explanation much more challenging than it already is for a simple split.

The situation may be clarified by still a third new experiment carried out at Brookhaven by a group from Northeastern University and Stony Brook under the leadership of Marvin Gettner. This group has attempted to duplicate the original CERN experiments using the recoil principle of the CERN experiment and bracketing the same energy and momentum-transfer regions. They claim ten times better statistics than the CERN results and have developed a way to monitor the mass resolution and calibrate an absolute mass scale. Their conclusions will have been made public by the time of the Spring APS Meeting in Washington, where a special session is planned to discuss whether the A_2 is split or not split. —HLD

Laser-induced reaction separates isotopes

The first successful use of a laser to separate isotopes has been carried out at the Aerospace Corp. laboratories in El Segundo, Calif. S. W. Mayer, Munson A. Kwok, R. W. F. Gross and Donald J. Spencer used a high-power hydrogen-fluoride laser[1] to separate methanol (H_3COH) from deuteromethanol (D_3COD), selectively exciting the methanol to react with bromine.[2] The method, although not now economically practical (it uses more power per milligram of deuterium produced than do existing methods), gives encouraging results: The mixture of products includes less than five percent methanol and about 95% deuteromethanol, whereas the original mixture contained equal amounts of the two compounds.

At least one other group has tried to use the laser's monochromaticity to separate isotopes.[3] In the early 1960's William B. Tiffany, H. Warren Moos and Arthur L. Schawlow (then all at Stanford) used visible light from a ruby laser, one of the most powerful lasers then available, in their attempt to separate two bromine isotopes. They achieved selective excitation in a Br^{79}–Br^{81} mixture, but the separation was unsuccessful, probably because the isotopes mixed again after the selective excitation. "We were fortunate," Mayer pointed out. "We were able to pick a reaction in which remixing did not occur. There was also the sheer good fortune of having a very powerful (output up to 1 kW) laser available."

The group at Aerospace selected a hydrogen and deuterium system for their experiment because the large mass ratio between the two isotopes leads to large differences in vibrational energies of molecules containing H on the one hand or D on the other. Monochromatic radiation of the proper frequency can then stimulate a reaction in the hydrogen-containing compound with very little effect on the deuterium-containing compound.

Mayer's group looked for a separation reaction whose key step is a bimolecular collision, because the potential-energy barriers to many bimolecular reactions tend to be low enough that the 0.44-eV photons of the continuous-wave hydrogen-fluoride laser can initiate them.

The system H_3COH–D_3COD–Br_2 satisfies these criteria. The energy barrier in the overall photobromination reaction is 0.38 eV;[4] the key step, the attack of Br on H_3COH, has a 0.27-eV barrier. In addition the frequency of the methanol OH vibration had been determined previously,[5] and its value led Mayer and his coworkers to expect that the methanol would absorb the HF-laser radiation.

In a typical run, Mayer's group irradiated a H_3COH–D_3COD–Br_2 mixture with a 90-W beam, taking the infrared spectrum of the mixture before and after the irradiation. The methanol bands, particularly the OH vibration at 3681 cm^{-1}, were greatly reduced, whereas the D_3COD spectrum was essentially unchanged.

The most likely reaction products, says the California group, are hydrogen bromide and formaldehyde, produced in the reaction

$$H_3COH + Br_2 \rightarrow 2HBr + H_2CO$$

They stress that a good deal more work must be done before the kinetics of the reaction are understood. And extrapolating the H_2–D_2 results to heavier, more commercially useful isotope-separation schemes would be much harder, if at all possible, because of the significantly smaller mass ratios.—MSR

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Photofragment spectroscopy looks at excited states

An elegant way to study dissociative molecular excited states has grown up during the past few years. At the "New Vistas for Chemical Physics" session at the New York American Physical Society Meeting, Kent R. Wilson of the University of California, La Jolla, described "photofragment spectroscopy," which enables Wilson and his coworkers to study both the excited states of a molecule and the photodissociation fragments it produces, by measuring the mass, translational energy and angular distributions of the fragments.[1] Detailed information on bound excited states has long been available from ultraviolet and visible spectroscopy, but such information for dissociative states has been rare, although the dissociative states are the more common. Because some of the molecules Wilson has studied are among the major photochemically active pollutants of the atmosphere, the results may be interesting to environmentalists as well as to chemical physicists.

The La Jolla group crosses a pulsed beam of molecules, for example I_2, ICN or NO_2, with pulses of polarized laser light, dissociating the molecules. A typical molecular beam is about 3 mm in diameter and has a density of 6×10^{13} molecules per cm^3; lasers used include fundamental ruby (6943 Å), second-harmonic ruby (3471 Å), second-harmonic neodymium-glass (5310 Å) and a tunable dye laser. Computer-

Photofragment spectrometer is used at La Jolla to study dissociative molecular reactions. Beam from laser (on table in front of Kent R. Wilson) enters vacuum chamber (behind Wilson) and interacts with molecular beam. Resulting fragments are analyzed by a quadrupole mass spectrometer that is also within the vacuum chamber.

controlled rotation of a half-wave plate selects the polarization direction of the light, and an adjustable lens matches the laser-beam diameter to the molecular-beam diameter.

