handers, and at least three times more frequent in the left-handers' relatives. This result agreed with what was already known about left-handedness and the learning disorders.

The results on autoimmunity were less predictable. About 11 percent of the left-handers reported suffering from autoimmune diseases, compared to 4 percent of the right-handers. The incidence of autoimmune diseases among the first- and second-degree relatives of the left-handers was about double what it was among relatives of the right-handers. The data on migraine were not usable in this study.

The first study could be criticized because of the way the left-handers were recruited, with questionnaires placed in a London shop that specializes in items for left-handers. Those who chose to respond may have included a disproportionate number with the learning disorders or autoimmune problems. Geschwind says, however, "We collected our left-handers for the second study in a very different way, from the general population of Glasgow, but got the same results. Again, the percentage of left-handers with autoimmune disease was about 2½ times the percentage of right-handers." For an autoimmune disease to be counted, it had to be diagnosed in a hospital. The diseases that turned up most often were Hashimoto's thyroiditis and conditions, such as celiac disease and ulcerative colitis, which affect the intestines. In a third study, left-handedness was found to be more frequent in patients who suffered from severe migraine headaches than in controls taken from the general population.

"... the pathology of these disorders is a pathology of superiority...."

"We are looking at an association of autoimmune disease with learning disorders and left-handedness," Geschwind says. "The obvious question is why this association. You could say that this effect is all psychological, due to stress caused by the learning disorders. I think that this is untenable because it then becomes extremely difficult to account for the high frequency of autoimmune disease in the relatives who do not have learning disabilities."

According to Geschwind, both the autoimmunity and the neurological ef-

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Superclouds

During the last several years, Patrick Thaddeus and his colleagues at Columbia University have been mapping out our galaxy's molecular clouds, those great cold masses of interstellar gas and dust that are the birthplaces of stars. These clouds are invisible to the human eye, and were utterly unknown until the 1970's. Now the Columbia survey has shown that they are far bigger than anyone realized. They are, in fact, the largest objects in the galaxy.

Strung out along the spiral arms like so many beads on a string, these superclouds are hundreds of parsecs long and more than a million times as massive as the sun. Columbia's Bruce Elmegreen told the AAS* that the great star-forming regions of our galaxy—the "giant" molecular clouds such as we see in Orion, Perseus, and Centaurus—have turned out to be nothing more than denser knots within the larger structures. In fact, these particular regions, which lie far apart in the skies of Earth, are associated with a large band of active star formation long known as the Gould Belt; Elmegreen argues that the belt outlines the supercloud that happens to encompass the solar system.

The clouds themselves consist almost entirely of molecular hydrogen, which for technical reasons is very difficult to observe. Far easier is a tracer molecule, carbon monoxide. (It was the detection of interstellar carbon monoxide in 1970 that led to the discovery of molecular clouds.) The molecule's signals are so strong that the Columbia group has been able to map the galaxy with a four-foot microwave dish on a rooftop in Manhattan.

The carbon monoxide maps that Elmegreen showed to the AAS (they are largely due to the thesis work of Thaddeus' student, T. M. Dame) covered the first quadrant of the galactic disk interior to the sun—that is, the quadrant visible from upper Broadway. The clouds clearly traced out the Sagittarius spiral arm, the next one inwards from the sun. After a gap, there were hints of another arm even further in. Some 30 separate clouds were visible, with an average spacing of 2 kiloparsecs. Elmegreen told *Science* that in separate work, he and Debra Meloy Elmegreen of IBM's Watson Research Laboratory have recently identified similar structures, with similar spacings, in the arms of other spiral galaxies.

According to the popular, but still-unproven, density wave theory of spiral structure, the stars and gas clouds of the galaxy slowly rotate through a set of standing waves—the spiral arms. It seems reasonable that gas might collect there into superclouds, says Elmegreen. (In fact, the size, density, and temperature of the superclouds are such that they might well be gravitationally bound.) Shock waves from supernovas and the like could then cause them to collapse further into star-forming regions like Orion—which explains why the arms of distant galaxies and the arms of our own galaxy are strewn with blue-white clumps of hot young stars.

*The 160th Meeting of the American Astronomical Society, Troy, New York, 6 to 9 June 1982.

Stellar Hurricanes

Only within the last 2 years have astronomers begun to realize what a violent process star formation really is. Newborn stars seem to spend their early years in astrophysical turmoil, emitting great quantities of high-velocity gas back into the interstellar medium that spawned them. These outflows are like the solar wind, except that they are more like stellar hurricanes: mass losses of 0.1 solar masses per year are not uncommon, while velocities reach hundreds of kilometers per second. The causes are unknown, but the phenomenon may well be universal. Outflows have been observed around virtually every kind of star, ranging from the hot, blue-white giants to dim yellow dwarfs like our own sun.

The field was reviewed for the AAS meeting by Charles Lada of the University of Arizona. Observations have accumulated rapidly, he said, most importantly from the millimeter-wave observations of carbon monoxide, which serves as a tracer for the cold, dark molecular clouds where stars form.

Motion within such a cloud can be determined by the broadening of the carbon monoxide emission lines as seen from Earth, Lada explained.

Temperatures in a cloud are typically 10 K to 100 K, so one would expect to see a random thermal velocity of about 0.2 kilometers per second. But in fact, the gas motions are 10 times higher. "This implies that the dynamics of these clouds are governed by very supersonic motions," he said.

