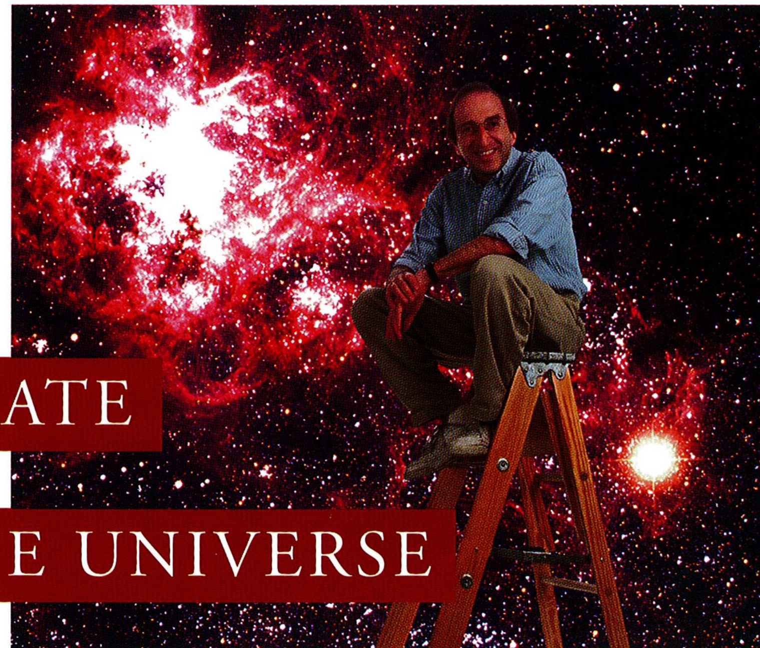
If you're trying to determine whether the universe will either collapse or continue expanding—and you plan on announcing your findings to the world—it's a good idea to cross-check your work.

That's what the Supernova Cosmology Team at Lawrence Berkeley National Laboratory has done. To analyze their data from 40 supernovae for errors or biases, they used the 512-processor Cray T3E-900 supercomputer at the National Energy Research Scientific Computing Center (NERSC), also located at Berkeley Lab. They also used the machine to simulate 10,000 exploding supernovae.

NERSC AND THE FATE OF THE UNIVERSE



Berkeley Lab astrophysicist Saul Perlmutter, with supernova 1987a in the background. (Supernova image: ©Anglo-Australian Observatory. David Molin, photographer)

Their conclusion?

Our universe, which began with the Big Bang, will never come to a standstill or collapse in a Big Crunch, but will expand forever. In fact, this expansion appears to be accelerating, according to findings announced in January 1998 by Saul Perlmutter, leader of the international Supernova Cosmology Project, a member of the Center for Particle Astrophysics based at Berkeley Lab, and an invited speaker at SC98.

Using ground-based telescopes plus the Hubble Space Telescope and the NERSC supercomputer, the Supernova Cosmology Project has determined that although the universe was expanding faster some 14 billion years ago and then slowed until seven billion years ago. Now, the expansion is again accelerating.

"On the basis of both the ground-based data and the new Hubble data, we find evidence for a universe which may ultimately expand indefinitely," Perlmutter said.

The evidence comes from observing Type Ia supernovae in very distant galaxies. To look at a distant object in space is to look into the distant past. To measure that distance, astronomers use "standard candles," objects whose intrinsic brightness is the same wherever they are found. In

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— Peter Nugent,
Berkeley Lab postdoctoral fellow

this case, Type Ia supernovae at their maximum brightness, which can be brighter than entire galaxies and bright enough for their light to have traveled billions of light-years and still be visible, were used as standard candles.

While the direct evidence came from astronomical observations, Perlmutter's team also double-checked their work on one of NERSC's Cray T3E supercomputers.

For example, the team must compare the light from nearby supernovae with that of the distant ones. To make meaningful comparisons, the light measurements from the more distant supernovae (which have been shifted to the red part of the spectrum due to the expansion of the universe) and the closer ones (which are in the blue) were altered slightly to examine the effects of dust along the line-of-sight to the supernovae and slightly different explosion scenarios. Then they were compared to make sure the team's observations matched their theoretical calculations. Because the measurements involved readings taken many times over a 60-day period from 40 supernovae, making the comparisons "is a task you only want to send to a supercomputer," says Berkeley Lab postdoctoral fellow Peter Nugent.

Nugent, who ran all of the simulations and analyses on the T3E for the project, said the Cray supercomputer was also used to make sure that the error bars presented in the research were reasonable. In addition to chi-square fitting, researchers also employed bootstrap resampling of the data. Here they plotted the mass density of the universe and the vacuum energy density based on data from 40 supernovae. Then they began resampling the data, taking random sets of any of the 40 supernovae, finding and plotting the minimum value for each parameter. The resampling procedure was repeated tens of thousands of times as an independent check on the assigned error bars.

"Currently this work takes about an hour using 128 processors on the T3E," Nugent says. "It's wonderful to be able to run six or seven of these in just one day and then compare the results."

The group also used the T3E to simulate 10,000 supernovae explosions to study their observation techniques. The cosmological values from the fits to the simulations were then plotted and compared with their known input to determine any biases which could have influenced the interpretation of the original data.

Visit the Center for Particle Astrophysics at:

http://cfpa.berkeley.edu/home.html

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