physical sciences

Waves of chemical reactions

The possibility of chemical reactions that proceed in waves has aroused a great deal of interest because they appear similar to some biological phenomena and may possibly play a role in biological control mechanisms. In the Nov. 6 NATURE PHYSICAL SCIENCE R. P. Rastogi and K. D. S. Yadava of the University of Gorakhpur in India report the observation of such waves in a reaction involving malonic acid, cerous sulfate and potassium bromate in sulfuric acid. A theoretical analysis by I. Prigogine and others had predicted the waves.

In the experiment, the mixture was homogenized at 30 degrees C. and allowed to stand for four hours. Then five milliliters of the mixture were transferred to a long, thin tube. Ten drops of an indicator called ferroin were added. Blue reaction waves started from the bottom of the tube and propagated through the solution. If the system was disturbed by shaking, wave formation started again from the bottom but with a longer period. The period was also found to depend on the concentration of malonic acid.

Solids at the moment of shock

An explosive shock is so destructive that scientists have tended to suppose that when a shock strikes a solid object it generates chaotic conditions on the atomic level. In spite of such suppositions, it appears that shocks can produce orderly changes in crystal structure.

Crystal structure is usually studied by X-ray diffraction. In the Nov. 13 PHYSICAL REVIEW LETTERS, Quintin Johnson and A. C. Mitchell of the Lawrence Livermore Laboratory report that for the first time they have obtained X-ray diffraction patterns from a sample at the moment of shock. Pyrolitic boron nitride was shocked to 245 kilobars, and in the moment of shock exhibited a crystal structure like that of wurtzite. What is more important than the particular material is that Johnson and Mitchell have shown that flash X-ray diffraction can be used to study crystal phase transitions during shocks, and this, they predict, will help answer many outstanding crystallographic questions.

Photon mass and the Doppler shift

Theoretically the photon, the light particle that mediates electromagnetic interactions, should have a rest mass that is exactly zero. Nevertheless some physicists keep looking for a photon mass (SN: 7/17/71, p. 46). In the Nov. 13 NATURE PHYSICAL SCIENCE A. R. Lee and J. Liesegang of La Trobe University in Bundoora, Victoria, Australia, present a mathematical analysis showing that the existence of some mass for the photon would add an anomalous Doppler shift to the normal Doppler shift experienced by light or radio signals emitted by a moving body.

The prediction leads to the suggestion of an experiment that would be done with two artificial satellites orbiting in opposite directions. Past experiments have shown that if the photon has a mass, it is less than 10^{-48} grams. To improve on this limit would require a frequency measurement accurate to better than one part in 10 billion for photons of about 100 hertz frequency. This is difficult because of the extremely low frequency, but Lee and Liesegang believe that the rapid advance of electronic technology may just make it possible.

aerospace

Flying the atmosphere's voltage paths

The earth's atmosphere is a huge capacitor or electric storage field with earth negatively and the air above it positively charged. Between earth and the upper layers are strong equipotential lines that appear to be horizontal and flat. Now Maynard Hill, John Rowland and Robert Givens of the Applied Physics Laboratory of Johns Hopkins University have found a way to use these voltage paths to stabilize radio-controlled model airplanes. Hill thinks the same method can be used to stabilize commercial and general aviation planes as well. And the system is orders of magnitude cheaper than current autopilots.

Hill and his colleagues equipped model airplanes with an electrostatic voltage stabilization system. The system is made up of electrodes or sensors on the tips of the wings and along the body of the aircraft, a differential voltmeter in the fuselage to monitor the sensors and an automatic disturbance compensation unit (servomechanism or autopilot) to stabilize the craft.

While flying at a given altitude, the aircraft is moving along a specific voltage path that is monitored by the electrodes. When the wing tilts, or the nose or tail moves up or down, the voltmeter records a difference in charge. This then is sent to the servomechanism which forces the aircraft back to level flight. In principle, says Hill, the aircraft could fly at one altitude relatively undisturbed completely around the globe.

Hill placed one of his models, "Catbird," in a spiral dive of 85 to 90 miles per hour and then flipped on the stabilization switch. The plane leveled off. He even placed a monkey wrench on the tail to shift the center of gravity, but the aircraft flew smoothly.

"The electrostatic autopilot is so simple and yet so effective that it seems almost unbelievable no one has proposed it before," says Hill. He has tested the system in over 150 flights.

Using lasers to measure air speed

Accurate measurements of air speed are essential when testing permanent changes caused by design modifications in aircraft. Commercial aircraft currently use Pitot tubes which measure air pressure. But accurate speed measurements are difficult because of boundary-layer effects on local air pressure as well as turbulence created by the sensor itself.

Now NASA's Ames Research Center is testing an air-speed indicator 10 times more precise than those in current use. The Doppler laser air-speed device, built by Honeywell Systems and Research Division for NASA, focuses a carbon dioxide laser beam as much as 20 meters ahead of the aircraft where the air is undisturbed. The system detects back scatter from aerosols and measures the apparent Doppler shift in frequency which is proportional to the air speed of the craft.

Studying the space tug

NASA's Marshall Space Flight Center has asked the aerospace industry for feasibility study proposals for an interim space tug system for use in the late 1970's. The space tug would operate as a third stage with the space shuttle to transfer cargo from shuttle orbit to high or synchronous orbits or propel spacecraft to other planets. It would be launched and then recaptured for reuse. Three study contracts will be awarded, each for $750,000.