The detecting is done by a mass spectrometer that selects fragments with the looked-for mass and rejects all others. Those of the looked-for fragments that recoil at a preselected angle with respect to the electric vector of the light are ionized and pass through the mass spectrometer to an electron multiplier, whose output pulses are counted every microsecond for 500 microsec after the laser is fired. From the time of arrival and the distance between the spectrometer and the point where the beams cross, the translational energy E_{tra} of the fragments is measured. And from the energy conservation relation

$$E_{par} + h\nu = D_0^0 + E_{ele} + E_{tra}$$

(where E_{par} is the initial internal energy of the parent molecule, $h\nu$ is determined by the laser and D_0^0, the dissociation energy, is usually known) for a diatomic molecule, Wilson calculates the energies E_{ele} of the electronic states of the atomic fragments. For a polyatomic molecule, Wilson can determine the total internal energy—only for special cases can he distinguish between electronic, vibrational and rotational levels. The angular distribution of the recoiling fragments gives information about the dissociative molecular excited state, for example, its symmetry and lifetime.

Other chemical physicists have studied the recoil spectroscopy of photodissociating molecules. At Harvard, Richard N. Zare (now at Columbia) and Dudley R. Herschbach[2] showed theoretically that the angular distribution of recoiling photodissociated fragments is linked to the symmetries of the excited states. Jack Solomon and Richard Bersohn[3] (Columbia) have studied a variety of molecules with a method they call "photolysis mapping," which gives them the angular distribution of the fragments but not the translational energy. And Ronald Diesen, John Wahr and S. E. Adler (Dow Chemical Co) have reported[4] results on NO_2 and Cl_2 from a method similar to the one Wilson uses.

Some earlier errors in spectroscopy have been corrected with the recoil method. Iodine in its main visible continuum, for example, was thought to dissociate almost entirely from the $B^3\Pi_{0u}^+$ state into one excited and one ground-state atom, but the energy and angular distributions that Wilson finds indicate a major contribution from a $^1\Pi_{1u}$ state, giving two ground-state atoms. This preferential population of the ground state helps explain why no iodine photodissociation laser has yet been successful.

The sun produces in the atmosphere many of the reactions that Wilson reproduces in his laboratory; NO_2 and ethyl nitrite (C_2H_5ONO) for example, have been extensively studied, and some of Wilson's support is from the Government agencies that are interested in controlling air pollution. Photodissociation reactions are also of interest to atmospheric scientists because these reactions help shield the earth from uv radiation and maintain the heat balance in the upper atmosphere.

Within the next few months, Wilson expects to start experiments with a high-power ultraviolet laser (1 joule per pulse at 2655 Å). This laser will be used to study ozone, which Wilson finds particularly interesting because of the spin conservation problems in its breakup and the importance of its photodissociation both to air pollution and to processes occurring in the upper atmosphere. —MSR

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X-ray conversion

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interaction. Eisenberger and McCall were pleased to find that they could observe conversion even in their slightly imperfect crystal.

A major experimental difficulty was reducing the random Compton-scattered background radiation to allow discrimination between the background and the coincident 8.5-keV pairs. Sodium-iodide detectors were chosen for their combination of energy resolution and speed of response, but their energy resolution was not quite sufficient to ensure rejection of all the random 17-keV photons. The Compton rate was about 3000 per sec, whereas the coincidence count rate was about one per hour, so that great care in experiment design was needed.

McCall and Eisenberger are now attempting to do an experiment mixing x-ray and visible photons. Neither ordinary x-ray scattering experiments nor nonlinear techniques at visible frequencies give microscopic details about outer electrons because both are dominated by the bulk properties of the material. An experiment that mixed x rays and visible light would, however, allow the x rays to probe the outer-shell electron distortions produced by the visible light.

What about the relation of their work to the possibility of an x-ray laser? "I don't know how to make an x-ray laser," says McCall, "nobody does . . . but working in a related field just might help." —MSR

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New telescope at Palomar

The first major addition to Mount Palomar since the 200-inch telescope was completed in 1948 is a 60-inch telescope, which was dedicated in October. A Raytheon 703 computer controls operation and acquires data. An unusual optical system of six mirrors and a corrector lens enables the telescope to combine the maneuverability advantages of a short tube (154 inches) and the higher magnifications possible with a long focal length of 1800 inches (at the coudé focus) or 525 inches (at the Cassegrain focus). The telescope, built largely in the Cal Tech shops, cost more than $1 million; funds came from NSF, the family of the late Oscar G. Mayer, NASA, Cal Tech and the Carnegie Institution.

The Hale Observatories operate the new telescope as well as the 200-inch and 48-inch Schmidt telescopes at Palomar and the 100-inch and 60-inch telescopes at Mount Wilson.

Paramagnetic temperature scale in 1–20 degree K range

A new temperature scale in the range from 1 to 20 degrees K has been developed by T. C. Cetas and Clayton A. Swenson of Ames Laboratory and Iowa State University. The new scale, which is preserved for use by germanium resistance thermometers, is based on precise susceptibility measurement of two paramagnetic salts, chromic methyl-ammonium alum and manganous ammonium sulfate. Based on the National Bureau of Standards 1955 platinum resistance thermometer scale, the Iowa scale is believed to be accurate to better than 1 millidegree K over the specified range. □