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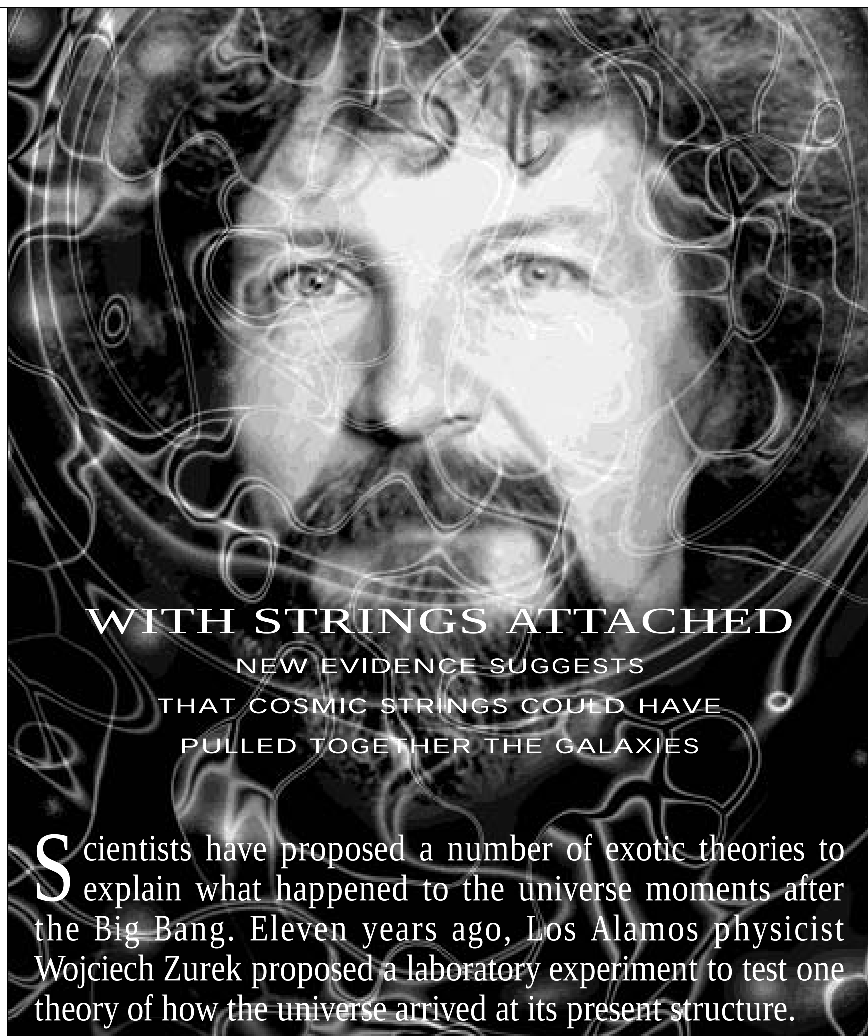
WHERE SCIENCE MAKES A DIFFERENCE

DATELINE LOS ALAMOS



WITH STRINGS ATTACHED

NEW EVIDENCE SUGGESTS THAT COSMIC STRINGS COULD HAVE PULLED TOGETHER THE GALAXIES

Scientists have proposed a number of exotic theories to explain what happened to the universe moments after the Big Bang. Eleven years ago, Los Alamos physicist Wojciech Zurek proposed a laboratory experiment to test one theory of how the universe arrived at its present structure.

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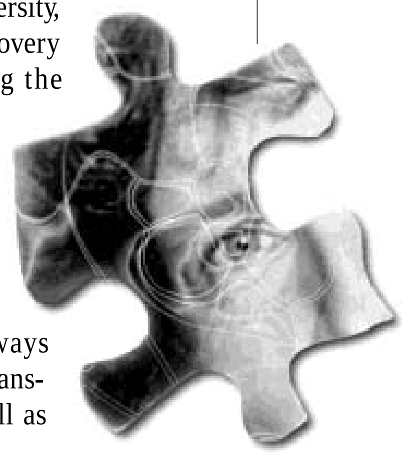
The results of laboratory experiments by three independent teams of researchers appear to confirm the validity of Zurek's theory: That one-dimensional fractures — dubbed "cosmic strings" — formed as the universe began to cool, just fractions of a second after the Big Bang.

