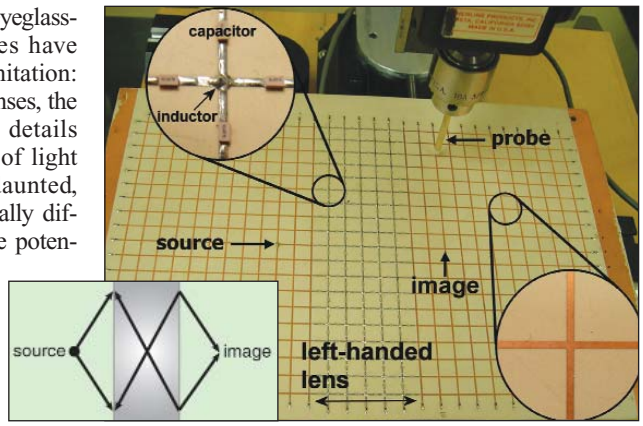
OPTICS

Lens Once Deemed Impossible Now Rules the Waves

For centuries, microscopes, eyeglasses, and magnifying glasses have slammed into a built-in limitation: No matter how good their lenses, the laws of optics dictate that details smaller than a wavelength of light are irretrievably lost. Undaunted, physicists have built a radically different breed of lens with the potential for perfect resolution. "It smashed the barrier; it crashed through the glass ceiling," says John Pendry, a physicist at Imperial College London.



Unnatural lens. Wire grid flouts optical limits by boosting trapped microwaves.

The new lens, which George Eleftheriades and Anthony Grbic of the University of Toronto describe in an upcoming issue of *Physical Review Letters*, focuses microwaves—long-wavelength radiation that falls next to radio waves in the electromagnetic spectrum. By etching a flat plane of plastic with a wire grid studded with capacitors and inductors, the researchers created a material with a negative refractive index—one that bends waves in the opposite direction from normal materials. Because of transmission losses, lenses made from normal materials cannot distinguish objects less than half a wavelength apart, but "left-handed" (negative-index) materials can. The new lens, for example, resolves objects just one-sixth of a microwave wavelength apart.

The left-handed lens achieves super-resolution by resurrecting waves that carry the subwavelength details of an object. Such so-called evanescent waves usually fizzle to nothing before they pass through a conventional lens. But the Toronto group's lens traps them like surf sloshing between two piers and amplifies them enough to reach the focal point (see diagram).

The super-resolving lens is a significant proof of principle, Pendry says. In 2000, Pendry predicted that left-handed materials would make possible marvels such as completely flat lenses with perfect resolution and zero loss (*Science*, 10 November 2000, p. 1066). Some physicists thought such materials were physically impossible, but researchers soon created them and began working on left-handed lenses (*Science*, 19 December 2003, p. 2043). In February, physicists at the Institute for Theoretical and Applied Electromagnetics in Moscow announced a super-resolving lens, but their technique required the object to be almost touching the lens, making it impractical for real-life applications. The new lens overcomes that limitation.

Eleftheriades dreams of applying the left-handed lens to medical imaging. "If you were to scale down to the frequencies of an MRI (20 megahertz), you could place the human body 1 meter away and still get super-resolution," he says—a vast improvement over current instruments. –KIM KRIEGER

CREDITS: (TOP) GEORGE ELEFTHERIADES AND ANTHONY GRBIC/UNIVERSITY OF TORONTO; (BOTTOM) ESA, NASA, J.-P. KNEIB (CALTECH/OBSERVATOIRE MIDI-PYRÉNÉES), AND R. ELLIS (CALTECH)

ASTRONOMY

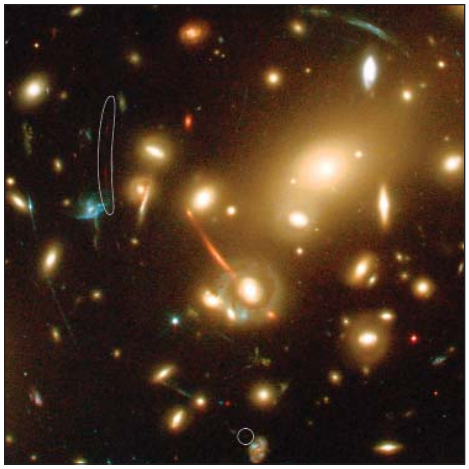
Galactic Stripling Gives a Glimpse of The Universe's Raw Youth

Redder is better, as far as astrophysicists interested in the early evolution of the universe are concerned. The more the light from a celestial object is shifted toward the red end of the spectrum, the farther away and older it is. Now astronomers claim to have found the most redshifted galaxy yet: more than 13 billion years old, a relic from an era when the earliest galaxies were forming.

"We knew they were out there," says Philip Solomon, an astronomer at the State University of New York, Stony Brook. The new discovery should help scientists figure out exactly how and when galaxies first came to be.

About 400,000 years after the big bang, the universe was a hot cloud of neutral hydrogen gas. One billion years later, that gas had burned away, ionized by the bright light from stars and galaxies. Somewhere in between, those stars had to ignite and the galaxies had to coalesce. Although scientists have theories about how and when this happened, they had few hard data. That has all changed in the past few years, thanks, in part, to a phenomenon known as gravitational lensing. The immense mass of clusters of galaxies bends and focuses light like a telescope lens, allowing scientists to spot much more distant objects.

Such a lens helped a team of astronomers find the most ancient galaxy yet. Using the Very Large Telescope in Chile, they scanned the region of a well-known cluster of galaxies, Abell 1835, as they report in an upcoming issue of *Astronomy & Astrophysics*. Its lensing effect revealed faint and distant galaxies. Among the venerable crowd, one seems to have a "redshift" of 10—a measure of how fast the galaxy is moving and how far away it is—beating the previous record holder, at a redshift of 7. According to team member Daniel Schaerer, an astronomer at the Geneva Observatory, the image shows an extremely small galaxy when the universe was a mere 460 million years old. Most theorists think that small galaxies were forming around that time and eventually merged into bigger ones.



Natural lens. Cluster Abell 1835 brought an ancient galaxy (circled, bottom) into focus.

California Institute of Technology astronomer Richard Ellis isn't sure the new-found galaxy is as far away as claimed, but he says there's no doubt that a current spate of high-redshift galaxies is shedding important light on the nature of the early universe. "They're giving us new information on how the earliest objects in the universe formed," he says. "The overall idea is that these objects began to evolve, building up from small to big, and this is borne out by these observations." –CHARLES SEIFE