fundamental: making subjective judgments about whether outcomes are good or bad, even before people are consciously aware of the results of what they've done.

"This starts to shed light on how subconscious processes can affect our decision-making and starts to provide a bit of the neural basis for that," says George Bush, a research psychiatrist at Harvard Medical School in Boston.

Gehring and Willoughby used electroencephalogram (EEG) electrodes to monitor the brain activity of people playing a gambling game. The gamblers chose one of two boxes that appeared on the screen of a computer monitor. One box indicated a 5-cent bet, the other a 25-cent bet. After a short delay, the boxes changed color. If the chosen box turned green, the amount bet was added to the person's stash; if it turned red, money was taken away. The color of the other box revealed how the players would have fared had they chosen differently. Win or lose, the EEG trace showed a distinctive dip arising from the medial frontal cortex—a response Gehring and Willoughby call the medial-frontal negativity (MFN). The MFN was more pronounced on loss trials—a difference that was evident within 200 to 300 milliseconds after the outcome of each bet was revealed. "This shows that the brain evaluates things very quickly," Gehring says.

The researchers don't see the MFN as simply a reflection of detecting mistakes, because the stronger response showed up even after correct choices, such as taking a 5-cent loss when the alternative was a 25-cent loss. Conversely, the MFN registered a win even when a choice led to the lesser of two gains. That might prompt people to reinterpret some of the studies linking the ACC to error detection, says experimental psychologist Don Tucker of the University of Oregon in Eugene: "You might even begin to think the reason this area responds to errors is because of their emotional significance."

Gehring and Willoughby also found that after losing a bet, people were more likely to bet big the next time around. Their MFN response to subsequent losses was enhanced, almost as if each successive loss was more painful. "It's the gambler's fallacy: If you lose money, you think you're due for a win," Gehring says. "Here's a brain system that's tuned the same way."

The findings fit well with studies of people with damage to the ACC and surrounding areas, says neurologist Antoine Bechara of the University of Iowa in Iowa City. These patients make poor decisions in lab tests and in everyday life, Bechara says, because they have difficulties judging the emotional significance of the results of their behaviors.

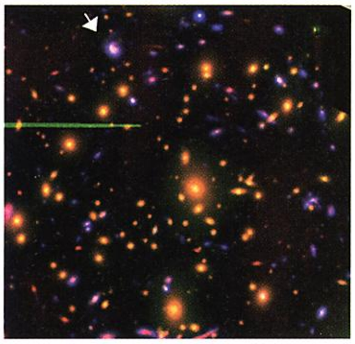
The study also represents a step toward the scientific study of human subjectivity, according to experimental psychologist Brian Knutson of Stanford University: "A basic feature of subjectivity is deciding whether things are good or bad. For a long time, scientists have considered that unstudiable." But as the new study shows, in some cases the difference between good and bad can be caught in a dip on a graph.

–GREG MILLER

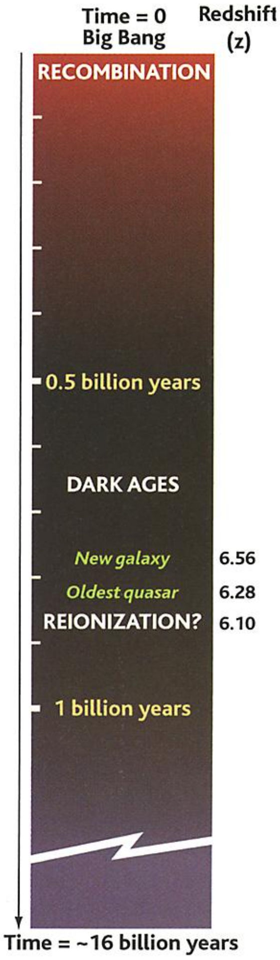
ASTROPHYSICS

Distant Galaxy Heralds End of Dark Ages

After the big bang and the scorching fireball that followed it faded, the infant universe fell into what cosmologists call its Dark Ages. Light returned half a billion years later, when galaxies formed and the first stars ignited. Now a team of astronomers claims to have seen a galaxy—the most distant object ever detected—that pushes back the date when the Dark Ages ended and may imply that they were not so uniformly dark after all. "It's an important paper—as long as the results hold," says theoretical astrophysicist Abraham Loeb of Harvard University.



Bright spot. The most distant known galaxy (arrow) appears to light up the universe's Dark Ages.



The Dark Ages began when the hot plasma of the fledgling universe cooled and recombined into neutral gas atoms, mainly hydrogen with some helium. This cold gas then slowly amalgamated into the first stars and galaxies. Only after those stars began cooking the opaque neutral hydrogen gas around them into a clear gas of ions did the Dark Ages lift and stars and galaxies become fully visible.

