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Source: NASA/Jet Propulsion Laboratory (<http://www.jpl.nasa.gov>)

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Entangled Photons Could Promise Lightning-Speed Computers

Defying traditional laws of physics, researchers may have found a way to blast through imminent roadblocks on the highway to faster and smaller computers.

Using modern quantum physics, a research team from NASA's Jet Propulsion Laboratory (JPL), Pasadena, Calif., and the University of Wales in the United Kingdom has discovered that entangled pairs of light particles, called photons, can act as a single unit, but perform with twice the efficiency.

Using a process called "entanglement," the research team proposes that existing sources of laser light could be used to produce smaller and faster computer chips than current technology allows. Their paper appears in today's issue of the journal Physical Review Letters.

"Our economy constantly depends on faster and faster computers," said JPL researcher Dr. Jonathan Dowling, a co-author of the paper. "This research potentially could enable us to continue upgrading computers even after traditional manufacturing procedures have been exhausted."

Currently, in a process known as optical lithography, manufacturers use a stream of light particles to sculpt computer chips. A chip is basically a grid of interconnected on-off switches, called transistors, through which electric current flows and enables computers to calculate. As companies crowd millions of transistors into tinier chips, electric current travels shorter distances, resulting in speedier

processes.

Chipmakers shine a laser light onto photosensitive material to create a stencil-like mask, which is used to carve silicon into the components of transistors. However, the producers can only provide transistors with dimensions as small as those of the masks.

Today's state-of-the-art chips have transistors measuring between 180 and 220 nanometers, approximately 400 times narrower than the width of a human hair. While traditional computers have the ability to perform with transistors as small as 25 nanometers, or 3,000 times narrower than a human hair, this presents manufacturing obstacles.

The light manufacturers use to produce today's transistors has a wavelength of 248 nanometers. It becomes increasingly difficult to use light with shorter wavelengths to produce transistors with smaller dimensions. In fact, according to a central principle of optics called the "Rayleigh criterion," 248-nanometer light can't create features smaller than 124 nanometers.

However, this new research, still in its theoretical stage, could provide a bypass of the Rayleigh criterion. The research team proposes that entanglement would allow the use of existing sources of laser light of 248 nanometers to produce computer chips with dimensions of a fourth of the wavelength (62 nanometers) or smaller compared to today's limits (124 nanometers).

Entanglement would allow researchers to use the intermingled properties of two or more photons to obtain subwavelength spatial resolutions. Albert Einstein called this intermingling of photons process "spooky action at a distance" because the particles can immediately influence each other over huge distances, even halfway across the galaxy.

Here on Earth, entangled photons can be produced by passing a light beam through a special crystal. In this quantum lithography proposal, a pair of entangled photons enters a setup with two paths. While the two particles travel together and act as a single unit, it is impossible to determine which of the two paths the pair has taken. In a strange effect of quantum mechanics, however, each photon actually travels down both paths.

On each path, the photons act like a rippling wave with peaks and valleys. After traveling on their own path for a while, the two photons converge on a surface. Because the light particles making up each wave were originally entangled, the result of adding the photon waves together is to create patterns on the surface equivalent

to those made by a single photon with half the wavelength.

This process, in essence, enables the entangled photon pair to produce patterns twice as small on each side of a chip's surface as can be created by the single photons in the conventional optical lithography procedures. Entangling more than two photons would improve results even further.

While a number of technical challenges remain, researchers are already working on developing materials that would be required for quantum lithography.

This research is part of the Revolutionary Computing Technology project in the NASA/JPL Center for Integrated Space Microsystems. The project is supported by the Deep Space Systems Program in NASA's Office of Space Science. JPL is managed for NASA by the California Institute of Technology in Pasadena.

Editor's Note: The original news release can be found at <http://www.jpl.nasa.gov/releases/2000/quantum.html>

Note: This story has been adapted from a news release issued by NASA/Jet Propulsion Laboratory for journalists and other members of the public. If you wish to quote from any part of this story, please credit NASA/Jet Propulsion Laboratory as the original source. You may also wish to include the following link in any citation:

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