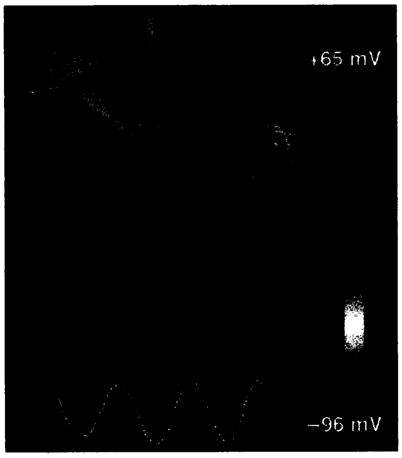
thing versus another," says Marbán.

So Winslow and colleagues constructed a computer model of a cardiac cell, incorporating everything known about the various proteins involved in ion movements and their interactions. Then, as they altered the concentrations of the various components to match what's seen in heart failure, they tracked the effect on the cardiac cell's action potential and subsequent muscle contraction. Contrary to expectations, they found that decreased potassium currents "had a minor effect on the action potential duration," says Winslow. But changes in the calcium-handling proteins dramatically lengthened the action potentials and the contractions.



Heart trouble. Misfiring of cardiac cells in one region of a computer model of a failing heart disrupts electrical activity throughout.

That makes sense in light of calcium's role in muscle contraction, says O'Rourke. Its release from an internal storage site known as the sarcoplasmic reticulum in response to an action potential first sets off a contraction, then helps shut off the action potential, resetting the system. What apparently happens in heart failure is that the decline of the calcium storage protein reduces the amount of calcium available for muscle contraction and for the negative feedback on the action potential. As a result, the cell's contraction is weaker and the action potential is prolonged. The cell partly compensates by turning up production of the shuttle protein, which moves calcium into and out of the cell. But this effort fails because less calcium can flow through the cell membrane than into and out of the inner storehouse.

But that's not all the Johns Hopkins group found. Another, as yet unpublished, computer model—this time of the whole heart—showed that elongated action potentials in a small number of cardiac cells could have grave consequences for the heart as a whole. Previous work has shown that elongated action potentials can lead to an altered electrical rhythm of cardiac cells, known as early after depolarization, or EAD, which in turn has been linked to arrhythmias. In their global heart model, the Johns Hopkins team found that EADs in a small region of the failing heart could have a ripple effect, triggering global abnormal electrical activity typical of arrhythmias.

"This is really valuable, high-quality work along the way to coming up with new treatments for heart failure," says Donald Bers, a physiologist and cardiac cell specialist at Loyola University in Chicago. The models, he says, suggest that if researchers can boost the amount of calcium available to cardiac cells, they should see changes in the duration of action potentials. Winslow says they've already begun such studies—in one case by adding a hormone that increases the activity of the storage protein—and that "the preliminary results are looking very promising." –ROBERT F. SERVICE

MEETING AMERICAN PHYSICAL SOCIETY

Celebrating a Century of Physics, en Masse

ATLANTA—The American Physical Society celebrated its 100th anniversary in grand style here from 20 to 26 March, producing a meeting whose list of abstracts alone filled two phone book–sized volumes. About 11,400 physicists participated in what was billed as the largest such gathering ever.

Hawking Blesses the Accelerating Universe

Stephen Hawking clearly wished to say a word about the cosmological constant, or lambda, the mysterious energy that seems to be permeating space and counteracting gravity on cosmic distance scales. In an overflowing third-floor room at the Ritz-Carlton Hotel here on 23 March, the celebrated cosmologist painstakingly answered a list of written queries from the press, generally with good humor, sometimes with impatience ("That is a ridiculous question," he responded at one point), and always with a razor-edged wit. But after apparently noticing a short discussion between his assistant, Chris Burgoyne, and the *Science* reporter about whether a question about Hawking's views on lambda could be added to the list, Hawking interjected with his synthesized voice: "The question about the cosmological constant."

It was a question he had answered a year ago, shortly after observations of exploding stars called supernovae began suggesting that lambda was causing cosmic expansion to accelerate (*Science*, 30 January 1998, p. 651, and 27 February 1998, p. 1298). At that point, Hawking had expressed doubts, calling the results preliminary and apparently regarding lambda as unnecessary in light of his own views of cosmic origins. But the staying power of the results seems to have impressed him along with the rest of the cosmology community. "I have now had more time to consider the observations, and they look quite good," he said. "This led me to reconsider my theoretical prejudices. I now think it is very reasonable that there should be a cosmological constant."

