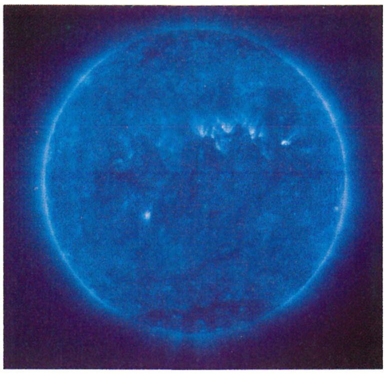


BY OBSERVING EMISSION LINES from highly ionized iron IX and X, SOHO's Extreme Ultraviolet Imaging Telescope reveals how the corona's $10^6$ K gas is shaped by the Sun's magnetic field. (Courtesy of the SOHO-EIT consortium.)

loops are perpetually sprouting on the solar surface and then disappearing. To Title, the tangle of small loops looked like a carpet.

The rate at which the carpet's magnetic loops regenerate was the biggest surprise. Totting up all the disappearances, Title found that the entire magnetic carpet replenishes itself every 40 hours.[1] Omitted from Leighton's diffusion model, the rapid replenishment requires, according to Title, a "fundamental change in the way we picture the formation of flux." SOHO team member Joe Gurman from NASA's Goddard Space Flight Center nearly fell out of his chair when he first heard about the rapid replenishment. "It's one of those things that changes your view, catastrophically, of what's going on," he says.

Direct evidence that the magnetic carpet really can heat the corona comes from two other SOHO instruments, the Coronal Diagnostic Spectrometer (CDS) and the Extreme Ultraviolet Imaging Telescope (EIT). Both instruments have recorded local brightenings of hot gas that coincide with disappearances of the carpet's loops, indicating that just about all the loops reconnect and cancel, thereby releasing energy, rather than simply sink back beneath the surface. The figure on the previous page shows that the magnetic loops occur on the surface in the same places as the local brightenings measured by EIT.

The statistical correlation of EIT and CDS brightenings with MDI loops is still under way, but, says Richard Harrison, who leads the CDS instrument team from the UK's Rutherford Appleton Laboratory, "First results are very encouraging. . . . I think it is pretty clear that the relationship is close."

One consequence of the magnetic carpet is that it dramatically boosts the amount of magnetic energy available to heat the corona. Over the coarse 100 000 km grid of Leighton's model, many opposite-polarity concentrations in the mixed-polarity regions cancel when you calculate averages. As much as 90% of the flux could be missed. And if you observe the carpet's rapid replenishment of flux too slowly, you'll drastically underestimate how much new flux contributes to the total. Since energy goes as the square of the field, the discrepancy can be enormous, and much more energy is available to heat the corona than previously realized—although, cautions Title, "It'll be a few years before we can tell you exactly what the numbers are."

## Spirits from the vasty deep

Pinning down the origin of the carpet is tricky. What's clear, however, is that it's related somehow to the Sun's dynamo. Karen Harvey found that the loops of the carpet are closest together at the same latitudes where the larger active regions emerge. And, in a given solar cycle, the loops' fields display a weak preference for the same alignment as those of the active regions.

Consistent with these observations are two basic ideas: Either the carpet is formed in the same way as the larger, dynamo-generated field; or it's produced independently but influenced by the dynamo.

If carpet and dynamo are indeed cut from the same cloth, then the question shifts to explaining how it is that both large and small pieces are produced. Large concentrations of dynamo-generated flux arise from deep in the interior of the Sun and float upward by magnetic buoyancy to emerge as active regions. It's conceivable that the carpet corresponds to small bits of flux that break off during their ascent. Another possibility, explains Title's colleague Karel Schrijver, is that large and small flux concentrations form at the same depth. Some support for this idea comes from observations made by Harvey, who has found that the rates at which large and small concentrations emerge, while correlated and in phase with one another, differ by more than a factor of four in amplitude.

Alternatively, turbulent motion in the upper convection zone could generate the carpet—a mechanism originally proposed in 1993 by Bernard Gurney of the National Solar Observatory in Tucson.

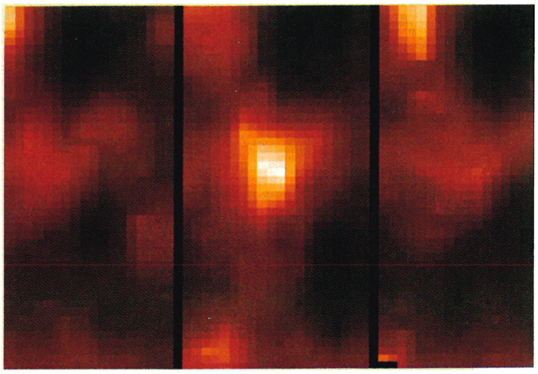
## Oranges are not the only fruit

To astronomers, the Sun is not the most interesting star, merely the closest. What does the Sun's magnetic carpet imply for other stars? According to Tom Ayres (University of Colorado at Boulder), one of the main implications is that stars—red giants in particular—can have low levels of magnetic activity without the need for a dynamo churning away in the stellar interior.

Red giant stars were long thought to be magnetically inactive. Not only do they lack the x-ray emission that characterizes active regions, but they're so bloated that they spin too slowly for the dynamo mechanism to

## Goodness Gracious, Small Balls of Fire!

It was only last year that "blinkers," the latest addition to the rich lexicon of solar phenomenology, were discovered by SOHO's Coronal Diagnostic Spectrometer (CDS). Lasting a few minutes, they appear as Earth-sized explosions—3000 or so pop off at the same time on the solar surface.



The three accompanying panels show the same area on the Sun, but not at the same time. The middle picture, which catches a blinker *in flagrante*, was taken 24 minutes after the left picture and 10 minutes before the right picture. As measured by CDS, the temperature of the fireball is 250 000 K, which places the event in the transition region just underneath the corona.

"Blinkers and the magnetic carpet are intimately linked," says Richard Harrison. Indeed, using Michelson Doppler Imager data, Ted Tarbell (Stanford–Lockheed Institute for Space Research) has found that blinkers and carpet loop cancellations occur in the same places, many simultaneously. (Courtesy of Richard Harrison, Rutherford Appleton Laboratory.)