Untangling the solar corona's structure

The cauldron of gases at the sun's visible surface measures 6,000 kelvins. But venture a few thousand kilometers higher, and temperatures typically zoom into the millions of kelvins. Welcome to the solar corona, where vast, arching magnetic fields hold sway and bursts of radiation can occasionally exceed the temperature at the sun's very core.

Scientists have tried for more than half a century to explain how the corona retains its heat. But they lacked the observational tools to discriminate clearly among various models. Examining new X-ray images obtained by the Japanese Yohkoh satellite, however, two researchers argue that coronal heat comes from energy released when tangles of magnetic fields unwind.

James A. Klimchuk of the Naval Research Laboratory in Washington, D.C., and Lisa J. Porter of the Massachusetts Institute of Technology report in the Sept. 14 NATURE their analysis of Yohkoh images of 47 loops of coronal gas sculpted by the arching magnetic fields.

Klimchuk and Porter note that in recent years, three models have taken center stage in the effort to explain the corona's high temperatures. In one model, wavelike motions that originate at the sun's turbulent surface propagate along magnetic field lines into the corona, where they act as a steady source of energy.

The other two models rely on energy generated when the corona's magnetic fields—either singly or in groups—twist or tangle. The twisting arises because these arching fields begin and end at "footpoints" in the sun's visible surface. The turbulence at the surface causes the footpoints to wander, tangling the magnetic fields.

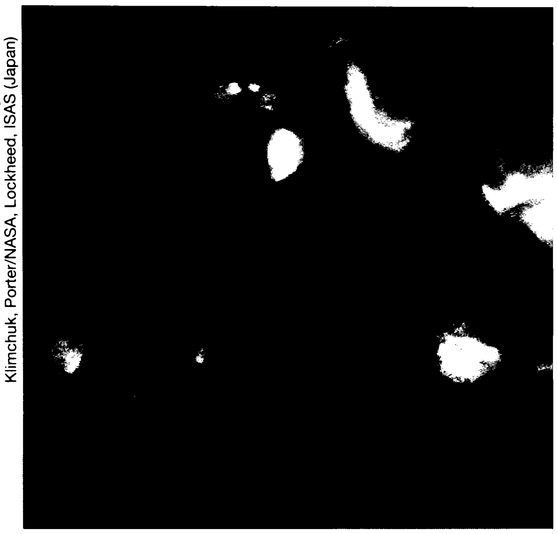
In one of these models, individual fields become so twisted that they eventually snap like rubber bands, unleashing energy fields. In the other, neighboring fields wind around each other, creating what the researchers call "a bowl of tangled spaghetti." The corona's heat comes from energy released as the spaghetti tries to untangle itself, while the footpoint motion continues to stir it up.

In their study, Klimchuk and Porter deduced from Yohkoh images that a coronal gas loop gains heat at a rate inversely proportional to the square of the loop's length. Combining this observation with earlier results from solar physicist Leon Golub of the Harvard-Smithsonian Astrophysical Observatory in Cambridge, Mass., and his colleagues, who analyzed 1970s Skylab data to relate pressure in the corona to magnetic field strength, Klimchuk and Porter say their work supports the heating predicted by the spaghetti model. But because no one else has done a study similar to Golub's, the two researchers caution that "it would be premature to rule out other models on the basis of this evidence alone."

"We clearly need more data, but [this] work is showing us a way to go about learning how the corona is heated," says Robert Rosner of the University of Chicago.

According to Golub, X-ray telescopes aboard SOHO, a joint NASA–European Space Agency mission scheduled for launch in December, may provide further

Klimchuk, Porter/NASA, Lockheed, ISAS (Japan)



False-color X-ray image shows part of the sun's corona observed by the Yohkoh satellite. White depicts the highest X-ray intensity. The X rays concentrate along vast loops that correspond to arching magnetic fields rooted in the sun's surface.

data on coronal heating. And a NASA small-explorer project called TRACE, set for launch in 1997, will have detectors with five times the resolution of any existing low-energy X-ray telescope, notes Rosner.

Researchers may already have found direct evidence of footpoints twisting the magnetic field, says Theodore D. Tarbell of Lockheed Palo Alto (Calif.) Research Laboratory. He and his colleagues used the Swedish Vacuum Solar Telescope in the Canary Islands, Spain, to show that tiny magnetic elements on the sun's surface, apparently linked to coronal gas loops, change shape in a matter of minutes. *—R. Cowen*

Kids take mental aim at others' goals

At age 18 months, children typically cannot express their thoughts in words. Nonetheless, they already ascribe goals and intentions to the actions of others, a new study finds.

The strength of "intention reading" in 18-month-olds supports the view that humans possess an innate capacity for attributing purpose to what others do, contends Andrew N. Meltzoff, a psychologist at the University of Washington in Seattle.

"Even a weak reading of the data suggests that infants are thinking in terms of goals that are connected to people and not to inanimate objects," Meltzoff asserts. "Infants apparently represent the behavior of people in a psychological framework involving goals and intended acts instead of purely physical movements or motions."

In the view of a growing number of researchers, children come to understand beliefs, intentions, and other mental states as potentially misleading interpretations of the world between the ages of 3 and 5 (SN: 7/17/93, p.40). But studies of the appreciation of states of mind by children younger than 2 1/2 have proved difficult in the absence of a nonverbal probe for this type of understanding.

Meltzoff developed such a measure by exploiting the tendency of young children to imitate what they see adults do. In one study—which included a total of 40 boys and girls, all age 18 months—some children watched an adult perform a simple procedure with each of five toys; some watched an adult try, but fail, to perform the same procedures; some watched an adult handle the toys in a random way without attempting to perform the procedures; and the rest saw no demonstrations of any kind.

In one instance, the toy consisted of two wooden cubes connected by two plastic cylinders, one of which fit snugly into the other. Children saw an adult pull the toy apart; try, but fail, to pull it apart; pick it up and bend it; or simply hand the toy to them.

Youngsters given the toy routinely pulled it apart only if they had watched an adult either succeed or fail at that task, Meltzoff reports in the September DEVELOPMENTAL PSYCHOLOGY.

In a second set of trials, 18-month-olds again performed toy tasks that an adult had either succeeded or failed at. However, they rarely performed the same tasks after watching demonstrations, whether flawless or inept, by a mechanical device.

Meltzoff's technique shows that a basic knowledge of others' intentions appears early in life, holds Alison Gopnik, a psychologist at the University of California, Berkeley. But the understanding of intent and other mental states gets progressively more complex throughout childhood, she maintains. *—B. Bower*