Any infant galaxy dating from this "epoch of reionization" at the end of the Dark Ages is likely to be at an immense distance and therefore very faint, at the limits of what existing telescopes can view. In an online paper (www.arxiv.org/abs/astro-ph/0203091) to be published in the 1 April issue of *Astrophysical Journal Letters*, Esther M. Hu of the University of Hawaii, Manoa, and colleagues describe how they found one such galaxy using a natural image intensifier: a gravitational lens. They trained the 10-meter Keck telescopes atop Mauna Kea, Hawaii, on a cluster of galaxies called Abell 370, about 6 billion light-years away. The gravity of this cluster acted as a lens, bending the light from a more distant galaxy behind it and brightening it by 4.5 times. "If it wasn't for the lens, you'd have to use a 30-meter [telescope] to get this data, which doesn't exist," says Hyron Spinrad, an astronomer at the University of California, Berkeley.

Hu's team looked for a red-glowing galaxy, the telltale signal of a star foundry whose ultraviolet emission has been stretched by redshift as it traversed the universe. The higher an object's redshift is, the farther the light has traveled and the earlier in the universe's history it left its source. The galaxy Hu and her team found has a redshift of 6.56, putting it about 15.5 billion light-years away, so we are seeing it as it was just 780 million years after the big bang. But seeing a star-forging galaxy that early on means that "the end of the Dark Ages lies earlier in time than people had previously thought," says Hu. "The thought had been that galaxies were put together somewhat later than this time," says Spinrad, so this new galaxy "is a little bit of a novelty."

Loeb is not entirely convinced. It's a "surprising claim," he says, not only because the galaxy formed so early, but also because stars and quasars must have already cleared a path for its light by sweeping away the opaque neutral hydrogen. That scenario, Loeb says, sits uncomfortably alongside the findings of Xiaohui Fan of the Institute for Advanced Study in Princeton, New Jersey, who reported a quasar at a redshift of 6.28, last year's candidate for the "most distant" prize. Fan and his colleagues believe that missing wavelengths in their quasar's light indicated that there was still neutral hydrogen around at a redshift of 6.10,

CREDIT: (LEFT) E. M. HU AND LENNOX L. COWIE which would have blotted out the star-forming signature of Hu's more distant galaxy.

But Hu says both observations may be right. Seeing the signature of star formation in the newly discovered galaxy suggests that enough galaxies already existed to see off the neutral hydrogen around it, in turn implying a largely transparent universe. By contrast, a quasar is so brilliant—about 1000 times brighter than an ordinary galaxy—that it clears away the neutral hydrogen fog around itself. So although the quasar itself may shine through, this says little about the condition of other parts of the universe. And the neutral hydrogen that Fan sees may well be due to cold, dark clouds of neutral hydrogen between us and the quasar, says Hu, rather than evidence of the widespread pre-reionization fog.

Spinrad is confident that Hu's faint source is a true early galaxy. "I think the result is right," he says. "The idea that the universe was dark … at that kind of redshift, it can't be a completely correct statement any longer." Loeb, however, would prefer to wait for more results: "It would be much more convincing if there were more objects of this type."

–ANDREW WATSON

Andrew Watson is a writer in Norwich, U.K.

CHEMISTRY

Whisper of Magnetism Tells Molecules Apart

High-energy physicists aren't the only scientists with a lust for power. For decades, chemists have built ever stronger magnets to improve nuclear magnetic resonance (NMR) spectroscopy, a technique that gleans the structure of molecules from the unique magnetic signatures of their component atoms. But generating those high magnetic fields is expensive, which drives up the cost of those probes and related medical imaging scanners.

A team led by researchers at Lawrence Berkeley National Laboratory (LBNL) and the University of California (UC), Berkeley, is bucking the trend with a strategy that could pay off for physicians and their patients. On page 2247, the group describes a new way to get detailed chemical information at ultralow magnetic fields. Because NMR forms the basis of magnetic resonance imaging (MRI), the new technique might someday eliminate the massive and costly magnets used in today's medical imaging systems.