The American team, David Lee and Robert Richardson of Cornell University, and Douglas Osheroff of Stanford University, received the Nobel Prize last fall for their 1972 discovery of the superfluidity of helium-3. In announcing the award, the Royal Swedish Academy of Sciences cited Zurek's theoretical work and the laboratory experiments by separate research teams in Finland and France.



Zurek is delighted with the recent recognition his proposal has received. "I hope it spurs enthusiasm for basic science because it can suggest new ways of looking at things," he said. "Basic science often translates into things of very practical interest, as well as cosmological implications."

Cosmic strings are important because they help solve the scientific riddle involving the formation of the structure of the universe. After the

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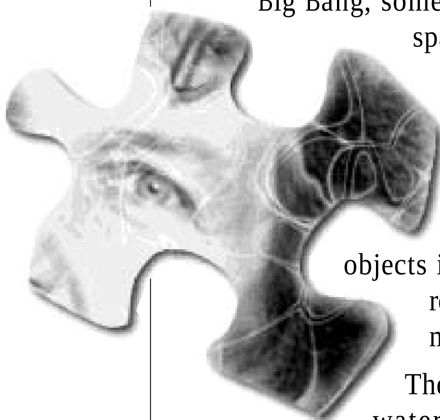
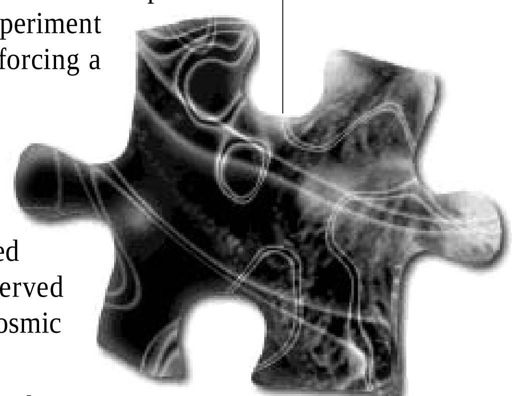


Big Bang, something happened to perturb the uniformity of space and time, allowing matter to coalesce into stars, galaxies, and other structures spread unevenly across the universe.

One theory suggests cosmic strings contained enough energy to exert a gravitational attraction and pull enough matter together to form objects in space. It also suggests that their formation resulted from one or more transitions of energy or matter from one form to another.

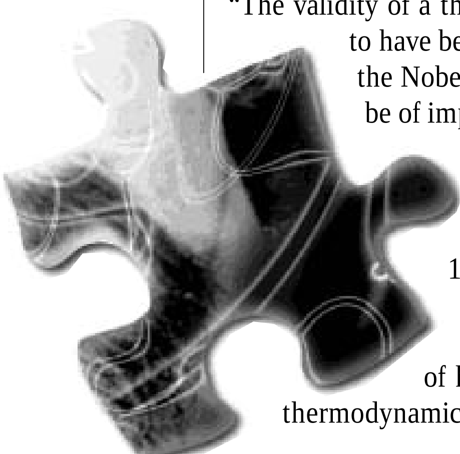
These phase transitions, much like steam turning to water and water to ice, also occur when a fluid becomes a superfluid, a state in which it flows without resistance. The transitions gave Zurek the clue for his proposal to test the cosmic string theory in the laboratory.

In a 1985 paper, Zurek said cosmic strings and vortices in a superfluid are analogous and suggested a laboratory experiment to test for key elements of string formation by forcing a fluid into a superfluid state rapidly.



