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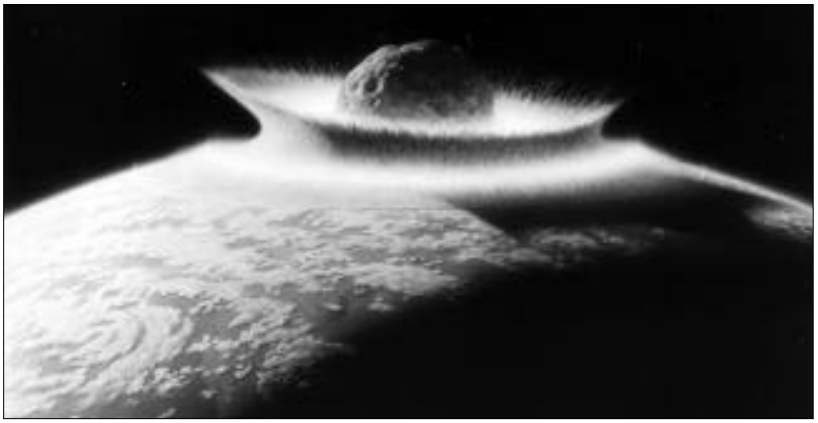
WHERE SCIENCE MAKES A DIFFERENCE

DATELINE
LOS ALAMOS

RESEARCHERS MAKING WAVES AT LOS ALAMOS

TSUNAMI TURNS WASHINGTON, D.C., INTO OCEANFRONT PROPERTY

Researchers are demonstrating the enormous damage of an asteroid strike — not from an impact on land but from tsunamis caused by an asteroid hitting Earth's oceans. Computer models show how impacts of various sizes will generate waves that could devastate entire coastlines on several continents. A surveillance and defense system could prevent such a disaster.



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Artist's conception of a catastrophic asteroid impact with the Earth.

Don Davis, NASA

A tsunami is a fast-moving ocean wave, usually caused by underwater earthquakes or volcanic eruptions, that runs up on a coastline, causing widespread damage. A tsunami retains its destructive energy while it travels enormous distances. When the wave strikes a continental shelf, its speed decreases and its height increases. An asteroid impact would induce a series of waves that could scour thousands of miles of coastline with walls of water and roiling debris.

Los Alamos astrophysicist Jack Hills and his colleague Charles Mader use a detailed numerical simulation with a 1-kilometer spatial resolution and comparative data from historical tsunami events.

The Los Alamos model estimates that an asteroid 3 miles across hitting the mid-Atlantic would produce a tsunami that would swamp the entire upper East Coast of the United States to the Appalachian Mountains. Delaware, Maryland and Virginia would be inundated, including Long Island and all the coastal cities in this region. It would also drown the coasts of France and Portugal.

Alternately, Hills' model shows how much of Los Angeles and Waikiki would be lost if the same rock struck the ocean between Hawaii and the West Coast.

Fortunately, Earth is likely to take a hit from an object that large only once every 10 million years. However, the chance of a strike by a relatively

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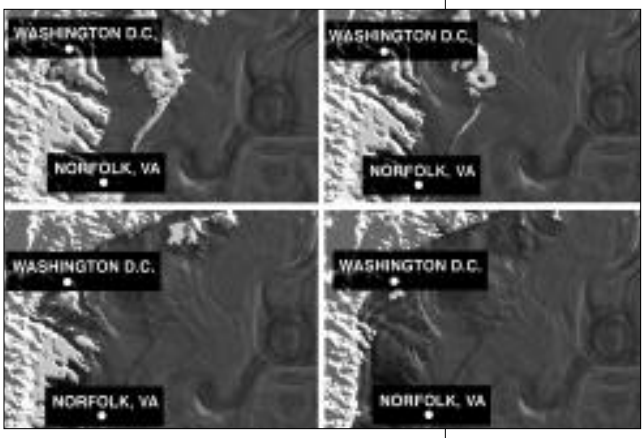
small asteroid is two or three thousand times more likely, or once every few thousand years.

Objects larger than about 600 feet across are virtually unaffected by the atmosphere and will reach Earth's surface at nearly full velocity to cause a crater on land or sea. Most of the damage from such an impact would come from a tsunami.



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Washington, D.C., would become ocean-front property if a 3-mile-wide asteroid impacted the Atlantic Ocean causing a huge ocean wave called a tsunami. Norfolk, Vir., would completely vanish and much of the coastlines of the East Coast and Western Europe would appear significantly different than they do today.

For example, the Los Alamos group finds that an asteroid about 1,300 feet in diameter could devastate thousands of miles of coastline with tsunami more than 100 feet high.