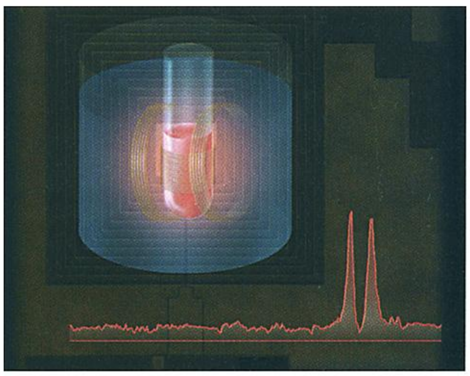
"It's a very elegant piece of work," says Warren S. Warren, who heads the center for molecular and biomolecular imaging at Princeton University in New Jersey. Allen Garroway, a physicist at the Naval Research Laboratory in Washington, D.C., says that the prospect of low-field medical imaging is "tantalizing" because of the "huge market" for low-cost MRI. But all agree that extending this technique to medical MRI machines still faces significant hurdles.

In traditional NMR, bigger magnets make it easier to track atoms. Some atomic nuclei behave like tiny bar magnets and align when placed in a magnetic field. In NMR, researchers disrupt that alignment slightly and use the telltale oscillation, or precession, of nuclei around the magnetic axes to identify particular atoms and their positions. The more powerful the external magnetic field is, the more pronounced this "chemical shift" signal becomes. That makes it possible to work out the structure of larger molecules and make use of smaller samples.

But NMR spots other telltale magnetic signatures beyond the chemical shift. In a related effect, called "J-coupling," for example, electrons around different atoms in a molecule influence one another in ways that split the atoms' spectral signatures from one line into two or more. "It tells you which atoms are bonded to which," says Alexander Pines, a chemist at UC Berkeley, who led the new study along with physicist John Clarke of UC Berkeley and LBNL. The signal for this effect, it turns out, remains constant as the applied magnetic field drops.

Pines and his colleagues decided to see whether they could use this effect to identify compounds using only a very small magnet and a simple two-part test. In a test tube, they placed a solution of water and two different test molecules: methanol and phosphoric acid. They then used an ultrasensitive magnetic field detector, called a SQUID, to try to pick up the characteristic spectral-line splitting signature of a phosphorus atom bound to an oxygen that is, in turn, bonded to a hydrogen. Phosphoric acid has this phosphorus-oxygen-hydrogen configuration. But when it's mixed with water, hydrogen atoms quickly drop off and reattach themselves to the acid molecules. The NMR detector didn't see this as a three-atom configuration and registered just a single spectral line.

Next, the researchers reacted the methanol and phosphoric acid to form trimethylphosphate, a compound that also has the three-part phosphorus-oxygen-hydrogen configuration, but with the hydrogens fixed in place. In this case, the SQUID spotted a phosphorus-oxygen-hydrogen configuration and registered it as a split in the spectral line.



CREDIT: ROBERT MCDERMOTT

Power-less. A sensitive detector (background) picks up molecular fingerprints in NMR spectra without high-field magnets.

Pines hopes the work will lead to a low–magnetic-field approach to MRI imaging. But that effort faces at least one very difficult challenge, says Warren. MRI builds images piece by piece, detecting the magnetic spins of hydrogen nuclei in small volumes of a material. Reducing the applied magnetic field makes it harder to pick the spins out of random background noise and could degrade the resolution of a scan. Warren says alternative advanced imaging techniques may solve the problem. If so, J-coupling could revolutionize medical imaging by making the machines, now housed in specialized centers at hospitals, cheap enough for the doctor's office.

–ROBERT F. SERVICE

FORENSIC SCIENCE

Judge Reverses Decision On Fingerprint Evidence

A federal judge in Philadelphia has changed his mind and decided that fingerprint examiners should have their say in court—even if what they do isn't science.

In January, Judge Louis H. Pollak of the U.S. District Court for the Eastern District of Pennsylvania found that fingerprint identification didn't meet the U.S. Supreme Court's standards for scientific evidence (*Science*, 18 January, p. 418). Pollak ruled that fingerprint identification failed three of four criteria set by the high court in its 1993 decision, *Daubert* v. *Merrell Dow Pharmaceuticals*. He said that the technique hadn't been scientifically tested, wasn't subject to scientific peer review, and didn't possess a known rate of error. Fingerprinting was "generally accepted" among forensic scientists, he found, but that did not establish its reliability. Pollak said fingerprint examiners could testify in an impending murder trial, but he forbade them from stating whether prints found at the crime scene matched those taken by authorities.

Worried that the ruling would undermine one of their most powerful tools, federal prosecutors persuaded Pollak to reconsider the issue. On 13 March, he ruled that his interpretation of *Daubert* had been too narrow. Fingerprinting is a form of technical expertise akin to accident reconstruction or art appraisal, he said, so it need not meet the scientific peer-review requirement. And although the method's error rate is unknown, he writes, there is no evidence that it is unacceptably