ASTRONOMY

Galaxies Keep Going With the Flow

A new observation has put astronomers in the position of sailors caught in a fog, who can't tell whether or not they are drifting. For years, astronomers have been mapping the so-called peculiar motions of ever more distant galaxies—motions that depart from the general expansion of the universe and carry these galaxies, including our own, across the sky in a tidal current. Now a pair of investigators has looked for peculiar velocities over a region of space four times larger than ever before, expecting to see the edge of the flow. Instead, astronomer Tod Lauer of the National Optical Astronomy Observatories in Tucson announced last month at the Texas/PASCOS (particles, astrophysics, and cosmology) meeting in Berkeley, galaxies are slipping across the sky at 500 kilometers a second for as far as he and Marc Postman of the Space Telescope Science Institute could see.

That observation, which takes in a region of the universe about half a billion light-years wide, has disoriented astronomers who were hoping for still waters. At face value, it implies the existence of a universe that is uneven on scales far larger than theorists can explain with current models of structure formation, says Princeton theorist Bohdan Paczynski. And if not that, he says, maybe there's something wrong with cosmologists' very definition of what is at rest and what is moving.

That ultimate frame of reference is the bath of heat left over from the Big Bang. Cosmologists have assumed that to an observer standing still while the universe expands around him, the temperature and intensity of this microwave background would look uniform in all directions. When various instruments detected a slight temperature gradient from one side of the sky to the other in the 1970s, cosmologists assumed the cause was our galaxy's own peculiar motion over and above the expansion of the universe. Correcting for our motion, they thought, would yield a true rest frame.

Based on that assumption, astronomers made the peculiar-velocity measurements that culminated in the discovery of a vast stream of thousands of galaxies all headed for a spot in the sky dubbed the "great attractor." Some astronomers assumed that the attractor must be a huge pile of mass, its gravity drawing these galaxies like a tide, but the attractor istself remained elusive (*Science*, 28 August 1992, p. 1208).

That was the puzzle Lauer and Postman initially set out to investigate. By sampling motions over a large enough volume of sky, they hoped to see stationary galaxies beyond the current. Using telescopes in Arizona and Chile, they studied 120 distant clusters of thousands of galaxies each, known as Abell clusters. To estimate the clusters' deviation from the smooth expansion of the universe, Lauer and Postman needed to know both their absolute distances—which would tell how much of the clusters' motion is due to expansion—and their velocities relative to Earth.

Lauer and Postman measured distances by assuming that the brightest galaxy in each cluster has the same intrinsic brightness; the apparent brightness of each benchmark galaxy should reflect the distance of the cluster as a whole. Then they derived the clusters' velocities from their red shifts, and subtracted the expansion velocity. If the clusters were at rest with respect to the microwave background, the only remaining motions should reflect our own galaxy's drift through that reference frame. Instead the clusters, too, seemed to be taking part in the vast flow toward one side of the sky.

Marc Davis of the University of California, Berkeley, thinks the result is more than surprising; it's possibly wrong. He has examined an equally vast region of space using data from the IRAS infrared satellite and finds no evidence of a flow this size. "Our results are completely contradictory," he says. But many of the participants at the Berkeley meeting were taking the finding seriously enough to puzzle over its implications. To Paczynski, the fact that the stream doesn't peter out no matter how far astronomers look suggests that the problem may lie in the microwave reference frame. Maybe the observed bias doesn't reflect our own motion; maybe the microwave background really *is* lopsided. In that case, he says, the great stream of galaxies might not exist at all.

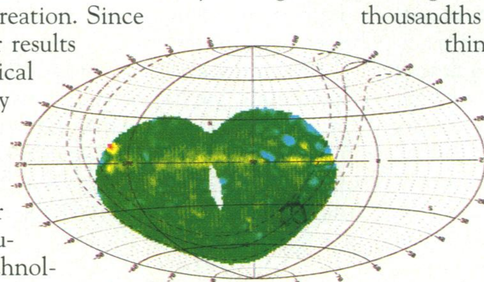
Other cosmologists at the meeting, including Lauer, thought the explanation as viable as any. But no one was ready to embrace it yet. Paczynski, too, says he'd like to see the observers cast a still wider net. If a sample twice as large as Postman and Lauer's still shows an overall flow, he says, cosmologists might be forced to conclude that the mappers of the cosmic flows have been led astray by their frame of reference. That might tame the current at last—but it would leave astronomers at sea, searching for some new way to anchor their measurements.

–Faye Flam

COSMOLOGY

Microwave Ripples Have a Reprise

When researchers running the NASA satellite known as the Cosmic Background Explorer (COBE) announced the discovery of "ripples" in the fabric of space-time, they ran the risk of cosmic-scale embarrassment. On the same day as they revealed their data to their colleagues, after all, they called a national press conference to claim discovery of the initial seeds of creation. Since then, however, their results have withstood critical analysis, and now they have confirmation from an independent experiment: a balloon-borne detector run by the Massachusetts Institute of Technology (MIT) and the NASA Goddard Space Flight Center in Greenbelt, Maryland.



MEYER *ET AL.*

True heart. Some patches in the balloon-based map represent real ripples in the cosmic background radiation.

"Now we have two independent measures completely consistent with each other," says MIT astrophysicist Steve Meyer, who announced the result at a Texas/PASCOS (particles, astrophysics, and cosmology) meeting in Berkeley last month. Because of instrument noise and gaps in the balloon data, gathered in a 1989 flight over New Mexico, the two maps look very different. But after a long analysis, Meyer says he's calculated a statistical correlation between his measurements and those of the satellite.

Both COBE and the MIT balloon measured the temperature of the pervasive sea of cool microwave radiation believed to be left over from the Big Bang. The instruments traced faint warmer and cooler patches in the background, differing in temperature by just a few thousandths of a degree. Researchers think these patches reflect slight unevennesses in the density of the infant universe—the same kind of unevenness that grew into stars, galaxies, and other cosmic structures. Now cosmologists just have to figure out how these ripples grew into the starry structures that fill the universe—a task that is harder than ever in light of the COBE and balloon measurements. The observed ripples aren't quite what you'd expect from what used to be the front-runner among theories of structure formation, the "cold dark matter" theory. Still, says MIT astronomer Edmund Bertschinger, "the fact that we have enough data to prove cold dark matter wrong shows we're making progress."

–Faye Flam