; even using a computer cluster or mainframe supercomputer, scientists can't approach the resolution required to model individual dark-matter particles.

That's where Brownian motion comes in.

"Just as Brownian motion can be understood without knowing the trajectories of zillions of molecules, we hope dark-matter motion can be understood in a similar way," says Chung-Pei Ma of the University of California, Berkeley.

She and Bertschinger, of the Massachusetts Institute of Technology, developed their theory through a statistical analysis, and so avoided the need to trace individual particles. The method doesn't replace *N*-body simulation, but compliments it, Ma said.

They submitted a paper to the *Physical Review* journal, but a preprint is available on Ma's Web site (http://astron.berkeley.edu/~cpma/), along with a movie that simulates dark-matter Brownian motion.

The movie, based on a traditional Newtonian simulation, shows scattered dark-matter filaments from the Big Bang coalesce to form a superstructure. The result looks much like a cluster of galaxies.

Next on the researchers' agenda is to solve the Brownian motion equation, the Fokker-Planck equation. Ma suspects that the task will involve some kind of finite-differencing scheme—a strategy that replaces time-consuming calculations with faster equations that produce the same result.

In the meantime, she hopes other scientists will take an interest in the fact that the Fokker-Planck equation—which is the "mother tongue" for many plasma, laser, and condensed-matter physicists and even some chemists and economists—is applicable to the universe as well. "I think the existence of this sort of universal language is a truly beautiful aspect of science," she says.

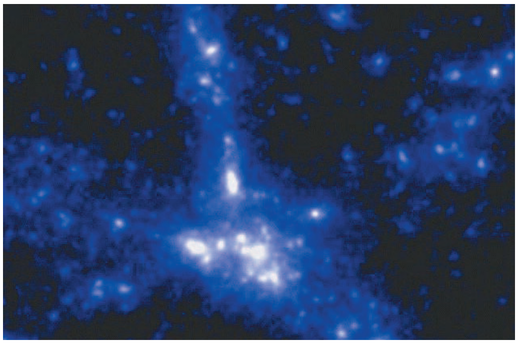

Figure 1. Dark matter. Depiction of large-scale dark-matter structure in the early universe.

Andrew Benson of Oxford University agrees. For the same equation to describe both tiny molecules and supermassive lumps of dark-matter motion is "a wonderful demonstration of how the laws of physics can produce very similar behaviors in very different regimes."

Pam Frost Gorder is a freelance science writer living in Columbus, Ohio.