The French and Finnish research teams cooled helium-3 to the temperature at which it undergoes the phase transition, moved it quickly back and forth through the transition, and watched what happened. Both teams reported they observed vortices that behaved the way the theory says cosmic strings behaved.

"The validity of a theory formulated by Zurek ... thus seems to have been confirmed," the Swedish Royal Academy said in the Nobel Prize citation. "The cosmic strings are believed to be of importance ... for the formation of galaxies."



The Nobel citation also noted the work of another researcher with a Los Alamos connection. John Wheatley, who worked at the Lab from 1981 until his death in 1986, headed a group at the University of California at San Diego in the 1970s that confirmed the superfluidity of the new phases of helium-3 and performed much of the fundamental thermodynamic research on the new phases.

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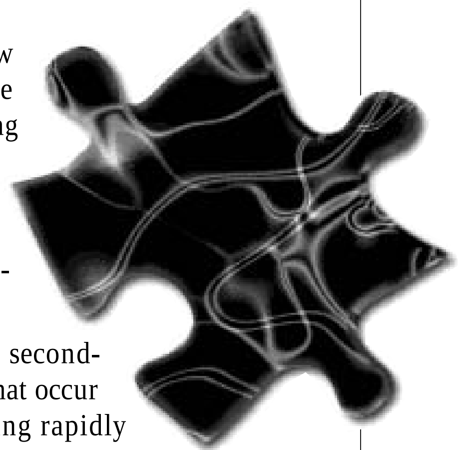
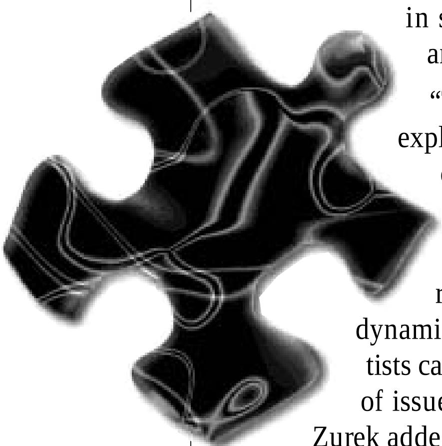


Zurek was a J. Robert Oppenheimer Fellow in theoretical astrophysics at the Laboratory when he proposed conducting experiments with superfluids to study cosmology. Now a Los Alamos Fellow, Zurek's research interests also include quantum computing, relativistic astrophysics, and quantum physics.

Interest in the study of the dynamics of second-order phase transitions, such as those that occur in superfluids, is growing rapidly among scientists, Zurek reports.



"There is a good chance that interest in the field will explode. It's interdisciplinary and very exciting scientifically. It's one of the few areas in physics where you can tie abstract and concrete thoughts together."

Zurek predicts the next big step in this field of research will involve superconductivity. By studying dynamics of the superconducting phase transition, scientists can learn a lot about superconductors. "There are a lot of issues that have to do with the strength of materials," Zurek added. "I think there is a gold mine there."

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THE HUNT FOR LUNAR WATER

LOS ALAMOS INSTRUMENTS USED IN NASA MISSION WILL DETERMINE IF THERE IS WATER ON THE MOON

Los Alamos delivered a trio of sensitive instruments last November for a NASA mission destined to orbit the moon. The Lunar Prospector spacecraft will fly in a low polar orbit, where the Los Alamos instruments will map minerals on the surface, catch signs of seismic activity, and hunt for water.

Human colonization of the moon may someday be more than a dream if Los Alamos instruments aboard a NASA spacecraft detect water on the lunar surface.

