tries depend upon the relative phases of the individual atomic orbitals. For example, a molecular orbital made up of two carbon orbitals added 180° out of phase will be anti-symmetric under reflection in the plane between the two carbon atoms. The bonding strength between individual atoms also depends on these very same phases. Qualitatively, atomic electron orbitals added in phase represent strong molecular bonds, while those added 180° out of phase produce repulsive "antibonding" molecular orbitals. Thus one can order the molecular orbitals of different symmetry in terms of their bonding energies in the reactant and product molecules without detailed calculation, simply by looking at the phases between relevant pairs of atomic orbitals in a given molecular-orbital symmetry state.

As the reactant molecular bonds are rearranged to form the product molecule(s), the phases between newly joined atoms are constrained by the requirement that each molecular orbital must preserve its symmetries throughout the rearrangement. If the topologies are felicitous, all the occupied bonding orbitals of the initial state can go over directly into bonding orbitals in the newly formed molecule. In that case the energy barrier of the reaction will be minimal. If, on the other hand, orbital symmetry conservation connects some of the occupied reactant orbitals only with higher-lying antibonding orbitals in the product molecules, the reaction cannot go in a concerted way; it must overcome higher energy barriers. Because the few-eV energy barriers typical of molecular bonds are in the far tail of the Boltzmann distribution at ordinary temperatures, a factor of two increase in the energy barrier of a molecular reaction can inhibit the reaction rate by many orders of magnitude. The Woodward–Hoffmann procedure generally gives a sufficiently good estimate of these energy barriers to predict whether or not the reaction will go at all.

Topology and Emily Post. Applying this procedure to the "cycloaddition" of carbon chains to form rings, one readily finds that the formation of rings of $4n$ carbons (where n is any integer; the classic case is the forbidden joining of two ethylenes to form cyclobutane) requires the promotion of bonding orbitals to antibonding orbitals, while the favored formation of $4n + 2$ carbon rings (for example, ethylene + butadiene → cyclohexene) proceeds entirely from bonding to bonding orbitals. Dudley Herschbach (Harvard) emphasized for us that this general result is largely topological; it doesn't depend on the detailed dynamics. He explains it to his physicist colleagues by an analogous rule for formal dinner parties. If the host and hostess are to sit at opposite ends of the table, he points out, the requirement of strict sex alternation in the seating arrangement limits dinner parties to populations of $4n + 2$; it can be done with 6, 10 or 14 people, but not with 4, 8 or 12.

The essence of Fukui's approach has been broadly the same as that of Hoffmann. The Woodward–Hoffmann procedure is however more widely used by organic chemists because its first formulation was more intuitively accessible and less mathematical. One thinks of the analogous situation with the Feynman and Schwinger formulations of quantum electrodynamics. On the other hand, Fukui's frontier-orbital approach is more general, Houk told us, in that it can be applied to the understanding and qualitative prediction of all types of chemical reactions, regardless of mechanism—whether concerted or unconcerted.

Herschbach, who studies collision processes in molecular beams, illustrated for us the usefulness of Fukui's concept of frontier orbitals in the interpretation of his collisional-reaction data. He has found, for example, that the angular and velocity distributions of hydrochloric acid molecules formed in collisions of Cl_2 molecules with atomic hydrogen are surprising similar to what one sees in the photodissociation of Cl_2. This result is readily understood, he told us, when one realizes that the frontier orbital in the intermediate state is a hybrid of chlorine bonding and antibonding orbitals, with the repulsive antibonding component dominating.

Fukui, an engineer by training, took his PhD at Kyoto University in 1948, having been appointed assistant professor three years earlier. He has been a full professor of physical chemistry at Kyoto since 1951. Hoffmann received his doctorate in chemical physics at Harvard in 1962. He joined the Cornell faculty in 1968, where he was appointed J. A. Newman professor of physical science in 1974. —BMS

Peking institute plans e^+e^- collider

After the Chinese government decided at the end of the last year to suspend work on its 50-GeV proton synchrotron, a research and development program for a smaller machine has been established at the Institute of High-Energy Physics in Peking. This smaller machine would be an electron–positron collider with 2.2 GeV in each beam.

The 50-GeV proton synchrotron was to have been built at a new high-energy experimental center near the Ming Tombs (an hour's ride from the center of Peking). Plans for both the proton synchrotron and the Ming Tomb center have been suspended.

A joint committee from China and the US met in March at Fermilab. According to Hsieh Chia-lin, now a vice-director of the Institute of High-Energy Physics, the consensus of US scientists was that China should instead build an e^+e^- collider with 2.2 GeV/beam. The collider would allow meaningful physics, permit the training of Chinese accelerator physicists and experimental physicists, and the cost would be reasonable. As a byproduct, the collider could also be used as a synchrotron radiation source.

Later, Chinese high-energy physicists met in suburban Peking to discuss plans for a high-energy physics accelerator, and again the general consensus was to build an e^+e^- collider. Reports were prepared describing the required research and development and the scientific justification for such a collider. Now Academia Sinica, after reviewing the reports, has agreed to provide 3.5 million Chinese dollars for prefabrication R&D. The total cost of the project is expected to be 60–70 million Chinese dollars.

In October and November, Zhu Hong-yuan, Deng Zhao-ming (deputy director of the division of physics and mathematics of Academia Sinica) and Hsieh visited the US to initiate a meeting on a joint collaboration between US high-energy labs and the Chinese High-Energy Physics Institute. Academia Sinica is expected to start its review process shortly. —GBL

in brief

LEP, the proposed 27-km-circumference European e^+e^- storage ring, now has the approval of all 12 member states of the CERN Council. At a recent special Council session, the Dutch, Norwegian and Swedish delegates made it unanimous (subject to confirmation by their governments). France and Switzerland, whose border the gargantuan accelerator will straddle, must still approve the civil engineering work.

DOE has authorized the Torsatron/Stellarator Lab at the University of Wisconsin to construct the Interchangeable Mode Stellarator. The IMS, a relatively small device, will be the first new stellarator built in this country in more than a decade. It will closely match Wisconsin's existing stellarator, Proto-Cleo, with discrete modular coils rather than a continuous helical coil. The new magnetic-confinement fusion machine is expected to be operational early next year. □