Astronomy

Ring around the sun

In 1993, astronomers reported indirect evidence that Earth is embedded in a ring of asteroidal dust orbiting the sun. The finding intrigues scientists because the ring may transport carbon and other elements to our planet (SN: 11/6/93, p.300).

The researchers based their finding on simulations of dust that escapes the asteroid belt and spirals toward the sun. As the dust moves sunward, some of it gets trapped in solar orbits that brush past the inner planets. A small fraction forms a dust ring near Earth, the team calculated.

The simulations indicated that the portion of the ring trailing Earth is closer to our planet and denser than the part ahead of Earth and therefore would appear brighter. A review of 1983 images taken by NASA's Infrared Astronomical Satellite (IRAS) revealed the predicted pattern.

But the IRAS data don't prove the existence of the ring, both because of uncertainties in detector calibration and because the craft didn't map the entire sky at one time, says William T. Reach of the Universities Space Research Association in Greenbelt, Md. The ring moves with Earth, and combining images taken at different times tends to smear its appearance.

In the April 6 NATURE, Reach and his colleagues report a new analysis of a sky map taken in 1990 by detectors aboard NASA's Cosmic Background Explorer satellite. The detectors simultaneously mapped half of the sky each week for 41 weeks. The team says it has confirmed the existence of the ring and predictions of its near-Earth structure.

"Before, you couldn't tell definitively whether it was a ring or not," says Reach. "Now, you can measure it."

Distant galaxies seen through cosmic lens

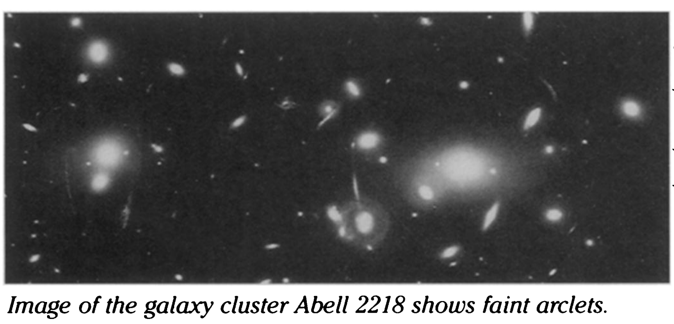
The Hubble Space Telescope has recorded one of the sharpest images ever taken of a gravitational lens at work. The telescope captured 120 faint arclets fanning out like a spiderweb around the massive cluster of galaxies known as Abell 2218.

The arclets represent light emitted by galaxies that lie far behind the cluster. These galaxies reside 5 to 10 times farther from Earth than the cluster does. The dense concentration of mass in the cluster magnifies, brightens, and distorts light passing through it, providing a zoom lens through which a telescope can view these faraway galaxies.

The sharp lensing features enabled Richard Ellis and Jean-Paul Kneib of the University of Cambridge in England and their colleagues to map the distribution of mass in the cluster's center. From this, they estimated the distances to the lensed galaxies behind the cluster, concluding that they belong to an era when the universe was about one-fourth its current age.

This suggests that most galaxies took their final form no earlier than several billion years after the birth of the universe, Kneib says. If an abundance of younger galaxies existed, they would have shown up as arclets. This finding contradicts models that hold that galaxies formed very early in the history of the cosmos and looked pretty much the same as they do now.

Ellis presented the image last month at the annual U.K. National Astronomy Meeting in Cardiff, Wales.



W. Couch, I. Smail, Ellis, et al./NASA

Image of the galaxy cluster Abell 2218 shows faint arclets.

Materials Science

Richard Lipkin reports from San Francisco at a meeting of the Materials Research Society

Teeny-weeny transistors

They keep getting smaller, and smaller, and smaller.

Seemingly without limit, electronic circuits and micromachines continue to shrink, zooming toward the utopian technological goal of devices built atom by atom.

Now, using scanning tunneling microscopes and atomic force microscopes, scientists are etching surfaces and building machine parts with features only a fraction of a micrometer in size. They can do so because of these devices' minuscule probes, or single-atom tips, which gently skate over a surface one atom at a time.

Though originally designed for imaging surfaces with atomic resolution, these "proximal probes" are yielding new techniques for making incredibly tiny electronics.

Eric S. Snow and P. M. Campbell, both physicists at the Naval Research Laboratory in Washington, D.C., have devised a way to use an atomic force microscope as "a unique lithographic tool."

"The key is the development of a fast, reliable exposure process that enables us to modify a surface and use it to transfer a pattern by selective etching," Snow says. Using a tiny metal-coated probe, the researchers draw a pattern on a silicon surface. The pattern, marked with oxidized silicon, serves as a "mask" for a subsequent etching process, whereby a corrosive liquid dissolves away silicon around the mask.

The technique yields etched details a few micrometers wide and less than 1 micrometer thick, Snow says.

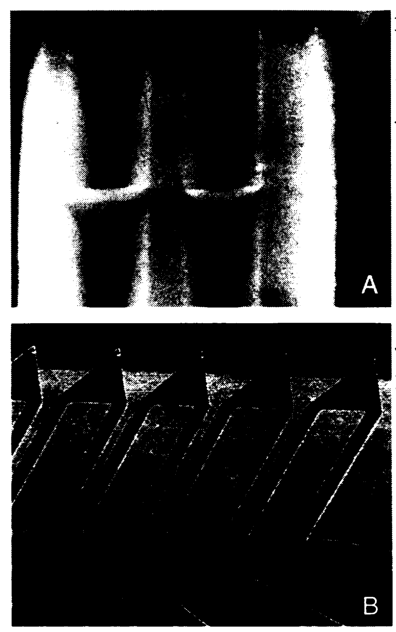
"A unique feature of this lithography process is that the exposure and imaging mechanisms of the atomic force microscope operate independently," Snow adds. Thus, while making a circuit, someone can make high-resolution images of the etchings without damaging them.

To demonstrate the technique's potential for making tiny electronics, Snow and Campbell have fashioned a key piece of a field-effect transistor only 30 nanometers wide.

Taking this lithography concept a step further, physicists Steven C. Minne and Calvin F. Quate of Stanford University and their colleagues are fabricating arrays of probes to draw circuit patterns in parallel. Since writing with a single probe is slow and tedious, the researchers figured that writing with many tips at the same time would speed up the whole affair.

To date, Quate's group has produced a row of five tips that write in concert. In the long run, the team is aiming for 1,000 tips that draw simultaneously. "In one configuration, there's a single row of 1,000 probes. In a second, there are 10 rows of 100 tips," says Quate. "The first one's easier to make, but the second one is more efficient, though harder to build."

Meanwhile, to confirm that such methods can yield usable microelectronics, Quate's group has made a transistor segment only one-tenth of a micrometer wide.



(A) Snow, Campbell/Naval Research Laboratory; (B) Minne, Quate/Stanford Univ.

A scanning electron microscopy of silicon wires, made with an atomic force microscope (A); an array of five tips (B).

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