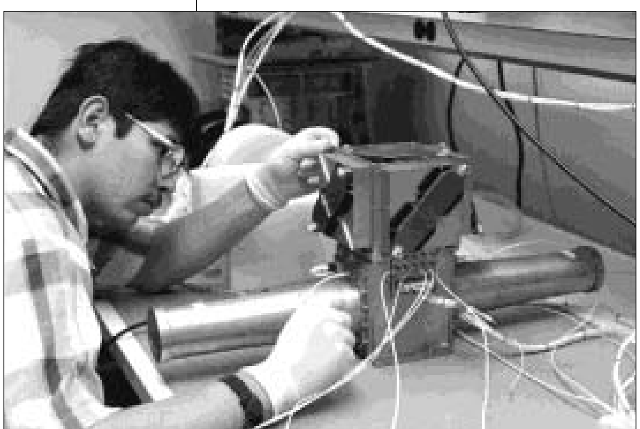
Scientists believe there is water on the moon, deposited by comet and meteoroid impacts, and accumulated in the permanently shaded regions of craters at the lunar poles. Any water that found its way into these craters would be frozen in place at a continuous temperature of minus 375 degrees Fahrenheit.

Los Alamos' neutron spectrometer on board the Prospector spacecraft can detect faint traces of ice. It will examine both poles with high sensitivity to the presence of hydrogen. Lunar Prospector is slated for launch in September 1997 for the 123-hour flight to the moon. Prospector will orbit in a circular mode above both poles at an altitude of about 60 miles. The mission is scheduled to last one year.

Los Alamos researcher Bill Feldman is confident that if there is water on the moon within about 1 meter of the surface it will be found. And if Prospector finds a large enough supply of water, human colonization of the moon may someday be feasible. Researchers expect to know within a month of Prospector's deployment in orbit if there is water.

When high-energy cosmic rays slam into the moon's surface, various particles spray outward in response, including neutrons traveling at a variety of speeds. The spectrometer will measure the speed, or energy, of all the neutrons it encounters; fewer medium-speed neutrons compared to the number of fast and slow neutrons is a unique signature for the presence of water.

Prospector also will carry a gamma-ray spectrometer experiment that will provide global maps of the major rock-forming elements on the lunar surface. The instrument records the spectrum of gamma rays and neutrons emitted by elements contained in the moon's crust. The map of certain elements will provide clues to lunar origin and evolution.



Los Alamos researcher John Madrid makes adjustments to the neutron spectrometer and alpha particle spectrometer sensor head. Both spectrometers as well as a gamma-ray spectrometer will be installed in the Lunar Prospector to map minerals on the surface, catch signs of seismic activities, and hunt for water.

The last moon sampling happened some 25 years ago during the Apollo missions, and the sampling only covered 20 percent of the moon. During the Prospector mission, researchers plan to explore the remaining 80 percent.

An alpha particle spectrometer from Los Alamos will give scientists more information about the seismic activity within all that "green cheese." Basaltic magma contains uranium, and as uranium-238 decays, it produces radon. If moonquakes vent radon to the surface, the spectrometer will capture the evidence by recording the alpha particle signatures of radon's radioactive decay.

The three spectrometers will undergo a year of tests and spacecraft integration by Lockheed Martin in Sunnyvale, Calif.

Lunar Prospector is part of the National Aeronautics and Space Administration's Discovery Mission series. Alan Binder of Lockheed Martin Missile and Space Corp. is the principal investigator. The Southwest Research Institute in Texas provided electronics for the Los Alamos instruments. Los Alamos researchers Bruce Barraclough and Dick Belian are scientific collaborators on the project. Los Alamos' Ken Fuller was the principal engineer.

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LOS ALAMOS OPENS DOOR TO ITS PAST

DECLASSIFIED DOCUMENTS IN ARCHIVES AVAILABLE TO HISTORIANS, JOURNALISTS, STUDENTS

As the birthplace of the atomic bomb, Los Alamos has a unique and important role in American history, which is well-documented in the archives of the Laboratory. More than a million pieces of information are filed away in cavernous vaults. These records include documents on the making of the first fission weapons used in World War II, the development of the hydrogen bomb, research in such areas as nuclear rocket propulsion, early reactor research, and nuclear test ban negotiations.

Archivist Linda Sandoval selects documents for classification review.

