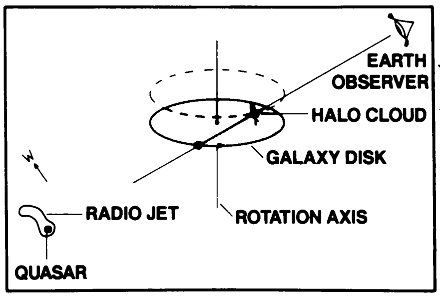
Magnetic studies may pose cosmic puzzle



Proposed location and orientation of a galaxy and its halo, believed to alter the polarization of a quasar radio jet.

Astronomers have long believed that a newborn galaxy possesses a magnetic field that's downright puny. Over billions of years, the tiny "seed" field would grow stronger, gathering energy from the rotation of its parent galaxy and from the turbulent motions of galactic gas. But new findings may put a different spin on magnetism: Either a galaxy's magnetic field grows stronger far faster than earlier imagined or galaxies are born with far stronger fields than researchers had thought.

The new studies focus on radio-wave jets emitted by quasars. As they travel through space, the jets pass through galaxies, gas clouds and other material. Such objects make their location known by absorbing specific wavelengths of light, leaving telltale gaps in the spectra of quasar light that reaches Earth. Magnetic fields make their presence, though not their location, known in a more subtle way: They alter the polarization of light — that is, the direction in which the electric field of a light wave vibrates as the wave heads toward an observer.

In 1983, Judith J. Perry of the University of Cambridge in England and Philipp R. Kronberg of the University of Toronto began studying a radio jet from a quasar called Parkes 1229-021, which lies about 6 billion light-years from Earth. Using the Very Large Array radiotelescope near Socorro, N.M., to scan the width of the jet at high resolution, they found something strange. Across the jet, the polarization of radio waves had been altered — some had their electric field twisted to the right, some to the left, in a repeating pattern.

That polarization pattern mimics those produced by magnetic fields found in some spiral galaxies near the Milky Way. After observing the jet's polarization at seven different wavelengths, Perry and her colleagues concluded that the strength of the inferred magnetic field matches that of the Milky Way and some of its neighbors. But there's a catch. The researchers propose that the culprit that altered the radio jet is an unseen galaxy residing some 4 billion light-years from Earth — nearly halfway to the edge of the observable universe.

If the distance estimate proves correct, the work may have major implications, Perry says. First, the radio observations indicate that the team may have mapped the large-scale magnetic structure of a galaxy 200 times farther away than any mapped previously. Second, the study suggests that the magnetic field strength of the young galaxy, measured as it appeared billions of years ago, equals that of the present-day Milky Way. Perry, Kronberg and University of Toronto colleague Edwin L.H. Zukowski report their work in the March 10 ASTROPHYSICAL JOURNAL.

Their results, note the researchers, hinge on a key assumption. The absorption spectra of light from the quasar indicate that a galaxy lies in the jet's path about 4 billion light-years from Earth. Based on studies with other quasars, it seems statistically likely that such a light-absorbing object harbors the magnetic field mapped by her team, Perry says. But she cautions that the field might belong to another celestial object, even the quasar itself. No one has yet observed the proposed galaxy, Perry notes, possibly because the quasar's light masks the dim emissions from the body.

Though speculative, the study's conclusions agree with results of an ongoing quasar survey that Arthur M. Wolfe and his colleagues at the University of California, San Diego, will report in the March 20 ASTROPHYSICAL JOURNAL. They examined, though in less detail, the polarization of quasars more distant than the one studied by Perry's team. Wolfe found indications that young galaxies far more distant than the one Perry proposes — dating to the time when the universe was just one-tenth its current age — nonetheless had magnetic fields as strong as the Milky Way's. Such youthful galaxies did not have enough time to build up big fields from extremely tiny ones, Wolfe says. The findings, he adds, suggest that even at its very beginning, the universe harbored magnetic fields of considerable strength. *— R. Cowen*

Light lens precisely guides atom beams

Today's semiconductor manufacturers use photolithography to etch microscopic circuits onto computer chips: They shine light through a mask onto a photosensitive surface to create the circuit's pattern. But to make nanometer-size circuits — about 1,000 times finer than current ones — these companies may one day use light in a very different way.

To work, photolithography depends on atoms in a mask to block light from parts of its target surface. But in a new process developed by AT&T Bell Laboratories in Holmdel, N.J., light does the blocking for atoms. "Instead of using matter to control light, we're using light to control matter," says Bell Labs physicist Gregory Timp. "We built a light pattern and transferred [the pattern] onto the surface."

For this technique, the researchers use a beam of atoms to deposit a thin film on a surface. To place the atoms, they tune a laser to a wavelength close to that which causes a particular atom to resonate. Because of light's wave-like nature, its intensity periodically increases, then decreases, creating peaks and valleys of high and low energy along its path, Timp says.

As an atom approaches this wave, it senses these energy differences because of its dipole moment (the internal polarization that causes the atom to prefer a specific position), Timp explains. The atom shifts to where the light's energy is most compatible with this dipole moment. If the laser's frequency is slightly lower than the one that causes the atom to resonate, then the atom heads to the brightest spots, Timp says. The light acts as a lens.

First, the scientists demonstrated how light affected the deposition of incoming atoms. Mara Prentiss, now at Harvard University, and her Bell lab colleagues describe these results in the Feb. 24 APPLIED PHYSICS LETTERS. In another report, submitted to PHYSICAL REVIEW LETTERS, they show how energy peaks in a standing wave of light focus sodium atoms into parallel lines.

The researchers say they can create interference patterns by using two standing waves at an angle to each other and can focus incoming atoms on a single, movable point. "You can distort the wave any way you want," Timp adds.

Timp sees great potential for light optics with neutral-atom lithography, as the team calls this technique. Because different atoms respond to specific wavelengths, one could theoretically guide the deposition of several kinds of atoms simultaneously by using light of different colors: for example, blue for indium, yellow for sodium. Moreover, engineers can refigure the circuit just by adjusting the angle or phasing of the lasers, a much simpler process than that used today. "The utility of light is that allegedly you can be very fast and also very precise," Timp adds. "It could represent a big savings."

Of course, such fine control means little if atoms still shift positions once they have landed, Timp says. And quantum mechanics may also limit the precision. *— E. Pennisi*