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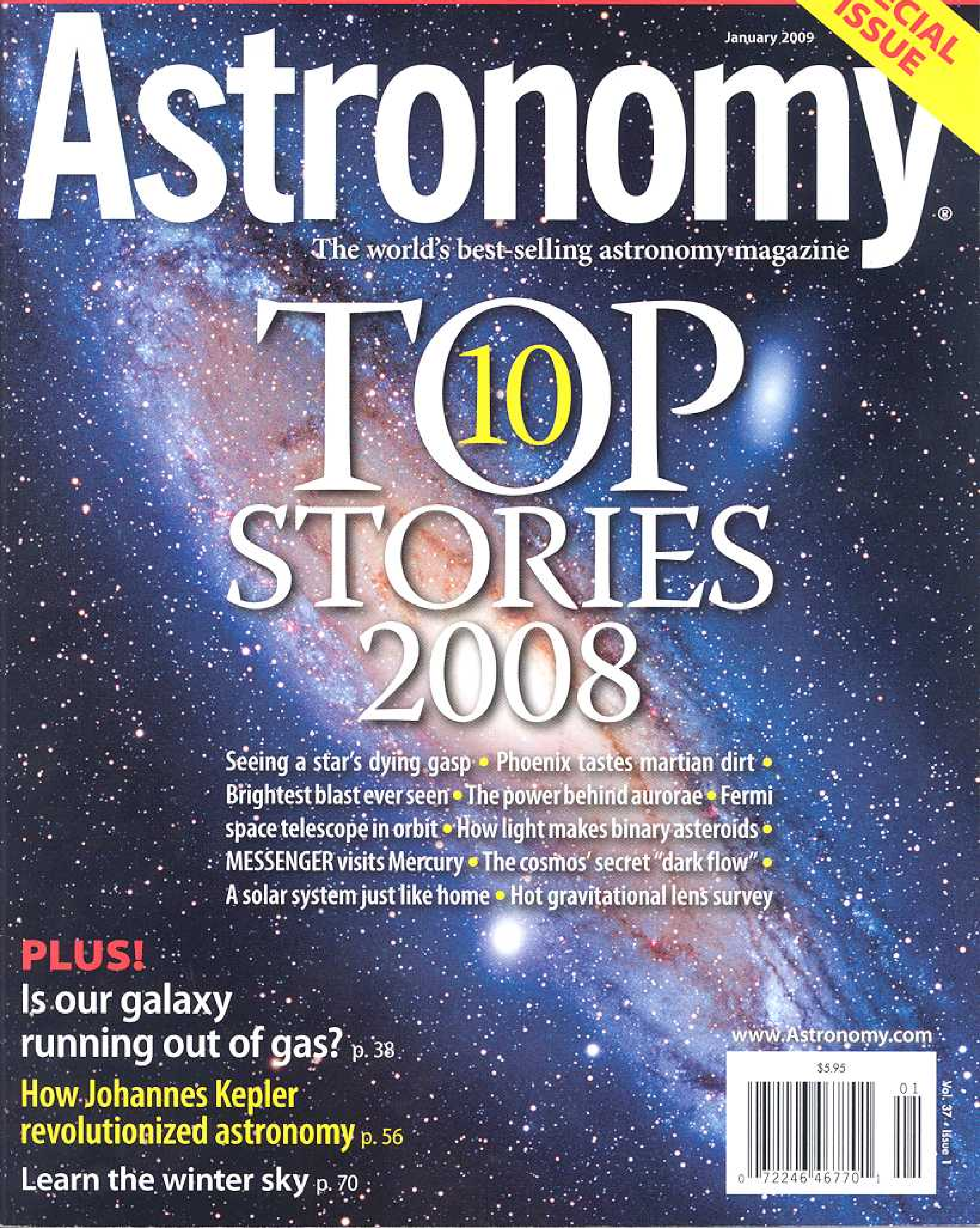

