Brownian particles last longer

If a sphere were shot onto an unmanned pinball machine surface, it would seem to randomly zigzag between bumpers until it lost all of its momentum and was stilled. If a pinball wizard were at the controls of this same surface, pushes from the flippers would keep the sphere moving for a much longer period of time. Had Scottish physician Robert Brown been able to compare the motion of the microscopic grains in liquid he observed more than 150 years ago to that of a pinball sphere, he would have chosen the former scenario. For the past decade or so, however, calculations that describe particle movement, or Brownian motion, have suggested that the latter scenario is closer to the truth—that the velocity of Brownian particles does not decrease as rapidly as was once thought. And now, these calculations have been experimentally confirmed.

Yong W. Kim and colleagues at Lehigh University in Bethlehem, Penn., have observed droplets of mineral oil colliding with nitrogen molecules in a gas chamber. The oil droplets—one-tenth of a micron in diameter—were illuminated by the blue-green beam of an argon ion laser. Taking successive measurements of the speed and direction of these droplets, the researchers found that the initial velocity decreases not exponentially over time $[(e)^{-\text{time}/\text{relaxation time}}]$ as the classical view of Brownian motion would have it, but rather by the much slower function $(\text{time})^{-3/2}$.

That velocity decay function was first predicted in 1967 by Lawrence Livermore National Laboratory researchers Berni Alder and Thomas Wainwright, who developed computer simulations of molecules on the move. Later, various groups of physicists, including Robert Dorfman and colleagues of the University of Maryland at College Park, worked to explain the discrepancy between the classical and newer Brownian motion decay times.

These physicists theorized that while the classical view assumes that the particle always hits a "fresh" target, the newer view takes into account the possibility of binary collision, or the fact that the particle can collide again with any given target. When a repeat collision occurs, the physicists explained, the target "returns" some of the momentum the particle lost in the initial collision. In such a fashion, the particle continually is "reminded" of its initial velocity so that the decay of that quantity is not as rapid as an exponential decrease.

Kim's work—submitted for publication in Physical Review Letters (preliminary results were published in the March 17, 1980, issue of that journal)—experimentally confirms this theory.

The "flurry of activity" in Brownian motion research, says Kim, has long-range implications for the effective use of future, high-tech analytical systems or energy sources that involve gases or liquids in motion. □

Cancer patterns in the chromosomes

All or most cancers involve a chromosome defect, and identifying the defect may provide valuable indications for a patient's treatment, suggests Jorge J. Yunis of the University of Minnesota Medical School. Speaking in Monterey, Calif., at the Arnold O. Beckman Conference on Genetic Disease, Yunis said that new methods of examining chromosomes and advances in working with solid tumor cells consistently have revealed defective chromosomes in patients with both hereditary and noninherited cancers. In some cases a type of cancer can be divided into subgroups by the specific defect, and thus the chromosome abnormality can predict the disease's course and its response to treatment.

When chromosomes from human cells are appropriately prepared and stained, they show a characteristic pattern of light and dark bands. In abnormalities, the banding pattern can reveal which pieces of a chromosome are absent, duplicated or moved to a new position. The earliest preparations showed about 300 bands per single (haploid) set of human chromosomes; later improvements raised the resolution to 900 bands. Yunis, who was introduced at the meeting as "the master of the high-resolution chromosome," reports that a new technique, which looks at stretched-out rather than condensed chromosomes, can reveal 2,000 bands, and recent preliminary work in his laboratory has extended that pattern to 5,000 bands. "We are getting closer to having just a few genes per band," he says. "We hope to reach 16,000 bands."

Two types of chromosomal defects can be involved in cancer. In the case of an inherited predisposition to cancer, from birth all cells in the body show the chromosomal abnormality. For example, Aniridia-Wilm's tumor and hereditary retinoblastoma each show a characteristic inherited deletion (SN: 5/9/81, p. 297).

In cases of nonhereditary cancers, only the tumor tissue has the chromosome defect, Yunis says. He works with newly diagnosed patients who have not yet had chemotherapy. For 15 types of acquired cancer, including six solid tumors, he finds one or more chromosome abnormalities consistently associated with the affected tissue. In some diseases, such as acute leukemias and some lymphomas, investigators had previously found that half the patients have chromosomal defects. Now, looking at the chromosomes' more detailed banding patterns, Yunis finds defects in some cells of *all* the patients. For example, in acute myelogenous leukemia, Yunis found defects in all of 32 consecutive patients. He observed seven specific defects and found some of the abnormalities associated with rapid disease progression, while patients with another abnormality had a better prognosis, surviving for several years.

