Yohkoh: A New X-ray View of the Sun

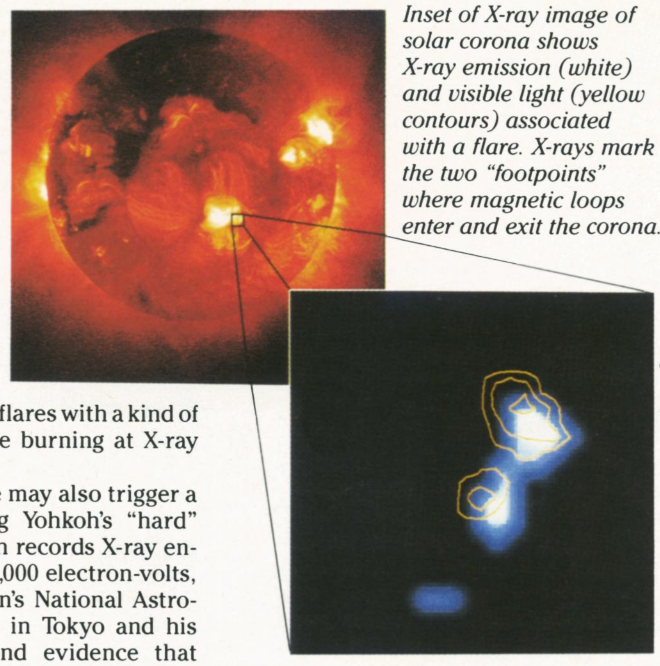
High above the spinning sun, the solar atmosphere seethes with X-ray energy unleashed when dense magnetic field lines, twisted like taut rubber bands, suddenly snap or change their structure. Vast areas of the atmosphere erupt without warning; gases heated to millions of degrees Celsius send out spectacular flares that glow like fire at X-ray wavelengths, forming giant arches and spewing out jets and ribbon-like streamers into space.

That's the violent, X-ray view of the sun as seen by Yohkoh, a Japanese-built satellite launched last August. A team of U.S. and Japanese researchers last week presented still images and videotapes from the mission, culled from thousands of photos made during Yohkoh's first eight months in orbit. And judging by their audience's reaction last week, the videos would be sellouts at any rental outlet.

Many short-term rocket flights and a few satellites, including the Solar Maximum Mission, have previously observed the sun's X-ray output, notes Keith Temple Strong of the Lockheed Palo Alto (Calif.) Research Laboratory. But Yohkoh has recorded more images of X-ray activity and traced the evolution of individual upheavals in the solar atmosphere in more detail than any other mission, he adds. Strong, his Lockheed colleague Marilyn E. Bruner and their collaborators presented their findings last week at a meeting of the American Astronomical Society in Columbus, Ohio. They say the results are already providing researchers with new data for understanding the magnetic structures believed to trigger outbursts in the sun's outer atmosphere, or corona.

Comparison of visible-light and X-ray images taken by Yohkoh confirms previous observations that clusters of sunspots — turbulent, optically dark regions of intense magnetic activity on the solar surface — coincide with the location of bright X-ray flares in the corona, says Bruner. Images of the corona taken with the satellite's two X-ray telescopes indicate that flares eject huge volumes of mass, comparable to the amount carried away in the same time period by the flow of charged particles known as the solar wind, notes Hugh S. Hudson of the University of Hawaii in Honolulu.

Rather than dying out rapidly, many of the observed flares last as long as half an hour, Bruner says. The Yohkoh images, she adds, suggest a mechanism for sustaining these outbursts, which trace out the looping patterns of magnetic field lines. Some newborn flares resemble arches that researchers suspect follow the path of tightly curved, stressed magnetic field lines that loop into and out of the corona like rubber bands near the breaking point. But as time goes on, the flares change shape, appearing as longer arches high in the corona. That transformation, says Bruner, suggests that the taut magnetic field lines have "uncoiled," releasing some of their energy and providing flares with a kind of pilot light to continue burning at X-ray wavelengths.



Inset of X-ray image of solar corona shows X-ray emission (white) and visible light (yellow contours) associated with a flare. X-rays mark the two "footpoints" where magnetic loops enter and exit the corona.

