SPACE SCIENCES

Stars that shuffle comets

It was in 1950 that Jan Oort, then director of Leiden Observatory in the Netherlands, proposed from a study of the semimajor axes of long-period comets that about 200 billion such comets may exist in a "cloud" surrounding the solar system and extending out to interstellar distances. His account is considered a classic paper, and the "Oort cloud" has become a part of many subsequent cometary hypotheses. Over the age of the solar system, the gravitational effects of the sun's motion relative to other nearby stars could have significantly perturbed the cloud, according to Paul R. Weissman of Jet Propulsion Laboratory, cutting its population of comets, reducing its size — and hiding its origin.

Combining the number and distribution of "local" stars with the sun's velocity relative to them, Weissman calculates that over the age of the solar system some 23,000 stars could have passed within 200,000 astronomical units of the cloud. At that distance, he reports in the Nov. 20 NATURE, a star with the sun's mass and a velocity of 20 kilometers per second would give a comet a velocity impulse of 43 centimeters per second, with bigger nudges resulting from closer encounters.

Adding up the total velocity perturbation on the cloud's comets over the same time span, Weissman notes that the present size of the cloud may be about 100,000 AU or less. The cloud, he points out, would shrink with time, as the stellar perturbations progressively eject, or "strip away," the comets whose orbits place them in its "outermost shells." Since the solar system formed, in fact, stars passing through the cloud may have ejected 9 percent or more of its cometary population.

Unfortunately, Weissman says, one implication of the size of the total perturbation is that, over time, the orbits of the comets in the cloud have been shifted past the ability of astronomers to retrace their evolutions. "Thus," he concludes, "it is unlikely that orbital data could be used to discriminate between various theories of cometary origin; that is, formation among the outer planets with subsequent ejection to the cloud versus formation in satellite fragments of the primordial solar nebula."

Signs of SO_2 on Europa

Voyager spectra of Jupiter's tiny moon Amalthea were reported last year as revealing the presence of sulfur, presumably transported in from volcanically active Io. Now measurements from the earth-orbiting International Ultraviolet Explorer satellite have indicated that Io may be making its presence felt outside of its orbit as well. Reflection spectra of Europa show a 280-nanometer absorption feature that resembles sulfur dioxide, which Arthur L. Lane and colleagues from Jet Propulsion Laboratory believe results from sulfur ions combining with oxygen in the water of Europa's icy crust.

The absorption feature shows most clearly on the side of Europa that trails behind as it moves in its orbit. This is what would result if the sulfur ions are being carried around by Jupiter's magnetic field, which rotates about 100 kilometers per second more rapidly than Europa and thus "catches up" with it from behind. Whatever process frees the sulfur from Io (the likeliest source), the material could be readily ionized by Jupiter's intense radiation belts and caught up by the field.

The absorption detected by the IUE indicates the presence of about 2×10^{16} molecules of SO_2 per square centimeter. Lane's group believes the spectra to result from sulfur atom-oxygen atom interactions within the water-ice lattice, since SO_2 frost has a very different UV signature from what has been observed and there is no evidence for a low-pressure SO_2 atmosphere on Europa, either from Voyager spacecraft data or from earth-based observations of mutual satellite eclipses and occultations.

ENVIRONMENT

Bees can't wing it on SO_2

Depending on whether they're flying or resting, the respiratory rate of many insects can vary 100 fold. That's why researchers at the University of Kansas in Lawrence decided to investigate whether insects with a proclivity for aerial activity are especially vulnerable to pollution. And results of their study, reported in the October PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES, suggest that levels of sulfur dioxide (SO_2) low enough to meet federal air-quality standards—0.14 parts per million — are high enough to hurt insects.

The male sweat bees studied spend about 85 percent of their daylight hours airborne, says entomologist Michael Ginevan (formerly with the Kansas team). Ginevan says it's reasonable, therefore, to expect that the vulnerability of the studied bees is indicative of what may be occurring in small bees important to pollination, such as honey bees. And what happened to Ginevan's prodigious fliers is that they were involuntarily grounded.

Bees were fumigated with low-level concentrations of SO_2 — 0.14 to 0.28 ppm—for 16 to 29 days. In three tests, flight activity of the exposed bees fell off more rapidly than in a matched group of identical, unexposed bees each time. What's more, the rate of decrease for exposed bees was similar in each experiment. That flying times decreased gradually suggests the problem is physiological, the researchers say, presumably an accelerated deterioration of flight muscles. "This hypothesis is supported by the fact that, at the end of each experiment, the experimental bees could walk normally but were able to fly only weakly if at all."

The observed falling off in flight activity did not change much when the SO_2 dose was doubled from 0.14 ppm. This suggests, the researchers say, that SO_2 levels lower than 0.14 should also produce measurable effects. But perhaps more important, the observed symptoms point to a serious threat for wild bees: Males that don't fly a lot do not mate successfully.

Mitochondria and PAHs: A cancer link?

Polycyclic aromatic hydrocarbons (PAH's) are a generic class of chemicals, many of whose members can cause cancer when metabolized in an animal's body. A number of PAH's are also strongly suspected of playing a role in human cancers. But how PAH's do their dirty work has never been clearly demonstrated, although a cell's DNA has often been implicated. (For example, several researchers have shown that PAH binding to DNA from mouse-skin cells correlates with the potential of the PAH's for causing cancer in mouse-skin tissue.)

When in the past experimenters have scrutinized a cell's DNA for cancer-potentiating changes, they usually have lumped all the genetic material together. Since in mammals almost all DNA is in the cell's nucleus, looking at the cell's total DNA reservoir collectively seemed a reasonable thing to do. But findings reported by two British chemists now suggest that is not so.

In mammals, 0.1 to 1 percent of a cell's DNA resides in its mitochondria — specialized energy-converting structures. This DNA is distinctly different from that found in the nucleus (SN: 9/15/79, p. 184) and it serves a unique function. But J. A. Allen and M. M. Coombs of the Imperial Cancer Research Fund in London also found this mitochondrial DNA was 50 to 500 fold more susceptible to modification by PAH's than was nuclear DNA. Among the six PAH's they tested were at least four known animal carcinogens, including DMBA and benzo[*a*]pyrene.

The significance of this finding "is not clear," the pair admit. One reason why is that rates of DNA repair may differ markedly between the cell's nucleus and mitochondria. Writing in the Sept. 18 NATURE, however, the authors note that recent research in yeast indicates mitochondrial mutations may play a significant role in cancer causation.