Yunis suggests that the chromosomal deletions, additions and exchanges are the result of carcinogen attack. He postulates that specific genes, which he calls cancer genes, are required to keep a cell from becoming malignant. When a chromosomal change disrupts one of these genes, cancer results. Work is already in progress to more specifically identify these genes. Meanwhile, Yunis concludes, in the clinic it is essential to study patients' chromosomes for their prognostic significance. □

Pow-wow of the planet people

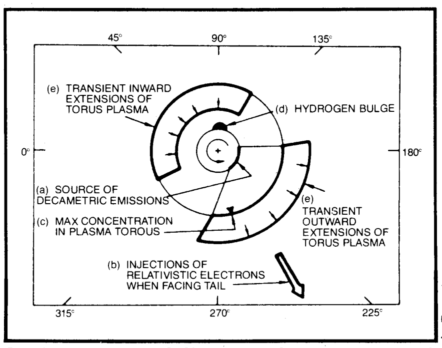
The biggest concern at the recent annual meeting of the American Astronomical Society's Division for Planetary Sciences in Pittsburgh was the possibility that budget cuts might cause the nation's entire program of planetary exploration to be scrapped. Heated comments on the issue were heard throughout the week-long gathering (SN: 10/24/81, p. 260), but the substance of the meeting was science: the latest results from hundreds of researchers engaged in the probing of other worlds.

With the Voyager 2 spacecraft's Saturn encounter less than two months past, one key topic was that planet's baffling rings. An early look at the spacecraft photos, for example, had surprised scientists by revealing no trace of the tiny "moonlets" whose gravitational effects were expected to account for the numerous gaps within the otherwise nearly continuous ring system. Since the flyby, researchers have had a chance to scan the images more closely, looking for still smaller moonlets, but so far, says Jeffrey Cuzzi of the NASA Ames Research Center, to no avail. "We've searched at least half the candidate gaps," according to Cuzzi, and found no moonlets even as small as 5 to 10 kilometers across.

Analysis of data gathered when Voyager's earthward radio beam passed through the ring plane confirmed that the rings contain particles of many different sizes, from dust to boulders, but it also indicated that the big and little chunks do not seem to be randomly mixed. The wide, main rings are composed of thousands of individual "ringlets," and in the C-ring, for example, notes G. Leonard Tyler of Stanford University, the centimeter-sized particles seem to be "segregated" along each ringlet's outer edge. Superimposed on such details, he adds, is a tendency for the general mixture of sizes to vary with distance from Saturn. "The rings that you see if you look at centimeter sizes," he told the DPS, "are not the same as the rings you see if you look at meter sizes."

Perhaps the most tantalizing ring mystery of all has been the separate, seemingly "braided" strands photographed in the F-ring by Voyager 1, but which revealed only an ordered, concentric pattern in Voyager 2's limited coverage nine months later. One proffered explanation for the braids had been the influence of two small moons that bracket the thin ring, until a Voyager 2 photo showed both moons and the intervening expanse of F-ring with no trace of braids or other irregularities (SN: 8/29/81, p. 132). But the earlier photos won't go away, and, says Mark Showalter of Cornell University, the little moons may explain not only the braids but their subsequent absence. The moons follow slightly noncircular orbits, he points out, so the exact force felt by a ring particle depends upon just how far away each satellite is when it passes by — a constantly changing relationship. Sometimes the particles would be "herded" together into "clumps" (another F-ring phenomenon seen only by Voyager 1), and sometimes not. In fact, he notes, "with the large perturbations from the shepherding satellites, we should never have expected to see a simple, circular ring. And so the rather plain Voyager 2 images are perhaps the most perplexing of all."

Another major topic at the DPS meeting was Jupiter, which presents its own set of exotic phenomena, from active volcanoes on its moon Io to radio signals that have been detected on earth since the earliest days of radio astronomy. An attempt to provide a unifying theory for many of the seemingly disparate Jovian oddities was offered by Alex Dessler of Rice University, who has been evolving his concept for several years and presenting it, step-by-step, at a variety of scientific gatherings. Several of the most-discussed such phenomena, he points out, seem to be linked with certain specific areas around Jupiter's circumference: The powerful decametric radio bursts appear to originate largely from within a particular range of Jovian longitudes; the torus of mostly sulfur and oxygen ions that circles the planet at Io's orbit has a particularly dense, outward-bulging portion that also stays over a certain longitude range. Additionally, there is a bulge of hydrogen atoms that has been detected by various spacecraft over a particular portion of the planet's upper atmosphere. And also part of the set, says Dessler, is the flow of relativistic electrons that have been monitored from outside the orbit of Saturn all the way in to the orbit of Mercury, always bearing the roughly 10-hour modulation of Jupiter's rotational period. All of these diverse effects, according to Dessler, are manifestations of the same underlying process.



