# 1973: Research Progress on a Broad Front

*Despite political and economic turmoil, the year was productive of a number of new ideas, unexpected discoveries, and quietly spectacular developments in research both basic and applied. The debate over solutions to the energy crisis dominated the news but yielded little in the way of substantive progress in energy research. In other areas, however, the story was different. This week the Research News section is devoted to a sampling of highlights and trends in research during the past year.*

## Earth and Planetary Science

That the solar system is heliocentric and not geocentric was first proposed by the Polish astronomer Nicolaus Copernicus on the basis of telescope observations. Now, 500 years after his birth, exploration of the solar system has advanced to the point where seven major planetary probes —three U.S. spacecraft and four U.S.S.R. spacecraft—were en route in 1973 toward targets ranging from Jupiter to Mercury. This was also a year in which Skylab astronauts gathered a multitude of new data about the sun and in which analyses of data from earlier explorations began to produce a clearer picture of the moon and of Mars. On the earth, scientists made considerable progress in understanding the ozone layer that shields living things from ultraviolet radiation, the large eddies that constitute the ocean's subsurface "weather," premonitory phenomena that may give warning of earthquakes, and a variety of other atmospheric, oceanic, and solid earth phenomena.

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## Biomedical Science

Immunology would have to rank high among the topics that dominated biomedical news in 1973. In particular, investigations into the genetic control of immune responses have received much attention.

The capacity to respond to certain antigens, including some viruses that cause cancer in mice, is determined by genes, called Ir or immune response genes that lie within the same chromosomal region as the genes for the histocompatibility (transplantation) antigens. Now, evidence from a number of laboratories has indicated that the products of the Ir genes may themselves be histocompatibility antigens and that they serve as recognition sites on certain cells of the immune system.

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## Chemistry and Biochemistry

Unsuccessful new scientific theories generally die quietly, but that rule met with a major exception in 1973. The highly controversial polywater theory, which postulated the existence of a unique new high-molecular-weight form of water, was interred this year with nearly as much publicity as accompanied the first description of the theory some 7 years earlier. Its much heralded demise was but one of the highlights of a year that also marked the identification of the viruses that cause both forms of hepatitis, the taming of a rather unpleasant vaccine, the development of a major new form of an old drug, the unraveling of the structure of an antibody, and the development of a new type of pesticide.

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## Physics and Astronomy

When the new discoveries for 1973 are analyzed, none of them have changed a scientist's view of the world—yet. The new experiments and observations are neither free of ambiguity nor easy to understand. Rather than reporting the discovery of a new particle with certain clear characteristics, physicists have found evidence for a subtle effect called "neutral currents." Rather than introducing the public to a new star in a growing cast of luminaries, astronomers reported finding two quasars apparently beyond the limit of last year's universe, radio signals that may carry new information about cosmology, and gamma rays that were never expected but come streaming toward the earth at least four times a year. Scientists may be forced to think about the dynamics of stars, cosmology, the properties of supercold matter, and the unification of the four fundamental forces of nature in new ways in order to understand the discoveries of 1973. Then again, they may not. Either way, much has been learned that is new.

The distances of objects far away from our galaxy, the Milky Way, are measured by the "red shift" of light that comes from them. The most distant galaxies ever discovered have red shifts of about 0.4, but quasars are found with larger red shifts. Only a year ago, the largest quasar red shift known was 2.88, and some astronomers were speculating that very few quasars with red shifts greater than 3 would be found. The red shift limit of 3 was likened to an indication of the limit of the universe or—because it takes more than $10 \times 10^9$ years for light from such distant objects to reach us—to a horizon in time. Last year the hypothetical limit was exceeded, as two quasars were found

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## Materials Science

The year 1973 was an exciting one in the superconductivity research community—beginning with the announcement that superconducting fluctuations may have been observed at temperatures near 60°K in an organic compound, and ending with awarding of the 1973 Nobel Prize in physics to researchers in superconductivity. Amorphous metallic alloys began to receive some of the attention long reserved to amorphous semiconductors this year. High resolution electron microscopy techniques came closer to visualizing individual atoms in crystals than previously, and surface science continued to become more sophisticated. The ubiquitous energy crisis began to make its presence felt in materials technology, with renewed emphasis being placed on high-temperature materials for, among other things, more efficient engines, on finding less expensive materials to use in place of more expensive ones, and on improving the efficiency of extractive metallurgical techniques.

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with red shifts of 3.4 and 3.53. The larger red shifts allow astronomers to look back through a slightly greater fraction of the time (91 percent instead of 89 percent) that has elapsed since the beginning of the universe, according to the "big bang" theory. No one knows what quasars will tell us about the beginning of the universe, but the two new quasars show that the evidence has not run out.

In a related discovery, astronomers at the National Radio Astronomy Observatory (NRAO), made the first measurement of a large red shift with a radio telescope. All previous red shifts of quasars were measured with optical telescopes. Although the radio red shift was observed against the background of radio signals from the quasar 3C286, there is reason to believe that the new feature was not caused by the quasar, but by a normal galaxy that happened to be in the path. Although some astronomers question whether red shifts are really indicative of the distances of quasars, the first observation of a radio red shift seems to support the answer that they are.