Asteroids smaller than the threshold 600 feet across lose most of their energy in the atmosphere but can still cause unprecedented damage. A "small" impactor hit near the Tunguska River in central Siberia in 1908. Though it never hit the ground, the shock wave flattened 800 square miles of forest.

An impact like Tunguska, which hit with a force a thousand times greater than the Hiroshima bomb, occurs over land every 300 years on average.

Hills and Mader have received Laboratory funding for an additional three years of model development. They expect increasingly sophisticated models to predict more extensive coastal damage than previously calculated. And Hills would like to see the research yield a practical plan of defense.

But to deflect an asteroid on a collision course, first it must be seen ahead of time. Then a nuclear-armed rocket must be ready to intercept it. A nuclear blast in space could either shatter or re-direct the incoming asteroid, Hills said. Currently, there is no such surveillance or defense capability in place.

"It's a problem that could be solved for much less than the cost of one hurricane. We could just set it up and be done with it," said Hills.

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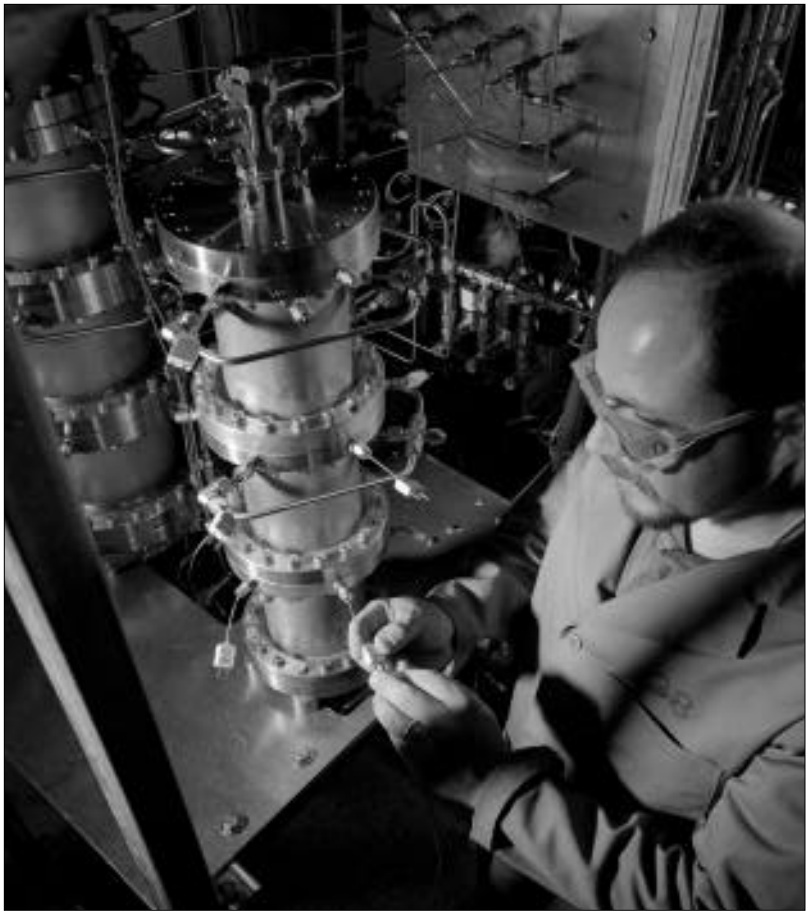
DATELINE: LOS ALAMOS

FOCUSING ON FUEL ALCHEMY

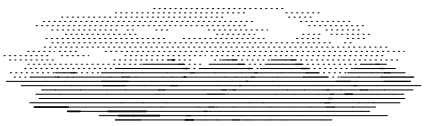
CHANGING GASOLINE INTO ELECTRICITY

Fuel cells operating on gasoline may power electric cars in the near future. The technology converts twice as much useful energy per gallon than internal combustion engines with more than 90 percent lower regulated emissions and 50 percent fewer of the greenhouse emissions per mile traveled.

Los Alamos researchers working with A.D. Little Inc. of Cambridge, Mass., recently demonstrated this important milestone in a new fuel cell



José Tafoya inspects part of the preferential oxidation reactor or PROX that Los Alamos recently provided for a Department of Energy demonstration in Massachusetts with Arthur D. Little Inc. The PROX reduces the carbon monoxide levels so low that they no longer poison the fuel cell.



technology. The experimental team processed gasoline, using the resulting hydrogen-rich gas stream to produce electricity in a low-temperature fuel cell stack. Gasoline fuel processing is a chemical process for making hydrogen from fuels.