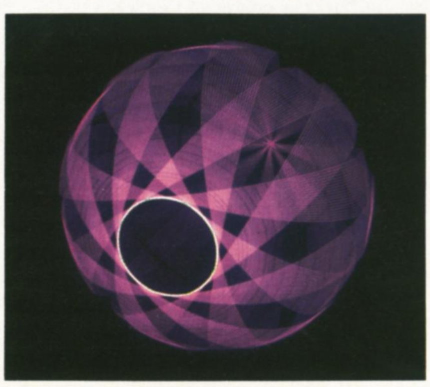
Kosugi et al/ Nat. Astronomical Obs. of Japan

A small, single flare may also trigger a chain reaction. Using Yohkoh's "hard" X-ray telescope, which records X-ray energies greater than 15,000 electron-volts, Takeo Kosugi of Japan's National Astronomical Observatory in Tokyo and his colleagues have found evidence that flares prompt adjacent magnetic field loops to unleash their energy. The finding indicates that a small group of flares may expand over time, involving larger volumes of the corona by progressively tapping the energy of larger magnetic loops at higher altitudes in the solar atmosphere, Kosugi says. — *R. Cowen*

Forging links between mathematics and art

To many people, art and mathematics appear to have very little in common. The seemingly rigid rules and algorithms of mathematics apparently lie far removed from the spontaneity and passion associated with art. However, a small but growing number of artists find inspiration in mathematical form, and a few mathematicians delve into art to appreciate and understand better the patterns and relationships they discover in the course of their mathematical investigations.

To prove the remarkable fruitfulness of such links, more than 100 mathematicians, artists and educators gathered last week at the Art and Mathematics Conference (AM '92), held in Albany, N.Y. Organized by mathematician and sculptor Nat Friedman of the State University of New York at Albany, the meeting represented his attempt to find people with whom he could share his deep interest in visualizing mathematics, whether in geometry, sculpture, computer art or architecture.



Apéry

Near the midpoint of an eversion, a sphere's meridians have flipped over the coincident poles to double up into a smaller sphere, with an open end (yellow circle) marking the equator's new position.

Attempts to visualize such mind-bending mathematical transformations as turning a sphere inside out without introducing a sharp crease at any point during the operation demonstrate how mathematics and computer graphics can lead to valuable insights that are potentially useful to both scientists and artists.

In 1959, when Stephen Smale, a mathematician at the University of California, Berkeley, first proved this particular operation possible, no one could readily visualize how it happens. By gradually simplifying the steps involved in turning a sphere inside out, mathematicians eventually found ways of picturing the entire process (SN: 5/13/89, p.299).

François Apéry of the University of Upper Alsace in Mulhouse, France, has now captured the essence of the process, known as sphere eversion, in a surprisingly simple model. Imagine a globe marked with an equator and lines of longitude, or meridians, that connect the poles. At the start of the sphere eversion, as one pole moves toward the other, the meridians twist sideways more and more.

When the poles meet, the meridians twist so much that they flip like a windblown umbrella over the coincident poles to double up into a smaller spherical shape having an open end marked by a ring showing the new position of the original sphere's equator (see illustration). The twisting continues until the equator closes up into a point and the meridians overlap and cross each other. At this stage, the sphere's outside becomes its inside, completing the eversion.

Apéry speculates that the first half of this sphere eversion may serve as a mathematical model of the way an embryo, starting out as a ball of cells, can pull in part of its outer wall to form a cavity among its dividing, differentiating cells. Biologists call the process gastrulation. *— I. Peterson*

New physics for liquids in tight spots

Liquids confined in very narrow spaces don't always behave as expected. But the way they do act suggests that some basic physical principles may be involved, theorists now conclude on the basis of computer simulations.

Increasingly, researchers depend on simulations to predict and visualize the molecular mechanisms of friction (SN: 5/30/92, p.360). During the past two years, Peter A. Thompson, a physicist at Exxon Research and Engineering Co. in Annandale, N.J., and his colleagues have used simulations to study lubricants made of spherical molecules.

Now, Thompson, Exxon colleague Gary S. Grest and Mark O. Robbins, a physicist at Johns Hopkins University in Baltimore, have examined lubricants made with flexible, chain-like molecules.

On the computer, the researchers compress a lubricant between two surfaces and watch on the terminal screen how the molecules — represented by beads or chains of beads — behave. Confined spherical molecules crystallize much more quickly when squeezed than do molecules that are not hemmed in, Thompson says. When rubbed hard enough between one moving and one stationary surface, these molecules briefly escape their orderly array, then recrystallize, creating a friction called "stick-slip" motion.

