The Sun's Environs: A Bubble Burst?

The bulk of interstellar space in the sun's neighborhood appears to be occupied by an extremely diffuse gas. This gas is so widely dispersed that astronomers have suggested that the sun and its stellar neighbors reside within a low-density gas bubble, about 600 light-years across, immersed in gas of somewhat greater density.

Now, the Roentgen satellite (ROSAT) and the Extreme Ultraviolet Explorer (EUVE) spacecraft have provided new details of the sun's environment. These observations – at wavelengths between 60 and 740 angstroms – reveal striking variations in the density of interstellar gas. They call into question some of the assumptions underlying the notion that the sun sits within a hot bubble, perhaps blasted out by the explosion of a nearby star hundreds of thousands of years ago (SN: 1/2/93, p.4).

"There may be serious problems with the local bubble picture," says Donald P. Cox of the University of Wisconsin-Madison. Researchers described the new observations and some of their implications at an American Physical Society meeting held this week in Washington, D.C.

Hydrogen and helium atoms—the main constituents of interstellar gas— readily absorb ultraviolet light. Nonetheless, the gas in the sun's vicinity is sufficiently thin and ionized that instruments aboard spacecraft can detect emissions of extreme ultraviolet (EUV) radiation from a variety of nearby sources, including various types of stars.

"The recent EUV studies are so exciting because they can probe the gas distribution at very low densities," Cox says. Such data enable astronomers to begin mapping the size and shape of the local bubble of low-density gas.

Both ROSAT and EUVE have now completed the first surveys covering the whole sky at EUV wavelengths. Analysis of data from ROSAT's wide-field camera has produced a catalog of 383 sources of EUV radiation. Most of these sources correspond to white dwarf stars or to "active, late-type" stars (SN: 5/23/92, p.344).

However, the ROSAT survey reveals significant differences in the distribution of these two types of stars. A deficiency of white dwarfs detected in the direction of the Milky Way's center indicates strong absorption of ultraviolet light, suggesting that the local bubble doesn't extend very far in that direction. In contrast, a surfeit of white dwarfs in the direction of the constellation Ursa Major apparently reveals a significant bulge in the bubble.

"And there's an excess of active stars in a region towards Orion," says B.A. Cooke of the University of Leicester in England. "The only way we can explain that is to reduce [previous estimates of] the gas density in that region."

The EUVE results, which cover a broader wavelength range than the ROSAT data, confirm this patchiness in the absorption and density of interstellar gas. In one instance, researchers observed a particularly hot star about 600 light-years away. For that star to be detected at EUV wavelengths, the density of interstellar gas had to be much lower in the direction of the galactic plane than astronomers had expected.

Earlier ROSAT findings at X-ray wavelengths had already indicated that absorption is low enough along lines of sight at right angles to the galactic plane that the region of hot, ionized gas characteristic of the local bubble may stretch beyond 3,000 light-years from Earth. Indeed, such "windows" have enabled both ROSAT and EUVE to detect EUV sources from outside our galaxy.

"We live in a very complex region [of the interstellar medium]," Cooke remarks.

Taken together, the findings indicate that astronomers may have to modify their picture of the hot bubble of low-density gas in which the sun apparently resides. "The question is how much is this bubble really a description of reality, and how many bubbles are there?" says C. Stuart Bowyer of the University of California, Berkeley, who presented the EUVE results.

"With EUV studies, we can begin to test these structures for their reality, their states, and their dimensions," Cox adds.

– I. Peterson

Chicks hatch chemical clues to memory

In the 24 hours after hatching, baby chicks learn to recognize and follow their mothers by a process known as imprinting. In fact, scientists have known for decades that chicks and some other newborn fowl will seek out any conspicuous object they have been exclusively exposed to during that critical period.

A new study finds that a key chemical reaction in a particular spot in the chick's brain fosters imprinting. The same mechanism may help promote long-term memory in humans and other mammals, the researchers contend in the April 1 PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

"This chemical process occurs in many animals, not just chicks who are imprinting," says Aryeh Routtenberg, a psychologist at Northwestern University in Evanston, Ill.

For the past decade, Routtenberg and his colleagues have studied an enzyme, protein kinase C (PKC), that plays a critical role in memory formation in rats and other animals. In a process called phosphorylation, PKC adds phosphates to proteins, thereby changing their shape and function. Two such proteins, MARCKS (myristoylated alanine-rich C-kinase substrate) and GAP-43 (growth-associated protein-43), amass in the spaces, or synapses, between brain cells and apparently affect the maturation and shape of the synapses, Routtenberg says.

The two proteins congregate in the areas of monkey and human brains associated with memory formation, he adds.

To determine whether these proteins play a direct role in imprinting, Routtenberg and Northwestern colleague Fwu-Shan Sheu teamed with Gabriel Horn and Brian J. McCabe, zoologists at the University of Cambridge in England. The British group had previously found that the left-brain portion of a specific structure, the intermediate and medial hyperstriatum ventrale (IMHV), supports imprinting in chicks.

Horn and McCabe exposed groups of chicks, hatched and raised in darkness for 15 to 30 hours, to a rotating, illuminated red box for two 15-minute periods. Shortly afterwards, the researchers compared the tendency of chicks to approach the red box or a stuffed animal they had never seen before. Control chicks got no training and remained in darkness.

The U.S. scientists then chemically analyzed brain samples from the chicks. Only the left IMHV displayed marked jumps in phosphorylation of the MARCKS protein following imprinting, particularly in chicks who showed the strongest memory for the red box. This alteration did not extend to the GAP-43 protein, although studies of adult rats have linked phosphorylation of both proteins to learning, Routtenberg says.

Such findings suggest that the chemistry of memory may operate differently in young and old animals, he theorizes.

Phosphorylation of the MARCKS protein alters its interaction with another protein that regulates synapse structure, suggesting that specific changes in the shape of synapses foster imprinting, Routtenberg holds.

– B. Bower