If one looks not at random in the cloud but at a region of active star formation, the supersonic line profiles suddenly acquire very broad, extended wings—hypersonic motion. In the Orion nebula, an extreme case, the speeds reach 127 kilometers per second. The phenomenon is very common, said Lada. About 30 such regions are now known with line-widths in excess of 25 kilometers per second. Moreover these hypersonic regions are relatively compact, ranging from 0.1 to 3 parsecs.

If these were gravitationally bound systems the hypersonic motions might possibly arise from rotation, turbulence, or collapse, he said. But to hold everything together the mass of a given core region would have to exceed 20,000 solar masses, which seems implausible. Besides, direct observation shows no more than 10 to 100 solar masses. So the hypersonic material is probably not bound by gravity, but is instead erupting outwards.

With such small masses the core regions can maintain their observed mass losses for no more that 1,000 to 100,000 years, said Lada. Given the observed abundance of flows in the solar neighborhood, new flows must be forming in the galaxy at roughly one per year—which happens to be about the same as the overall rate of star formation. "This is strong evidence that these things are associated with all types of stars, and may even be a consequence of star formation," he said.

Recently, the carbon monoxide observations have revealed an especially intriguing aspect of the outflows, he added: most of them seem to be bipolar, with material streaming outward from the central core in two opposing beams. The collimation of the beams is usually poor, but 11 of the 12 sources mapped so far show one lobe of red-shifted (receding) gas, a separate lobe of blue-shifted (approaching) gas, and in between an infrared source where stars are forming.

Bipolar flows are understandable if the central star is surrounded by a disk of gas and dust that directs the outflow along the path of least resistance—the axis. Such disks are thought to be common around young stars, said Lada. The sun had one that agglomerated into the planets. But this is only one model among many, he warned, and no one knows anything for sure.

What is causing the outflows? No one knows that either, said Lada, although one possible source, radiation pressure, can almost certainly be ruled out. It is difficult to see how photons emerging from the central star could exert enough pressure on the surrounding gas. The mechanical energy of the outflows is a comparatively huge fraction of the central core's radiant energy, typically 1 to 10 percent.

On the other hand, as the hypersonic flows diffuse outward, they quite likely give rise to the supersonic turbulence that permeates the rest of the cloud, said Lada. This mechanical energy in turn provides a kind of internal pressure that allows the molecular clouds to survive for tens of millions of years without collapsing under their own gravity—a phenomenon that until now has been a mystery.

Neptune: A Ring at Last?

Some half-forgotten stellar occultation data have recently been resurrected to yield evidence for a ring around the planet Neptune. If it is really there, says Edward F. Guinan of Villanova University, then all the giant planets—Jupiter, Saturn, Uranus, and Neptune—are now known to have rings.

The observations were made on 7 April 1968 from Mount John Observatory in New Zealand. Guinan and colleagues were interested in getting profiles of Neptune's atmosphere from the photometric light curve of a 7.8-magnitude star, first as it disappeared behind the planet, and later as it reappeared. (It was a particularly good occultation for that, since the star was as bright as the planet.) Their high time-resolution data (0.1 second) were recorded on a strip chart; 1-second and 10-second averages went onto punch cards.

Unfortunately, on the trip home Guinan placed the strip chart in a *Time* magazine that disappeared from his luggage during a stopover in the Soviet Union. That left the low-resolution punch-card data, which was useless for deriving any information about Neptune's atmosphere. Besides, the cards had gotten wet on the boat ride from New Zealand and had warped so badly they would have stuck in a card reader. The experiment seemed a washout. Back at Villanova Guinan filed the cards away and forgot about them.

In 1977, however, Guinan suddenly had reason to be interested in those cards again. In a similar occultation experiment, James Elliot of the Massachussetts Institute of Technology had discovered rings around Uranus. Guinan's cards were in bad shape, however, and it wasn't until this year that a student, Craig C. Harris, finished duplicating them, one-by-one, by hand. The result: a light curve showing a beautifully sharp occultation by Neptune itself—and 3 minutes later, a 30 percent dip that lasted about 2 minutes. Guinan, Harris, and Villanova colleague Frank P. Maloney interpret this dip as evidence for a ring about 5000 kilometers above the Neptunian cloudtops. The inner rim of the ring is about 28,600 kilometers in radius; the outer edge, 32,900 kilometers.

Guinan maintains that the Villanova findings are not inconsistent with Elliot's observation of a Neptunian occultation last year, which showed no evidence of rings (*Science*, 11 September 1981, p. 1240). The geometry of Guinan's proposed ring is such that Elliot's occultation path would have missed it. However, if the ring is assumed to lie in the plane of Neptune's equator (as do the rings of Jupiter, Saturn, and Uranus) then Guinan must shift the location of the Neptunian north pole by several degrees from its accepted location. On the other hand, Elliott himself agrees that this location, obtained by analyzing the motion of Neptune's moon Triton, is quite uncertain.

"It's extremely exciting if true," says Elliot, who would still be willing to bet even money—but no more—that there is no ring. The question could be settled with Neptune's next occultation on 15 June 1983, which Elliot will observe from NASA's Kuiper Airborne Observatory flying out of Australia.

—M. Mitchell Waldrop