Long molecules also work this way, "but here the solid state is a glassy, entangled system," Grest says. The scientists simulated lubricants with six to 20 building blocks, called monomers. All of the long molecules remained fluid much longer than the spherical ones, they report in the June 8 PHYSICAL REVIEW LETTERS.

Also, unexpectedly, these fluids showed a similar response to rubbing — shearing — by a surface moving at increasing speeds: Friction increased exponentially as the shear rate increased, and that exponential relationship held constant over a range of molecules and surfaces. "That's very surprising," Thompson says.

Last year, Steve Granick's group at the University of Illinois at Urbana-Champaign observed a similar relationship between shear rate and friction in ultrathin films of the flexible molecule dodecane. Some researchers questioned those results, says Grest, "but seeing it in simulations of a totally different system in a totally different situation helps" support the earlier finding. Thompson's group suggests a universal relationship may exist among polymer fluids because, when confined, these fluids convert so easily to glassy states. *— E. Pennisi*

Two steps forward in AIDS vaccine search

Researchers seeking a vaccine to stem the spread of AIDS have taken two significant strides toward that goal. They have found a primate species besides humans and the endangered chimpanzee that they can use to test the safety and efficacy of possible AIDS vaccines. And they have developed an AIDS vaccine that provides protection in chimps against white blood cells — such as those in infected blood or semen — that carry the AIDS-causing virus HIV-1.

In the first discovery, a group led by Lawrence Corey of the University of Washington in Seattle has successfully infected with HIV-1 a common type of Indonesian monkey called the pigtail macaque. Because pigtail macaques are more plentiful than chimpanzees — the only other animals known to be susceptible to HIV-1 infection — Corey and his colleagues say their finding should expand the number of candidate AIDS vaccines that researchers can evaluate at any given time. This, in turn, should speed the development of an effective vaccine, they say.

Corey's group tested whether HIV-1 could infect pigtail macaques after finding that the monkeys are especially vulnerable to HIV-2, a related but separate virus responsible for many AIDS cases in Africa. The researchers began by demonstrating that four different strains of HIV-1 could infect pigtail macaque white blood cells grown in laboratory cultures and cause the cells to produce new infectious viruses.

Next, they injected a group of eight pigtail macaques with infected white blood cells, purified HIV-1 or a mixture of both. In a paper scheduled for publication in the July 3 SCIENCE, the researchers report that all of the monkeys became infected with HIV-1 and produced telltale antibodies to the virus. Moreover, the monkeys developed swollen lymph nodes, rashes and fever — early symptoms of HIV infection that previously have been seen only in humans.

Corey says these results suggest that the pigtail macaques may later develop the wasting, loss of immune system function and neurological symptoms that afflict humans with AIDS. This would make the monkeys the first true animal model for AIDS, because chimpanzees do not get sick following HIV infection.

AIDS vaccine researcher Jonathan S. Allan of the Southwest Foundation for Biomedical Research in San Antonio, Texas, agrees that pigtail macaques offer "a nice alternative to chimps, or an addition to chimps" for AIDS vaccine testing. "They are more amenable to AIDS vaccine research," he says, "because there are enough around so that you could use statistically relevant numbers of unvaccinated controls" in vaccine studies.

Because of an international treaty barring the importation of chimpanzees — which are endangered in their native Africa — the National Institutes of Health funds a program to breed the animals in captivity (SN: 3/11/89, p.155). Even so, only some two dozen chimpanzees are available for AIDS vaccine studies each year. In contrast, between 200 and 300 pigtail macaques are born in U.S. breeding facilities annually, and there are no restrictions on their sale.

In the second AIDS vaccine development, a U.S.-French research team led by Patricia N. Fultz of the University of Alabama at Birmingham demonstrated that multiple immunizations with several HIV-1 proteins protected three chimpanzees from infection with HIV-1 carried by white blood cells. Although several AIDS vaccines have been shown to protect chimpanzees against infection with purified HIV (SN: 6/9/90, p.363), Fultz and her colleagues assert that this is the first time a vaccine has shielded against cells carrying HIV. They report their results in the June 19 SCIENCE.

Fultz says the finding suggests it will be possible to develop a long-acting human vaccine to protect against HIV particles carried by infected white blood cells. She says that one of the chimpanzees her group studied resisted infection from such cells even a year after its vaccination. *— C. Ezzell*