Processing liquid methanol had previously been demonstrated at Los Alamos and is easier, according to engineers, because of the simpler methanol molecular structure. Gasoline, however, contains more complex molecules and requires higher temperature conditions for hydrogen production.

The new technology demonstrates a unique way to generate electricity simply, efficiently and cleanly from gasoline. The fuel processing step mixes oxygen with gasoline vapor, essentially breaking up the gasoline molecules to form simpler compounds such as hydrogen, carbon dioxide and carbon monoxide.

Unfortunately carbon monoxide is poisonous to low-temperature fuel cells and must be carefully controlled. Therefore the experiment integrated the gasoline fuel processor together with an advanced carbon monoxide cleanup device developed at Los Alamos.

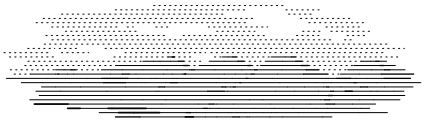
The Los Alamos team designed and built a preferential oxidation (PROX) reactor to reduce carbon monoxide levels from more than 10,000 parts per million down to 20 parts per million or less. At this lower level, the fuel cell operates well.

The Los Alamos technology converts the hydrogen reformer-product gas by oxidizing carbon monoxide to carbon dioxide, which is harmless to the fuel cell. The team did this with only a minimum loss of fuel hydrogen.

The purified hydrogen-rich gas then flows into the fuel cell. The hydrogen atoms traverse one side of an ionic-conducting, impermeable membrane. Air is fed to the other side of the membrane. Accelerated by catalysts, hydrogen is converted to hydrogen ions, or protons, and electrons.

Protons cross the membrane, reacting with oxygen on the other side to form water. An electric charge moves from the hydrogen side, through an external load such as an electric motor and to the air side.

This overall process generates electricity directly from hydrogen and oxygen with pure water as the product. Sufficient power density is available to turn the vehicle wheels using electric motors.



The fuel processing hardware converts 84 percent of the energy in gasoline to hydrogen for subsequent fuel cell electricity production. In contrast, a contemporary gasoline-powered internal combustion engine can lose more than 80 percent of the energy as heat or friction.

If the efficient conversion of hydrogen to electricity in fuel cells can be achieved in practical systems, while achieving zero emission standards, this fuel cell technology could find a place in the cleaner, more fuel-efficient car of the future, the researchers say. Any increase in efficiency in transportation modes will directly reduce the emission of carbon dioxide, a greenhouse gas.

Researchers believe this approach could be a valuable intermediate step toward hydrogen-based cleaner car technology. The technology could be available worldwide without having to develop a new network of refineries, pipelines, trucks and service stations, which would be necessary for a new fuel like hydrogen or methanol.

Los Alamos, with Department of Energy support, is researching the entire fuel side of the low-temperature fuel cell technology.

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DATELINE: LOS ALAMOS

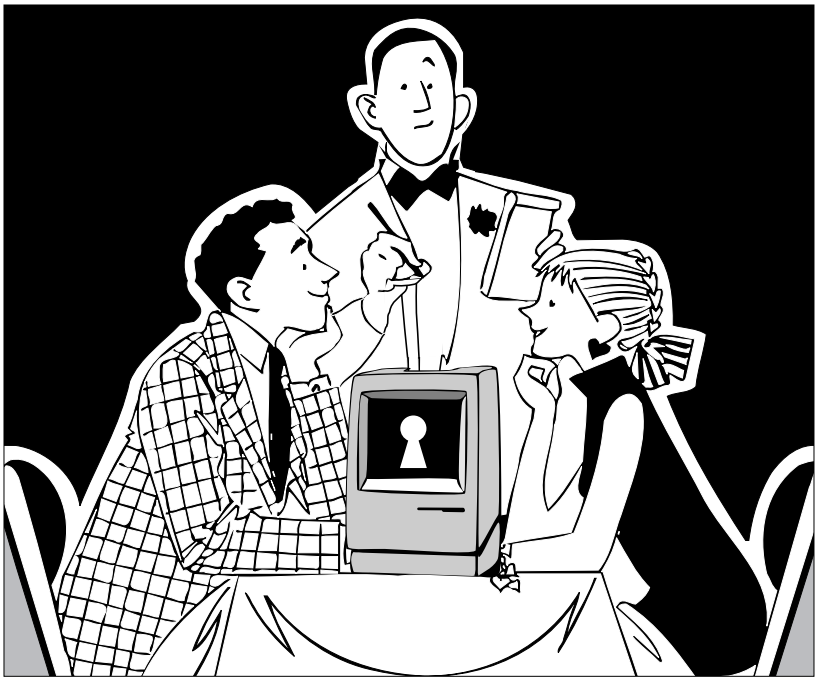
SH-H-H ... IT'S A SECRET

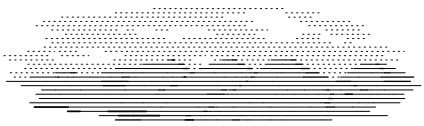
QUANTUM CRYPTOGRAPHIC KEY GENERATOR PERMITS SECURE COMPUTER TRANSMISSION OF INFORMATION