About 5 years ago it was predicted that as a star undergoes the incredibly explosive stage of becoming a supernova, a single sharp burst of gamma rays would be emitted. To find these gamma ray bursts was one of the goals of the U.S. program in gamma ray astronomy. Last year it was revealed that the Vela satellites, designed to monitor the Nuclear Test Ban Treaty, found gamma ray bursts from space in 1967. Since then four or five sets of bursts have occurred each year. Each burst is a little longer than originally expected for supernovas, and the bursts aren't always singular. Often two or three occur within a minute, but then whatever causes the gamma rays apparently ceases. Some of the theories proposed to explain the bursts are comets falling onto neutron stars, phenomena like solar flares, and younger supernovas than originally proposed.

The Copernicus satellite, which has a remotely operated telescope capable of detecting ultraviolet light, confirmed what astronomers at the Naval Research Laboratory had detected earlier with a rocket-borne experiment: that much of the interstellar medium is composed of molecular hydrogen. Although atomic hydrogen can be readily detected with radio telescopes molecular hydrogen is radio-invisible. The implication of finding great clouds of molecular hydrogen is that the galaxy has much more interstellar matter than astronomers previously thought, and the finding seems to preserve the concept that the ratio of gas to dust is relatively constant throughout the interstellar medium of our galaxy. The Copernicus satellite also detected the deuterated form of molecular hydrogen, HD.

Astronomers observing x-ray and infrared sources were also very active in the past year. The idea that the x-ray source Cygnus X-1 is a black hole is more and more widely accepted, and the data from the x-ray satellite Uhuru provide compelling, though not irrefutable, evidence that there is hot intergalactic gas in at least six large clusters of galaxies. Infrared observations seem to be slowly unfolding the complex story of what happens in the dense, dusty regions of our galaxy where stars apparently are formed and destroyed, and probably formed again.

In physics, the discovery with the greatest potential importance was the observation of effects ascribed to "neutral currents." Members of a very large team at the European high-energy accelerator, CERN, measured the results of neutrino interactions. Of the four fundamental interactions —namely, the strong, electromagnetic, weak, and gravitational interactions—neutrinos can participate only in weak interactions, which are the processes responsible for radioactive beta decay. Previously it had been observed that a neutrino would initiate a reaction which had a muon (a weakly interacting charged particle) as a product. Hence, a net change of charge for the "weak" particles would occur. The CERN researchers reported reactions where a neutrino entered the reaction and a neutrino went out, so charge change occurred for the weak particles. Such a reaction is a neutral current phenomenon. The CERN experiment is not unanimously accepted by high-energy physicists as evidence for neutral currents. But many physicists are excited over the CERN results, because several theories for unifying the weak and electromagnetic interactions predict neutral currents.

Laboratory experiments with liquid helium have shown that it becomes a superfluid when cooled within a few degrees of absolute zero. New research seems to indicate that the rare natural isotope of helium, helium-3, may also become a superfluid, but only when cooled within a few thousandths of a degree from absolute zero. In fact, helium-3 appears to have at least two new fluid phases, which occur at temperatures of 2.7 and 2 millidegrees Kelvin. Because helium-3 has a nuclear spin, it may be the first known example of a magnetic superfluid. Superfluidity occurs in natural helium (helium-4) because the atoms have no spin. For helium-3, the effect of no spin is thought to be achieved when pairs of helium-3 atoms combine in such a wey that their spins cancel.

Very high-powered lasers are needed to make laser fusion possible, and the same lasers will have to be very efficient in order to make laser fusion practical. For other reasons, it appears that an ultraviolet laser would work better for fusion than an infrared one. Last year three groups in the United States reported successful lasing of a cell of high-pressure xenon gas, which was energized by a burst of relativistic electrons. The radiation occurs at about 1700 Å, well into the ultraviolet. This is the first ultraviolet laser that has the potential of being high-powered, and the efficiency for converting electrical energy into laser light may be as good as for any other laser yet developed—at least 10 percent.

Two other findings in physics were not surprises, since the phenomena had long been expected. In atomic physics, evidence was reported for the detection of an excited state of positronium—the exotic atom in which an electron orbits an anti-electron, or positron. (A similar experiment on positronium contradicts this result, however.) In nuclear physics, several experiments seemed to detect a giant quadrupole resonance—an excitation in which all the protons and neutrons oscillate collectively in a complex pattern. Both phenomena were almost required to exist, as parts of well-proved models of atomic and nuclear structure. But the effects have been extremely difficult to detect.

Although the work mentioned above is only a small fraction of the research in physics and astronomy that was undertaken during 1973, these short synopses should be enough to show that both sciences are intellectually alive, and producing an adequate amount of the basic scientific commodity—the unexpected result.—WILLIAM D. METZ