This led to what Herschbach called the "harpoon" model of reaction dynamics. One molecule sneaks up on the other, uses a very specific valence electron orbital as its harpoon, spears its target in one selective and vulnerable spot, and hauls it in. Once these mechanisms are known, many of the other potentially obscuring complexities of molecular shapes, bonds, and electron potentials, fall away as being irrelevant.

The experimental technique used in these studies, developed by Herschbach and Lee, is today known as "crossed-molecular beam" research. The facility recently constructed at Lawrence Berkeley Laboratory, under Lee's direction and with continued support from Basic Energy Sciences, is widely acclaimed as the best molecular beam instrumentation facility in the world.

In recent years, this facility enabled Lee to study more complex molecules, such as those having long hydrocarbon chains. Pioneering exploration was begun in two key areas of pressing national interest—hydrocarbon (oil and natural gas) combustion and atmospheric chemistry.

With these advances, understanding chemistry from first principles is now a practical goal. Its applicability extends beyond fuel burning and ozone depletion. Insights gained using crossed-molecular beam research may yield new models of how catalysts operate in specific chemical reactions. Because the velocities of molecular collisions, which determine reaction potentials, are related to temperature, the nature of reaction rates is now a subject of detailed and quantifiable research.

Perhaps more importantly, crossed-molecular beam research permits a better understanding of reaction intermediates, the short-lived arrangements of atoms and molecules that are the first results of a molecular collision, but which soon decay to some other or more stable forms. Manipulating the reaction intermediates offers one of the best hopes for precisely controlling chemical reactions and, thus, determining the nature of the final reaction products.

For Herschbach and Lee, more than two decades of fundamental research culminated in the Nobel Prize. They envisioned and devised a productive experimental approach, built and perfected the necessary hardware and instruments, gathered data with sufficient variety and scope to yield robust conclusions, and presented the scientific community with a wholly new view of chemistry and the dynamics of reactions.

Crossed-molecular beam research is now firmly established as a fundamental research tool. With continued support from Basic Energy Sciences, it is being used in a growing number of inquiries. With expanding knowledge, focused more on applications, improved understanding of reaction dynamics and, perhaps, the ability to control the reactions themselves, move closer to reality.

Despite all the wondrous advances of modern chemistry, new frontiers remain to be explored. Crossed-molecular beam research lies at the forefront of this endeavor, with great potential for continuing contributions to industry, health, and environment.

ENERGY FROM PHOSPHATE ROCK

Phosphoric acid, used primarily to make agricultural fertilizers, ranks in total economic value among the most important industrial chemicals manufactured in the United States. By a happenstance of nature, much of the phosphate rock which serves as the raw material also contains a trace amount of uranium—the elemental source of energy which fuels the Nation's nuclear power and research reactors.

Basic Energy Sciences research provided the scientific knowledge and the patented methods which subsequently enabled the efficient extraction of uranium as a valuable byproduct of the phosphoric acid manufacturing process. In recent years, large manufacturing plants in Florida and Louisiana, representing about half of the industry's phosphate rock processing capacity, recovered uranium using methods based on this original work.

The incentive to separate and recover uranium was recognized early in the 1950's. Concentrated primarily in Florida, Louisiana, North Carolina, Idaho, Montana, Utah, and Wyoming, the natural reserves of phosphate rock were estimated to contain over 600,000 tons of uranium. However, because the uranium typically appeared in weak concentrations of about only 1 pound for every 4 tons of phosphate rock, these reserves were considered to be too poor for economic extraction of uranium alone.