Wouldn't it be nice to make personal or financial transactions electronically knowing that the contents of each transaction are secure from intruders? With the emergence of computer technology as a means of disseminating information and the possibility of information warfare, the development of the Quantum Cryptographic Key Generator will allow senders and receivers of confidential information by way of fiber-optics to rest easy.

The key generator allows two parties to exchange messages without revealing them to a third party using cryptography — the science of secret communication.

It uses a security tactic known as quantum key distribution, or QKD, which is based on fundamental principles of quantum physics. In the





encryption process, the quantum key generator produces and distributes digital keys that can be used to encode and decode messages between two parties separated by up to 60 miles.

Key generation is controlled by ordinary personal computers. The key can't be stolen or copied because attempts to do so can be detected. It also can be used to secure electronic fund transfers.

Cryptography dates back to the ancient Greeks; however, a particular form of cryptography, known as "public key cryptography," was invented in 1977. In this method, the receiver receives two keys: one made available publicly for the sender to encrypt a message, and a private one used to decode the message. But due to advances in computer algorithms, no foolproof method exists to keep eavesdroppers from obtaining the private key.

The Los Alamos quantum key generator allows the sender and receiver to exchange messages in secrecy by using a cryptographic key that is generated and shared using quantum-mechanical properties of single photons that are transmitted to the receiver over a fiber-optic cable.

The two parties begin the key generation procedure by producing their own independent sets of random bits. They control an optical fiber "quantum channel" over which they compare their numbers to distill a common subset.

The sender proceeds by preparing a single photon for each bit in the set of numbers in one of two ways, which depends on whether the bit is a 0 or a 1. Each photon is sent over the quantum channel. The receiver performs one of two possible measurements on each photon. This also depends on whether the receiver's number is a 0 or a 1.

A photon won't trigger the receiver's detector if his or her number is different than the sender's. It will trigger the detector 50 percent of the time if both numbers are the same.

The receiver labels a number from the set as a "hit" if a photon is detected. Then, the receiver passes the list of hits — but not corresponding bit values — to the sender over a public channel. The sender labels the numbers that were hits on the receiver's end, and a shared secret key emerges as the common set of hit bits.

Anyone who attempts to break into the quantum channel is unable to intercept the key data because it is impossible for that person to attach 0 or 1 labels to the photons that the sender transmits.

Someone tapping into the quantum key transmissions on the fiber-optic cable will divert some of the photons. However, because the photons are indivisible, the diverted photons never reach the intended recipient, which in turn, does not form part of the key. Tapping the key transmissions doesn't reveal key information to an eavesdropper.

Also, an eavesdropper can't copy the photons because of a feature of quantum physics that prevents cloning.

The quantum key generator supports many encryption systems, including the unbreakable "one-time pad" method, where the sender adds the key in its binary form to the message — another string of bits — and transmits the sum to the receiver. The message is decoded by subtracting the key from the sum and translating the resulting binary string to a series of letters that are read. An eavesdropper can obtain a copy of the transmitted sum, but, because the message has been randomized by the sender's key, the eavesdropper can't read it.

The quantum key generator offers many security and ease-of-use advantages over existing key distribution methods.

Traditional key distribution using trusted couriers requires cumbersome security procedures for preparing, transporting and handling the key before any communications can take place. It may even be impractical because keys must be physically delivered to the sender and receiver by courier.

The key generator provides secure communications in metropolitan areas between banks, between off-site stock-trading centers and central stock exchanges, between corporate offices and between offices of federal agencies such as the Federal Bureau of Investigation.

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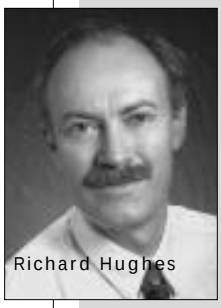
LOS ALAMOS RESEARCHER HONORED WITH FELLOWS PRIZE

Laboratory physicist Richard Hughes has received Los Alamos' 1997 Fellows Prize for his work in quantum information physics. The Fellows Prize is the highest technical honor bestowed to individuals at Los Alamos and is given for outstanding research performed over the past 10 years that has had significant impact in that researcher's discipline or program.


