New Probe to Chart The Milky Way

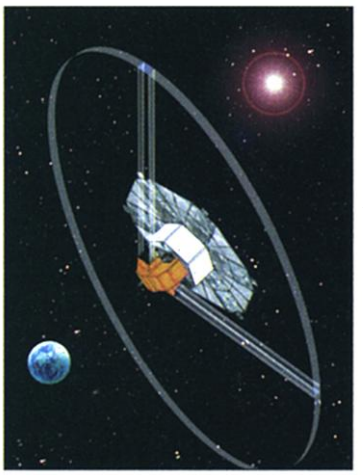
The oldest branch of astronomy is about to get a new boost. Called astrometry, it began in the 2nd century, when Greek astronomer Hipparchus of Nicea measured the brightness and positions of more than 1000 stars in the celestial sphere. Now an upcoming NASA mission promises to pinpoint millions of stars and uncover perhaps thousands of planetary systems in the Milky Way.

Astrometry took a back seat to astrophysics and cosmology for decades, until the European Space Agency (ESA) launched a satellite in 1989 named Hipparcos. By the time it had completed its mission in 1993, Hipparcos had determined the positions of over 1 million stars, 120,000 of them with an accuracy 10 times better than can be achieved from the ground, providing a fine-scaled map of our galactic neighborhood out to 500 light-years. Hipparcos scientists were also able to determine precise distances to many stars from their parallax—the ellipse a star appears to describe on the background of more distant stars as Earth circles the sun. "Hipparcos opened the eyes of many astronomers," says Lennart Lindegren of Lund University in Sweden.

Now NASA is hoping to grab some of this limelight with its Full-Sky Astrometric Mapping Explorer (FAME), a $162 million satellite set for launch in 2004. The brainchild of astronomers at the U.S. Naval Observatory in Washington, D.C., and the Harvard-Smithsonian Center for Astrophysics, FAME will feature a telescope with mirrors that allow it to observe stars in two different parts of the sky at one time, increasing the data flow. Thanks to FAME's bigger telescope and better charge-coupled devices, it will peer 10 times deeper into space than Hipparcos—covering about 1000 times more volume—and chart a whopping 40 million stars.

Over its 5-year lifetime, FAME will observe every star 1000 times, enough repetition to plot stellar positions to within 50 millionths of an arc second—the apparent size of a house on the moon, as seen from Earth—and determine precise parallaxes. Among the 40 million twinkles FAME plans to keep an eye on are a number of Cepheids, variable stars that wax and wane in brightness. Because the interval between pulses is directly related to a Cepheid's absolute brightness, these beacons are used as yardsticks for measuring distances from Earth to other galaxies. By precisely determining the parallaxes (thus distances) of about 40 nearby Cepheids, FAME will allow scientists to reduce the uncertainty in this cosmic scale bar from as much as 20% down to about 1%.

Sifting the data for unpredicted wobbles in star movements should turn up a bounty of other prizes, from unknown binary systems to an estimated 25,000 extrasolar planets that FAME scientists say might be hiding among these millions of stars. Observing the speeds at which stars whip around the galactic center should also help scientists better calculate the total mass of the galaxy and refine its proportion of dark matter, which is believed to make up about 90% of the total mass. "I think [FAME] will be a same leap forward as the one we had with Hipparcos," says George Gatewood of the University of Pittsburgh, who will use the satellite to hunt for extrasolar planets.



Starry-eyed. FAME will pinpoint precise positions for 40 million stars.

Nor will FAME have the last word: NASA aims to track stars with even greater precision with its Space Interferometry Mission, a satellite it hopes to launch in 2006. And ESA is considering plans for the most ambitious mission of all, the Global Astrometric Interferometer for Astrophysics. A possible go after 2008, this satellite would chart nearly the whole Milky Way. The renaissance of astrometry will continue.

–ALEXANDER HELLEMANS

Alexander Hellemans writes from Naples, Italy.

hundreds of dim galaxies should survive in our cosmic neighborhood today, Klypin and several co-workers claim in the 1 September *Astrophysical Journal*. Instead, astronomers have found only about 40. The high-velocity clouds could make up part of the difference.

The throng of nearby dwarfs should be dwindling slowly as they merge with the Milky Way, and astronomers may now be identifying traces of these collisions. Amina Helmi of Leiden University in the Netherlands and her colleagues studied data from the European Hipparcos satellite, which measured the motions of thousands of nearby stars. They found evidence for about a dozen stars moving at nearly identical clips and along similar paths through the tenuous but enormous spherical "halo" of stars girdling the galaxy's central bulge. "It's very unlikely to have that many stars comoving in the halo unless they had a common origin in a small galaxy that fell onto the Milky Way many billions of years ago," says Helmi, whose findings appeared in the 4 November issue of *Nature*. According to astronomer Sidney van den Bergh of the Dominion Astrophysical Observatory in Victoria, British Columbia, the research jibes with a growing suspicion that the halo is a melting pot of "little bits and pieces that have accreted over time."

Although it may seem extraordinary that stars would preserve signatures of their original orbits so long after their parent galaxies disintegrated, simulations show that those tracers are feasible, says astrophysicist Joshua Barnes of the University of Hawaii, Honolulu. "My bet is that as we look farther, we'll be able to tease apart the entire halo as a collection of these star streams from past mergers," he says. Help on this front may come from two planned NASA satellites—the Full-Sky Astrometric Mapping Explorer in 2004 (see sidebar) and the Space Interferometry Mission in 2006—which will greatly expand the number of stars with known orbits.

However, analysis of the Milky Way's dynamics suggests that most major mergers must have happened before the galaxy formed its thin disk of stars and gas, which orbits the starry central bulge like a spinning Frisbee. Astronomers think the disk is too fragile for mergers to have contributed more than a few percent of its mass in the last 5 billion years. Otherwise, the disk would be severely distorted or puffed up from the gravitational eggbeater effects of incoming stars. Thus, it seems, "not much has happened" of late on the merger front, says astronomer Rosemary Wyse of The Johns Hopkins University in Baltimore, Maryland. "We may have continued to accrete little dwarf galaxies, but that's about it."

What giveth shape, taketh away

That is not to say that the era of mergers is past. For evidence to the contrary, one need look no farther than the Sagittarius dwarf galaxy, a motley bunch of stars discovered in 1994. Nearly hidden behind the dense central regions of the Milky Way, the Sagittarius dwarf contains about 1000th the mass of our galaxy. Its orbit is not yet clearly defined, but it appears to loop around the Milky Way on a

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