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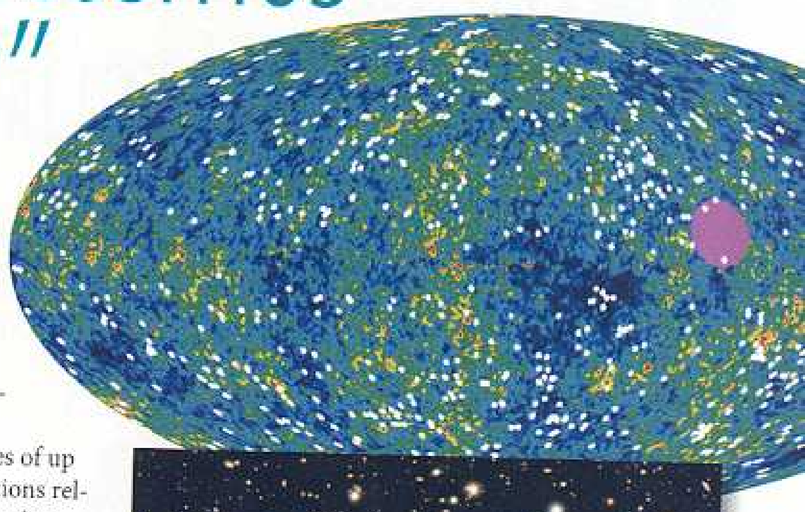
9 Seeing the cosmos' "dark flow"



Astronomers discovered a bizarre and unexpected "dark flow" of galaxy clusters possibly extending beyond the observable universe. Astrophysicist Alexander Kashlinsky of Goddard Space Flight Center in Greenbelt, Maryland, and his colleagues announced the surprising finding October 20 in *Astrophysical Journal Letters*. Kashlinsky dubbed the cluster motions dark flow in reference to two other cosmological mysteries — dark energy and dark matter.

The study focused on 700 massive galaxy clusters at distances of up to 6 billion light-years. Kashlinsky's team measured cluster motions relative to the cosmic microwave background (relic radiation from the early universe). The clusters move as a group toward a small patch of sky between the constellations Vela and Centaurus. The flow extends for at least 1 billion light-years — probably farther, Kashlinsky believes.

Nothing exists in the observable universe with gravity strong enough to account for the clusters' motions. One possible cause is a concentration of mass beyond the universe's visible frontiers. Such a mass would be consistent with cosmic inflation theories.

Inflation refers to a brief period of hyper-expansion that occurred when the universe was young. But massive structures could exist beyond the observable cosmos, pushed there by inflation.

Dark flow surprised even the scientists who found it. "We were and still are certainly very puzzled," Kashlinsky says. "It was not the result that we ever expected to measure." The researchers will need strong evidence to convince their colleagues that dark flow is real. Kashlinsky says his team is working to confirm its discovery using a larger sample of galaxies and the latest cosmic microwave background data from NASA's Wilkinson Microwave Anisotropy Probe.

White dots (top image) mark 700 galaxy clusters moving as a group toward the same region of sky (pink oval). Astronomers measured in the flow relative to the cosmic microwave background (CMB), relic radiation from the early universe. Galaxy cluster 1E 0657-56 (above) is one of clusters swept along by this mysterious "dark flow." NASA/WMAP/A. Kashlinsky et al.

planets around a star about 4,900 light-years from Earth. Based on their sizes, both are probably gas giants like Jupiter and Saturn, but with masses 30 and 10 percent smaller, respectively.

Still, the planetary system shares some important traits with our own. For example, the ratio of each planet's mass to that of its host star is similar to the ratios for Jupiter and Saturn. The exo-Saturn is twice as far away from its star as the exo-Jupiter, just as our Saturn orbits the Sun at twice the distance as Jupiter does.

The exoplanets' star is half the Sun's mass and radiates 5 percent of its light. But because the planets orbit closer to their star, their temperatures would still be similar to those of Jupiter and Saturn.

"If we scale everything to the mass and brightness of the parent star, the masses of these planets relative to their star's mass and the amount of sunlight they receive are close to our own Jupiter and Saturn," Gaudi says.

The discovery, published February 15 in *Science*, proved the value to exoplanet studies of a technique called gravitational microlensing. "It's now not just detecting new planets, but providing fundamentally new information about extrasolar planets," Gaudi says. "For example, microlensing has uncovered an entirely new class of planets, cool 'super-Earths,' which were expected theoretically but had not been seen previously."

Microlensing exploits chance alignments between stars. When a star passes in front of a background star, the foreground star's gravity bends the passing light rays inward.

From Earth, this gravitational lensing effect slightly boost's the background star's brightness. If the foreground star also has a planet, it adds a tiny "blip" of light to the general brightening. Calculations based on the blip reveals the planet's mass and distance from its star.

The planets Gaudi's team discovered were only the fifth and sixth detected with gravitational microlensing. Since then, astronomers using the technique have notched two more exoplanets — one of which is a rocky planet of only about 3 times Earth's mass.