Hawking's new public stance comes a few months after similar statements by Alan Guth of the Massachusetts Institute of Technology, who originally devised the theory of inflation, the most influential explanation for how the big bang expansion got started. The simplest versions of inflation predict a universe filled with far more matter than it appears to hold, so Guth had been exploring alternative, low-density versions of inflation. But the supernova results now have Guth favoring a universe fleshed out, or "flattened," by a combination of matter and lambda (whose energy is equivalent to matter). "With these observations, I am comfortable with an inflationary universe that is flat," he told *Science* during a January meeting of the American Astronomical Society in Austin, Texas.

No one yet knows just what might produce a cosmological constant of the size indicated by the supernova results. Some theories, in fact, predict that it should be as much as 10^{123} times larger than that. But such a powerful cosmic repulsion would presumably keep galaxies, stars, and intelligent life from forming. Uncomfortable with the idea that physical parameters like lambda are simply lucky accidents, some cosmologists, including Hawking, have suggested that there have been an infinity of big

CREDITS: (TOP TO BOTTOM) R. WINSLOW; AP PHOTO/PBS bangs going off in a larger "multiverse," each with different values for these parameters. Only those values that are compatible with life could be observed by beings such as ourselves.

Such "anthropic" reasoning was the subject of another question put to Hawking. "Do you believe that intelligence determines the nature of the universe rather than vice versa?" asked Phillip Schewe of the American Institute of Physics. Hawking first made light of the question, asking, "What intelligence?" before calling the anthropic principle "fairly obvious" and reaffirming his support for it. –JAMES GLANZ

From Lasers, Tabletop Nuclear Bursts

Physicists gathered here last week to celebrate longevity—the APS centennial—but one of the most remarkable experiments described was above all a triumph of brevity. The tabletop experiment used laser light concentrated into unimaginably brilliant pulses lasting just 35 femtoseconds (10^{-15} seconds) to spark nuclear fusion in a chilled gas containing clusters of deuterium, or heavy hydrogen, atoms. The spike of energy caused the clusters to explode; fast nuclei from the explosions collided and fused, creating helium and a burst of neutrons.

The usual fusion laser is a warehouse-sized behemoth that trains long pulses on pellets of fusion fuel, crushing their atoms together—hardly a tabletop operation. "To my knowledge, it has never been done before," said Misha Ivanov of the National Research Council of Canada in Ottawa, who chaired the session at which Todd Ditmire of Lawrence Livermore National Laboratory in California presented the results for a team of six researchers. Tabletop laser fusion is an unlikely energy source. But the new work could lead to compact sources of neutrons for testing materials that might be used in real fusion reactors. The virtues of brevity were also illustrated elsewhere in the meeting, when another team described using a larger short-pulse laser to induce fusion's opposite number—fission—and create specks of antimatter called positrons.

Ditmire did not describe his tabletop laser in the talk and declined to speak to reporters about the fusion result, which will appear in next week's *Nature*. But his previous work has relied on "chirped-pulse amplification" to produce short pulses, says Howard Milchberg, a laser physicist at the University of Maryland, College Park. The technique uses optical gratings and special amplifiers to compress a modest-energy laser pulse into one that packs trillions of watts of power into tens of femtoseconds (*Science*, 26 November 1993, p. 1379).

Ditmire and his colleagues aim the pulses at deuterium clusters that are "bigger than a molecule, smaller than a bread box," as he put it. Formed spontaneously in a jet of deuterium gas cooled to about 100 kelvin, the clusters probably contain from a few hundred to a few thousand atoms each. In the laser's glare, the clusters explode.

The blast probably occurs in several stages. First, electrons are stripped from their atoms and then rattle around inside the clusters, heating it into a tiny, superhot ball of charged gas, or plasma. Milchberg explains, "It's the electron pressure that drives the explosion of the plasma ball," which throws off ions with thousands of electron volts (eV) of energy. The deuterium ions then collide and fuse, producing helium and 2.45-million-eV neutrons.

The team detected the neutrons directly, estimating that each laser pulse liberated roughly 10,000 of them. The process seemed to convert laser energy into neutrons at about the same efficiency as what Ditmire called a "modest-yield" shot on Livermore's giant fusion laser, Nova. Because the total energy is small, however, his setup probably has no hope of producing net energy from fusion. "The answer is never," said Ditmire when asked about those prospects.