Richard Hughes

"His pioneering theoretical and experimental work demonstrates the practicality of what had been purely theoretical concepts form the foundations of quantum physics," said Jerry Wilhelmy, chair of the Fellows Prize Committee.

"The work by Richard and his colleagues in quantum cryptography, quantum communications and quantum computation has brought the Laboratory into a position of world leadership in these fields," Wilhelmy said. (See related article on Page 7 of this issue.)

Quantum cryptography potentially may be the most secure means of protecting communications. Based on the fundamental laws of quantum mechanics, any possible interception can be detected because it would disturb the quantum coherence of the transmitted signal.

Practical use of this technique depends on the ability to transmit a quantum-mechanically coherent, single-photon signal over significant distances.

Quantum computing is a long-term project that offers the promise of unparalleled computing capability. The approach adopted by Hughes and his colleagues is to use laser manipulation of trapped ions.

By exploiting quantum superpositions of these ions, an exponentially large number of computations could be performed in parallel, thus providing computing capabilities greatly exceeding any existing or proposed conventional computing systems.

Hughes has published an algorithm for trapped-ion quantum computations in the scientific journal Physical Review Letters that has been acclaimed by renowned quantum computing expert Artur Ekert of the University of Oxford as the most "comprehensive, detailed and realistic model of quantum factorization proposed so far."

In addition to receiving the fellows award, Hughes received Los Alamos' 1997 Distinguished Performance Award as part of the Optical Fiber Quantum Cryptography Project Team.

DATELINE: LOS ALAMOS

SURFING THE SEA OF TRANQUILITY

SCIENTISTS FIND WATER ON THE MOON

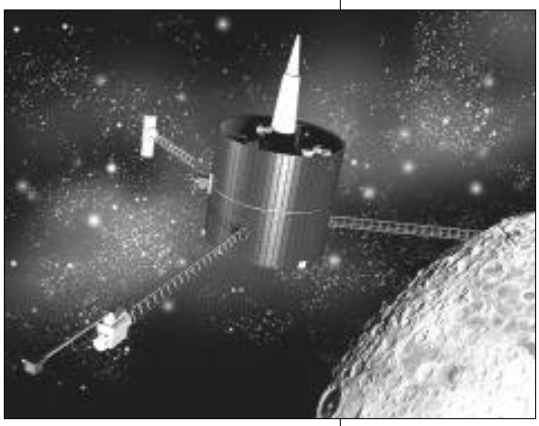
Los Alamos and NASA space scientists responsible for the recent Lunar Prospector Mission announced that they have detected water on the moon.

At a joint news conference held March 5, Los Alamos scientist Bill Feldman said that there is enough water ice on the moon to allow a modest amount of colonization.

Feldman led the Los Alamos team that built the neutron spectrometer, gamma ray spectrometer and the alpha particle spectrometer for the mission.

Scientists believe that water reaches the moon from impacting comets. Comets are primarily made of water and various frozen gases.

When they impact the moon the comets disintegrate and the water molecules bounce around until they find a really cold zone, such as a permanently shaded region near one of the poles, where the molecules are trapped and become bound to the soil. Over several thousand years, continuous meteor showers roto-till the soil until the comet ice becomes incorporated into various soil layers.



The Lunar Prospector hovers over the surface of the moon in this artist's conception.

NASA

The total amount of water is still unknown. The first estimates, based on a month's worth of data, indicate about 1 percent water in the soil. That's nearly equivalent to a gallon of water dispersed in a pickup truck-load of dirt.

"We thought we'd either find water in the Atlantic Ocean (if the launch failed) or on the moon," Feldman said.

(For information on the mission see *Dateline: Los Alamos* January/February/March 1998 issue, Page 23.)

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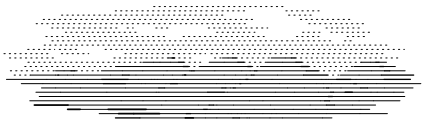

BRIEFLY ...

THe LOS ALAMOS-DEVELOPED WORLD WIDE WEB TOOL "EXPLORER" HAS RECEIVED VICE PRESIDENT AL GORE'S HAMMER AWARD. The award recognizes efforts to reduce costs and improve business practices across the Department of Energy complex. Explorer allowed the DOE to begin publicizing and distributing all DOE orders online, saving months of time and millions of dollars across the complex. Explorer combines the robust search and retrieval capabilities of Verity's *Topic* search engine with Adobe's *Acrobat Reader* and PDF, or portable document format. It performs information-mining tasks, set in an environment designed for quick navigation and both comfortable and useful to those with varying levels of experience.

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