A. Dessler

Jupiter-centered diagram shows proposed link among diverse Jovian phenomena.

The crux of Dessler's model is what he describes as "a very large weak spot" in Jupiter's magnetic field over a certain range of longitudes in the northern hemisphere. There, he says, the Io-spawned torus of sulfur and oxygen concentrates into a particularly dense region, which, because the torus is pulled rapidly around the planet by the magnetic field, bulges out due to centrifugal force. This also produces an inward (Jupiter-facing) bulge on the torus's opposite side, which extends so far in that it actually contacts the planet's hydrogen-rich upper atmosphere, producing the observed hydrogen bulge. Meanwhile, the electrical current that flows along the Jovian magnetic field lines through the torus is enhanced where the torus is most dense, contributing to the generation of radio bursts from the same, longitudinally fixed sector. "Of course," says Dessler, "just because this is the only such unifying theory doesn't necessarily mean it's right. Jupiter is enormously complicated, and there's room for lots of ideas."

Ideas will continue to abound. The concern of the DPS scientists is about whether there will continue to be spacecraft from whose data such ideas can find a firm footing. □

Intercepting genetic disease

The notion of preventing genetic defects by altering the womb environment is unorthodox, to say the least. One reason is that it involves preventing disease in the fetus, which is no small feat in itself. Another reason is that it implies that so-called genetic defects can be due to environmental factors as well as to genes. Still, there is increasing evidence that this concept can be successfully applied, Guillermo Millicovsky and Malcolm C. Johnston of the University of North Carolina at Chapel Hill Dental Research Center report in the September PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

In 1966 and 1971 some researchers prevented specific ear abnormalities in a strain of mice genetically predisposed to these defects by giving pregnant females a diet containing large doses of manganese. During the 1970s other investigators found that abnormally short fingers and toes could be prevented in a strain of rabbits genetically susceptible to these defects by exposing pregnant rabbits to high levels of oxygen or by supplementing their diets with folic acid or vitamin B_{12}. In 1975 and earlier this year still other scientists prevented inherited defects in vitamin synthesis in two human fetuses by giving their mothers large doses of the missing vitamins during pregnancy (SN: 5/23/81, p. 326).

Now Millicovsky and Johnston have prevented cleft lip and palate in mice genetically predisposed to this malformation — the so-called CL/Fr strain — by exposing pregnant mice to high levels of oxygen. What's more, they have shown that by decreasing the exposure of such pregnant mice to oxygen, the incidence of cleft lip and palate in the mice's offspring was increased. "To our knowledge," Millicovsky and Johnston say, "a decrease *and* an increase in the incidence of a genetic malformation in response to variation in the maternal environment has not been demonstrated heretofore." Just how oxygen affects cleft palate in the fetus is unknown.

In their experiment, Millicovsky and Johnston divided 15 pregnant mice of the CL/Fr strain into three groups of five each and placed all of them in chambers controlling breathing gases from day 10 to day 11 of gestation, the time during which the palates of fetuses of the CL/Fr strain undergo critical development. One group of pregnant mice was exposed to room air (22 percent oxygen, 78 percent nitrogen), another group to low oxygen (10 percent oxygen, 90 percent nitrogen) and a third group to a high level of oxygen (50 percent oxygen, 50 percent fitrogen). The animals were returned to their cages and sacrificed on day 18 of gestation in order to examine their fetuses for cleft lip-palate abnormalities.

There was a highly significant difference in the percentage of normal fetuses (those without cleft lip-palate) among the three groups of pregnant mice. Whereas only 11 percent of fetuses from the group exposed to low oxygen were normal, 63 percent of fetuses from the group exposed to air, and 87 percent of the fetuses from the group exposed to high levels of oxygen, were.

Millicovsky told SCIENCE NEWS that high levels of oxygen during pregnancy might be used to prevent genetically based cleft lip and palate in humans. For instance, high levels of oxygen might be given to pregnant women who already have children with cleft lip and palate because the women's chances of having a second child with the same malformation are high. Millicovsky is quick to caution, however, that more animal studies have to be performed before such disease prevention can be tried in humans. □