Livermore's L. John Perkins notes, however, that with a more reactive mix of deuterium and another hydrogen isotope, tritium, the technique should produce about 100 times more neutrons, at an energy of 14 million eV. "The world fusion program needs a neutron source [for materials testing], and it doesn't have one at the moment," says Perkins, who adds that neutrons from fission reactor sources generally have less than a million eV of energy.

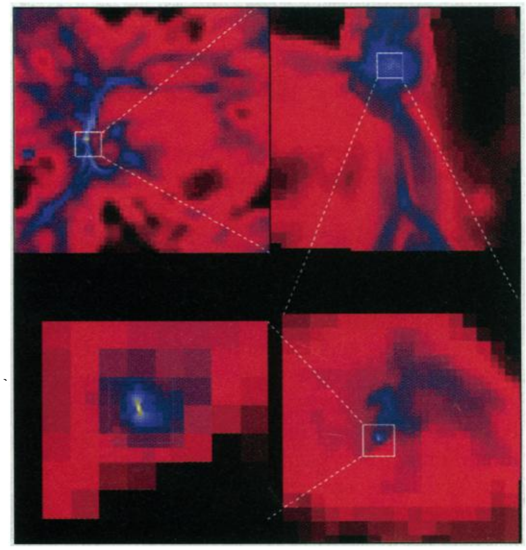
One of Ditmire's collaborators in the deuterium experiments—Livermore's Thomas Cowan—showed that fusion is not the only nuclear reaction that short-pulse lasers can drive. Cowan and his colleagues on a multi-institution team blasted a layered, solid target of gold and uranium with the Petawatt laser, a device that applies chirped-pulse amplification to one of Nova's beamlines. The intense pulse kicked up a storm of fast electrons, which then drove a cascade of energetic processes. The electrons bounced off gold nuclei, producing gamma rays, which banged neutrons out of other gold nuclei and cracked uranium nuclei into smaller pieces.

The gamma rays also occasionally split into particle pairs consisting of electrons and their antimatter counterparts, positrons, which Cowan says is "the first time laser energy has been converted to antimatter." He adds that the work shows that lasers have crossed an energy frontier into a domain that was once the sole province of large particle accelerators. The initial results had a kinetic effect on more than the targets, says Cowan: "They floored us." –J.G.

Baby Giants of the Cosmos

A supercomputer has opened the baby photo album of stars in the universe to page one, and this is what it shows: brilliant giants up to 100 times bigger than our sun. These stars began lighting up the cosmos about 50 million years after the big bang, according to research presented at the meeting last week.

Astronomers have long wondered what the first objects in the universe looked like. Theories predict that after the big bang, gravity slowly pulled parts of the expanding gas into clumps, but the agreement ends there. Some models show the clumps coalescing



First light. A supercomputer simulation of gas in the early universe zooms in on a growing clump (clockwise from upper left) to reveal a tight knot of gas containing a mass a few hundred times that of our sun.

CREDIT: TOM ABEL AND MICHAEL NORMAN, UNIVERSITY OF ILLINOIS/NCSA, AND GREG BRYAN, MIT

into Jupiter-sized bodies or small dim stars. Others predict titanic stars or even black holes. Computer simulations—often used to model clusters of galaxies later in cosmic history—were little help, because they lacked the three-dimensional resolution needed to track the collapse of myriad parcels of gas into small primordial clouds.

Now a team led by cosmologist Michael Norman of the National Center for Supercomputing Applications (NCSA) in Urbana-Champaign, Illinois, has broken that barrier. The team used "adaptive mesh refinement," in which the program zooms in on developing clumps of gas and increases the resolution only in those areas. Each simulation starts in a vast cube of space measuring

18,000 light-years on a side. But by the end, it can resolve details as small as 0.3 light-year—about the size of the cloud of comets thought to surround our solar system. "The higher resolution allows them to follow the process in far greater detail, essentially to the stellar scale," says astrophysicist Jeremiah Ostriker of Princeton University.

In this way, the team can track the growth of a nebulous blob until it forms a tight knot ready to spawn a star. The simulation indicated that most such knots were a few hundred times more massive than our sun. The program can't yet track the gas until it becomes dense enough to ignite nuclear fusion. But Norman says, "The most likely result is a star with 10 to 100 times the sun's mass."

Such stars were giants that lived fast and died young, consuming their fuel within a few million years. Then they blew up and began seeding the cosmos with the heavy elements forged in their cores, such as carbon, oxygen, and iron. Those elements grew more abundant with each stellar cycle of birth and death. That explains why subsequent generations of stars were smaller, says Norman. Heavy molecules such as carbon monoxide radiate heat far more efficiently than the molecular hydrogen that filled the infant universe. That allowed smaller masses of gas to lose energy and collapse.

