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Yuan T. Lee - 1986 Nobel Prize in Chemistry

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LEE, YUAN TSEH (November 29, 1936 -)

Nobel Prize for Chemistry, 1986

The American chemist Yuan Lee was born in Hsinchu (a city of 200,000), Taiwan to Tse Fan Lee, an accomplished artist, and Pei Tsai, an elementary school teacher and later homemaker. His parents' ancestors moved from mainland China to Taiwan during the sixteenth century. He started his early education while Taiwan was under Japanese occupation - a result of the war between China and Japan in 1894. However World War II quickly interrupted his education, as Hsinchu's population was relocated to the mountains to avoid the daily bombing by the Allied Forces. It was not until after the war that Lee was able to attend classes normally, as a third grade student in elementary school.

Due to his extraordinary high school academic record, in 1955 Lee was admitted to the National Taiwan University (Taipei) without having to take the

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normal entrance examination. Prior to this time the biography of Marie Curie had made a strong impression on him. As Lee stated in 1986, "It was Madame Curie's beautiful life as a wonderful human being, her dedication toward science, her selflessness, and her idealism that made me decide to become a scientist." By the end of his university freshman year Lee had decided on chemistry as his lifelong field of endeavor. Although the facilities at the National Taiwan University were less than ideal, the free and exciting atmosphere, the dedication of some professors, and the camaraderie among the students made up for material shortcomings. Lee worked under Professor Hua-sheng Cheng on his B.S. research thesis, which involved the separation of the elements strontium and barium using the paper electrophoresis method.

Upon graduation in 1959, Lee went on to the National Tsinghua University for his initial graduate studies. There he received a Master's degree for studies of the natural radioisotopes contained in Hokutolite, a mineral found in hot spring sediments. Subsequently he stayed on at Tsinghua University as a research assistant to Professor C. H. Wong and carried out an x-ray crystallographic determination of the molecular structure of the organolanthanide compound tricyclopentadienyl samarium. It may be seen that his research experience prior to the beginning of his Ph.D. studies was much broader and more sustained than was the case for typical beginning American graduate students.

Lee entered the University of California at Berkeley in the fall of 1962. One choice available to him was working for Professor DUDLEY HERSCHBACH, with whom he would eventually share the Nobel Prize. However, Herschbach offered Lee a research project in the area of microwave spectroscopy, rather than one involving Herschbach's new interest in crossed molecular beam studies. Perhaps for this reason Lee chose to do chemical research under Professor Bruce H. Mahan on chemiionization processes involving electronically excited alkali atoms.

During his Ph.D. studies, Lee developed major interests in ion-molecule reactions and the dynamics of molecular scattering. Thus it was not surprising that he chose to continue at Berkeley for an additional year and one-half as a postdoctoral fellow in Bruce Mahan's laboratory. Lee's postdoctoral research at Berkeley is best viewed as a critical prelude to the work he completed less than two years later that resulted in the Nobel Prize. Upon receiving his Ph.D. in 1965, Lee mastered the art of designing and constructing a highly sophisticated and powerful scattering apparatus. He then carried out unprecedentedly successful experiments on the chemical reaction

$$N_2^+ + H_2 \rightarrow N_2H^+ + H$$

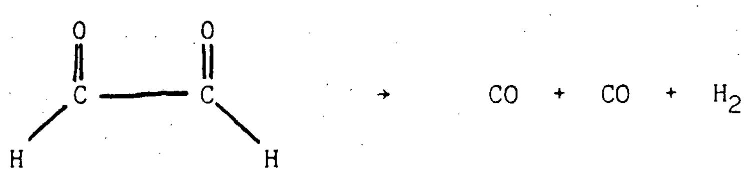
and obtained a complete product distribution contour map, a remarkable accomplishment at the time.

