gen molecules are in specific vibrational and rotational states, characterized by the quantum numbers v and j, respectively. In some of the reactions the initial hydrogen molecule was prepared in a single vibrational and rotational excited state with quantum numbers ($v = 1, j = 1$). One would expect the state-to-state cross sections to be particularly sensitive to any phase shifts in the reaction amplitudes.

In the Stanford experiments the initial deuterium atom is generated by photolysis of a deuterium iodide or deuterium bromide molecule, and the H_2 is prepared in a state-specific manner by Raman pumping. The experimenters detect the final HD state using a method known as 2 + 1 resonance-enhanced multiphoton ionization. In this technique, the molecule can be ionized only if it is in a specific state of both vibrational and rotational motion. Thus the Stanford group could find the (v,j) distribution of the product HD molecules.

The results of the Stanford experiments have been compared with theoretical calculations, which in recent years have been extended to these higher energies. The comparisons have revealed new disagreements.[7] In particular, with the initial molecule in the $v = 1$ state, plots of the rates of formation as a function of the angular momentum of the outgoing diatom peak at a lower value of j than do those of the calculations. These differences start showing up at a total energy of 1.8 eV and are significant at the highest total energy for which both calculations and measurements are available (2.3 eV).

Wu and Kuppermann decided to see if the discrepancies could be explained by the effect of the geometric phase. They started by doing calculations on the simpler system, $H + H_2 \rightarrow H_2 + H$. When they compared their results with the rotational state distributions measured by the Stanford group on the $D + H_2$ system, they found qualitative agreement.[1] Specifically, the values calculated with the geometric phase tended to peak, like the experimental data, at lower values of j. They also saw an effect in the total cross sections: When Wu and Kuppermann took the difference between the values calculated with and without the geometric phase, they found that the differences varied with energy in an oscillating manner suggestive of phase interferences. Indeed, one expects that the phase shift when the geometric phase is present will vary with energy differently than when the effect is not present.

More recently the Caltech theorists have completed the calculations for the $D + H_2$ system, so that their results can be compared directly with the experimental cross sections. They made these calculations for three different total energies and a range of initial and final vibrational states.[8] The correspondence with experiment is shown in the figure on page 18 for reactions in which the total energy is 1.8 eV, the initial diatomic molecule is in the ($v = j = 1$) state and the product molecule is in the ($v = 1, j$) final state. Kuppermann and Wu's calculations also indicate that the differential cross section is far more sensitive than is the total cross section to the inclusion of Berry's phase. —Barbara Goss Levi

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Tunnel Boring Begins at Superconducting Super Collider

SSC LABORATORY

The first of the Superconducting Super Collider's 60-foot-wide tunnel-access shafts opens down into a cavernous magnet-transfer area 236 feet below the sod of Ellis County, Texas. Some eight thousand 50-foot-long superconducting bending magnets will eventually be lowered down such access shafts, arrayed around the 54-mile-circumference underground SSC ring. Just after this picture was taken at the end of December, the first of the SSC's 250-ton "inchworm" tunnel borers was lowered down the shaft in segments to begin the actual boring of the 14-foot-high SSC tunnel.

Tunneling began in mid-January, starting at the "tunnel stub" visible at the far end of the cavern. Most of the boring will be through Austin chalk, but in this region the inchworm is boring through shale that necessitates a concrete tunnel liner. One of the virtues of the state-of-the-art inchworm is that it applies the concrete liner as it bores. The SCC schedule calls for tunnel boring to be completed by the end of 1996, but budget cuts proposed by President Clinton last month could stretch this out by several years.

—Bertram Schwarzschild