It's still possible that tiny stars could have formed in the first generation if turbulence—a process the current simulation does not capture—split some of the gas into smaller clouds. "That's a possibility, but we have every indication that most of the initial stars were massive," says Norman.

So far, observations support him. Stars smaller than 80% of the mass of our sun would have survived to this day, rationing their nuclear fuel in long, slow burns. But astronomers have searched without success for these primitive stars within the ancient globular clusters that swarm around the Milky Way. A few dim stars contain just a dash of heavy elements—about 1/10,000th as much as the sun. That makes them old, but not first-generation objects.

Despite the uncertainties, the work by Norman's team impresses Ostriker. "This is the best work that has been done on seeing the conditions that led to the formation of the first stars," he says. **–ROBERT IRION**

Robert Irion is a science writer in Santa Cruz, California.

CONSERVATION BIOLOGY

A Species' Fate, By the Numbers

A popular approach for predicting a population's survival is coming under scrutiny now that its use in critical decisions on endangered species is on the rise

SAN DIEGO—When the National Marine Fisheries Service (NMFS) announced on 16 March that it was adding nine populations of Pacific Northwest salmon to the endangered-species list, the agency had barely begun to consider the question of how, exactly, to save this regional icon. The fish face threats from many quarters, including water pollution, dam spillways, and logging practices that harm river ecosystems. Which threats should government officials spend precious dollars trying to address? No single field study can provide the data needed to answer this question. Instead, NMFS scientists must rely, at least in part, on a technique called population viability analysis (PVA).

First developed more than 20 years ago, PVA has become "conservation biology's greatest scientific contribution," according to Steven R. Beissinger, an ecologist at the University of California (UC), Berkeley. The technique focuses on the likely fate of a population and what factors can determine or alter that fate. In its most common form, PVA combines stochastic models of population dynamics with field data on a species and its habitat—everything from birth and death rates to the frequency of natural disasters—to predict how long a given population will persist under given circumstances. PVA has had some notable achievements, such as helping to identify measures for boosting grizzly bear populations in Yellowstone National Park. And as one of the few predictive tools ecologists can call on, PVA has become "practically mandatory in planning for endangered species," says Michael Gilpin of UC San Diego.

But increasingly, PVAs are being attacked as too simplistic, overly demanding of data, error-prone, and hard to verify. "Even good PVAs are almost always fraught with very serious statistical problems," says Mark S. Boyce, an ecologist at the University of Wisconsin, Stevens Point. "The confidence intervals are enormous, the error bars explode into the future, and they're very rarely field-tested." Still, Boyce says, ecologists must make do with this imperfect approach to predicting species survival, because it's the best they've got. "At the moment," he says, "there's no other choice."

Under new management. Researchers have used PVA to protect the desert tortoise in the western U.S.

CREDIT: JOHN GERLACH/VISUALS UNLIMITED

To assess the state of the art of what PVA pioneer Michael Soulé of the Wildlands Project in Hotchkiss, Colorado, calls conservation biology's "flagship industry," 330 scientists gathered here last month for the first-ever major conference on the technique.* They discussed hurdles facing attempts to extend PVA to cover a wider range of species, and how to factor in the behavior of our own species. And, in an important development, one scientist described how he crash-tested PVA models in the lab, a practice that could help ecologists refine the technique.

Growing pains. For decades empirical studies of wildlife populations resembled stock market analyses, with graphs projecting future trends based solely on historical upturns and downturns. That began to change in 1978 when Mark Shaffer, then a Ph.D. student at Duke University, examined the fate of Yellowstone's grizzly bears, which had been on the endangered list since 1967 and were under increasing stress from tourists. His analysis for the first time incorporated randomly occurring demographic and environmental events, such as unusually low birth rates or sparse food supplies, into a computer model of population growth. From this hybrid, Shaffer, now at the nonprofit Defenders of Wildlife, estimated the likelihood that bear populations of a given size would survive over given periods of time. From this he derived the "minimum viable population," which he defined as the smallest bear population with a 95% probability of surviving 100 years.

Shaffer's analysis, coupled with field data, revealed that the foremost factor determining how long a bear population would survive is the death rate of adult females.

* Population Viability Analysis: Assessing Models for Recovering Endangered Species, 15 to 16 March.