The award of the 1986 Chemistry Nobel Prize was for the study of neutral molecular species, not the positive ion systems discussed above. During the period 1960-1967 the two dominant pioneers in this field of neutral atom-molecule crossed molecular beam studies were Richard B. Bernstein and Dudley Herschbach. However, the single discovery that revolutionized the field took place after Y. T. Lee moved from Berkeley to Harvard in February 1967 to join Herschbach's laboratory. This discovery was the design and construction by Lee of a new instrument for crossed molecular beam studies. Lee's design has since constituted the prototype for a succession of (progressively improved) crossed molecular beam experiments with angularly resolved detection of products by means of a differentially-pumped mass spectrometer ("universal detector") that can be rotated, inside the vacuum chamber, about the beam crossing point. Several important papers co-authored by Lee, Herschbach, and other Herschbach students quickly appeared, reporting research based on the spectacular new instrument.

A bit more detail concerning the nature of the 1967 discovery and the environment in which it took place is required here. Until that time, the use of a surface ionization detector had limited crossed molecular beam studies to those systems containing alkali atoms. For this reason the period prior to 1967 is often referred to as the "alkali age" of crossed molecular beam experiments. It was quite clear at that time that in order for the crossed molecular beams method to have a major impact on the chemical sciences, it was necessary to go beyond the scatterings of alkali atoms. And that was exactly what Y. T. Lee set out to accomplish in Herschbach's group. Lee's previous experience in the construction of an ion-molecule scattering apparatus turned out to be an important factor for this endeavor. His ability to absorb new technologies needed for the project and sort out the many conflicting factors which were facing the new sophisticated apparatus was truly exceptional. His imaginative way of pushing the art of differential pumping to the limit in the design of the universal mass spectrometric detector is one thing, but the way he established three stages of differential pumping in a rotatable ultrahigh vacuum detector using an ingenious nested design is an entirely different matter. It must be credited to Professor Herschbach's encouragement, confidence, and trust in Lee that the new universal crossed molecular beam apparatus was completed, and the first halogen atom exchange reaction $C\ell + Br_2 \rightarrow BrC\ell + Br$, was carried out within a period of ten months. It certainly took a superhuman effort by Lee to put into operation such a sophisticated apparatus in such a short time starting from scratch. This new instrument was the first truly successful universal crossed molecular beam apparatus and was orders of magnitude more sensitive than all the other dozens of attempts around that time. It revolutionized the crossed molecular beam study of reaction dynamics and made the technique a powerful tool for modern chemical research.

Lee accepted a position as Assistant Professor of Chemistry at the University of Chicago in October, 1968 and was promoted to Associate Professor in October, 1971 and to Full Professor in January, 1973. In 1974 he returned to Berkeley as Professor of Chemistry and Principal Investigator at the University of California's Lawrence Berkeley Laboratory.

Following his return to Berkeley, Lee's laboratory quickly established itself as the most outstanding in the world in the general area of physical chemistry/chemical physics. Specifically noted in the Nobel Prize citation were Lee's contributions in making the crossed molecular beams method applicable to relatively large molecules. His elegant studies of the reactions of oxygen with hydrocarbons as large as benzene and toluene have provided a fundamental basis for combustion chemistry beyond that imaginable in 1970. Moreover, Lee has imaginatively merged molecular beam chemistry with laser technology to solve a host of important chemical problems, such as the mechanism of the glyoxal triple dissocation



In summary, the most important early chemical applications of the crossed molecular beam technique came from the laboratory of Y. T. Lee.

In 1963 Lee married Bernice Chinli Wu, whom he had known since elementary school. The Lees have two sons, Ted and Sidney, and a daughter Charlotte. His modest demeanor, coupled with an intense devotion to his research, has consistently attracted bright young scientists from all over the world to his laboratory. His laboratory is characterized by a degree of excitement and esprit de corps rarely observed elsewhere.

In addition to the Nobel Prize, Lee's many prizes and awards include the Ernest O. Lawrence Award (1981), the Harrison Howe Award (1983), the Peter Debye Award (1986), and the United States National Medal of Science (1986). He received an honorary doctorate from the Univeristy of Waterloo (Canada) in 1986 shortly before his receipt of the Nobel Prize.

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