In addition to the records of the Laboratory's technical work, the archives hold records of administrative activities, including the earliest interactions between the University of California, which has operated the laboratory since its inception, and the Manhattan Engineer District, the unit of the U.S. Army Corps of Engineers that managed the national wartime effort to produce an atomic bomb.

Since 1982, Los Alamos has maintained an archives and history program to preserve the documentary heritage of the Laboratory. The program promotes and manages declassification of all possible records, and produces histories on various aspects of Laboratory activities.

With the creation of an archives and history program, Los Alamos recognized its public responsibility to provide access to its documents collection. Because most of Los Alamos' records were classified, the archives program participated in the declassification of records based on researcher requests. Since 1984, more than 5,000 documents have been declassified and made available to researchers all over the world.

Currently, Los Alamos is declassifying National Security Information documents under Executive Order 12958, part of the Clinton Administration's openness in government initiative. Over the next year, the Laboratory will make these documents available through several additional sources including the World Wide Web, Open Net, and the Office of Scientific and Technical Information.

Information in the Laboratory's archives has been used in numerous publications. In 1993, Cambridge University Press published "Critical Assembly: A Technical History of Los Alamos During the Oppenheimer Years, 1943-1945." The book is the first technical history of Los Alamos published since 1983. A second technical history, now in the planning stage, will cover the tenure of Los Alamos' second director, Norris Bradbury, who headed the Laboratory from 1945 to 1970.

The archives and history program has also published shorter histories and provides documentation to historians, journalists, and students for use in their individual works.

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RESEARCHERS USE ADVANCED FLOW CYTOMETRY TO STUDY PROGRAMMED CELL DEATH

TECHNOLOGY COULD UNCOVER CHAIN OF EVENTS THAT TRIGGER APOPTOSIS

Los Alamos scientists are using a home-grown cell-sorting technology to investigate apoptosis, a phenomenon whereby cells induce their own death by chopping their DNA into little pieces. The technology has uncovered a new parameter for studying a cell's DNA just when the apoptosis trigger is being turned on.

Apoptosis has been acknowledged since the late 1970s, but the study of how and why programmed cell death occurs is a relatively new field of research. The technology being used to study apoptosis is phase-sensitive flow cytometry, a recently upgraded version of the tool developed at Los Alamos in the late 1960s to distinguish individual cells of interest within populations or subpopulations.

Because flow cytometry can detect damage or changes in DNA on a cell-by-cell basis, it's feasible the technology can someday be used to monitor cell populations for diseases such as AIDS, cancer, or sickle cell anemia.

Flow cytometry uses lasers to excite cells or subcellular components such as chromosomes that have been stained with fluorescent dyes. Scientists then analyze the fluorescence emissions to obtain detailed information on such properties as DNA protein, enzymes, calcium,

← Los Alamos researcher Harry Crissman looks for the presence of ordered DNA fragments, indicating that apoptosis occurred in a sample population of cells.

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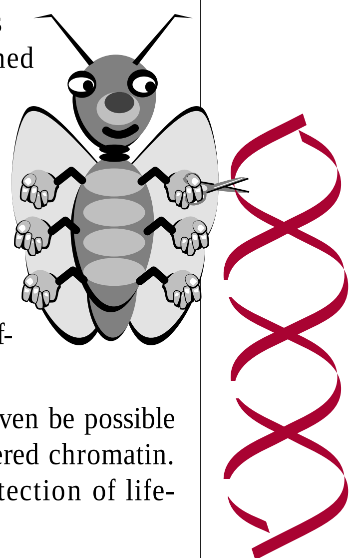
and cell-surface receptors. On the basis of these properties, cells or chromosomes can be characterized and physically isolated for further study. The Los Alamos researchers have determined that the fluorescence lifetime of dyes bound to the chromosomal material of cells undergoing apoptosis is shorter than lifetimes obtained from normal cells.



Their studies so far have demonstrated the feasibility of using the phase-sensitive flow cytometer to detect changes in chromatin structure caused by harmful environmental insults.

They speculate that the lifetime changes are the result of fluorescent dye binding to damaged chromatin in a different way than it binds to normal chromatin.

As the sensitivity of flow cytometry improves, it may even be possible to detect pre-malignant conditions on the basis of altered chromatin. This kind of breakthrough could lead to earlier detection of life-threatening diseases.

Because of its precision and sensitivity, the phase-sensitive flow cytometer is an excellent tool for examining in more detail the events leading up to apoptosis. The tool makes measurements on a cell-by-cell basis, unlike related equipment whose measurements are typically a population average.

Scientists believe that apoptosis is a multi-step process that culminates with suicide genes making messenger RNA, ribonucleic acid, which in turn makes an enzyme called endonuclease. Like a pair of scissors snipping a ribbon, the endonuclease nicks cell DNA at specific and regular intervals. The cell membrane remains intact during the early stages of apoptosis; ultimately, the cell's neighbors cannibalize its remains.

Apoptosis is one of the body's ways of maintaining a balance between cell growth and cell death. A common example of apoptosis in human embryos is the cell death that carves out the spaces between our fingers and toes.

In other instances, damaged cells that lack functioning suicide genes are unable to induce apoptosis; instead, they continue to divide and can proliferate into tumors and cancers. In the reverse scenario, suicide genes that turn on too easily can cause excessive apoptosis. This phenomenon may lead to neurodegenerative diseases such as Alzheimer's disease, strokes, or certain immune deficiency diseases.

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The mammalian cell cycle is divided into four distinct phases. During the first phase, cells prepare for DNA replication, which takes place in the second phase. Cells must go through a number of checkpoints in the first phase before entering the second phase. These checkpoints are nature's system of quality control.

Any cells with damaged DNA must repair the damage before they progress to the next checkpoint. Cells unable to make adequate repairs typically induce apoptosis in the first phase so their faulty DNA will not be replicated. The researchers believe that phase-sensitive flow cytometry can be used to detect at what decision point in the cell cycle a cell enters apoptosis.

The researchers use the flow cytometer to measure fluorescence decay from individual cells while directing a killing agent at a cell population but before full-blown apoptosis has occurred. The killing agent causes irreparable damage to cell DNA, which then activates the cell suicide genes. The researchers are interested in studying the chromatin structure of the cells during this initial period.

Studies to date reveal that the flow cytometer can detect differences in the lifetimes of different fluorescent dyes bound to damaged DNA, something the researchers did not anticipate. This lifetime, also known as fluorescence decay, is shorter in cells about to undergo apoptosis. This measurement is in addition to the tool's ability to distinguish cells based on a multitude of other fluorescent probes. The lifetime measurements will give scientists a new parameter to study apoptosis. They hope to study cells immediately before they pull the trigger on cell suicide. (See related article in *Dateline: Los Alamos*, November 1994.)

Los Alamos researchers John Steinkamp (left) and Harry Crissman prepare the phase-sensitive flow cytometer for detection of apoptotic cells.

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BRIEFLY ...

LOS ALAMOS EMPLOYEES HONORED BY DOE FOR DEVELOPMENT OF THE NUCLEAR AND REGULATORY SAFETY STRUCTURE FOR HANFORD CLEANUP PROJECT. The Department of Energy recently recognized a group of Los Alamos employees who helped develop a plan to clean up 177 dangerous high-level nuclear waste tanks at the Hanford Site in Eastern Washington. In August, DOE awarded contracts to two contractors to carry out the remediation program: one headed by British Nuclear Fuels Ltd. and the other by Lockheed Martin Corp. Los Alamos employees who made major contributions to the Hanford effort were: Sandy Wagner, Charlie Bell, Mike Terry, Liz Affeldt, Steve Agnew, Bob Drake, Rick Johnson, Jeff Martin, Bill Sailor, Rob Schroeder, and Harold Sullivan.

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