Fig. 1. Kent Wilson (1937–2000), in Torrey Pines State Park, Del Mar, California, August 1999

The Odyssey of Kent Wilson: Holding Molecules in the Light

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1 Introduction

Anyone pursuing laser chemistry is indebted to Kent Wilson as an inspiring architect of the field. Many are now using innovative laser techniques conceived by him to probe the molecular dynamics of chemical and biochemical reactions. Many will know too that, as a remarkably wide-ranging physical chemist, he also contributed much seminal work, both theoretical and experimental, to several other fields, among them economics, engineering, computer science, environmental science, archaeology, and educational filmmaking.

His legacy to science over the past four decades is immense, but his death on 27 March at the age of 63 deprived him of fully enjoying three major projects brought to fruition in the last few years by his group at the University of California, San Diego. Each required development of powerful new apparatus, exemplifying Wilson's architectural vision. One machine achieves "quantum control" of photochemical processes using iterative feedback to automatically tailor optimal laser excitation pulses. Another, the culmination of long effort, enables direct observation of atomic motions by means of ultrafast x-ray diffraction and spectroscopy. Most recently, a laser microscope has been built that can obtain very high resolution images of living tissue without killing the cells. These remarkable achievements have opened up exhilarating frontiers.

Those privileged to know Kent personally cherished him as wonderfully excitable and creative in his work but also ardent and devoted as a friend, eager to share his enthusiasms and adventures. His intense affection and admiration for his students, colleagues, and family was warmly reciprocated. A reunion of the Wilson group, held in 1996 to celebrate Kent's 60th birthday, produced a book of reminiscences by group members [1]. The book is amply illustrated with photos, many of parties, outings, or trips Kent had initiated, and conveys vividly the exuberant, joyful spirit he fostered in work and play. In a dedication, Kent wrote:

> Freud said that the two most important ingredients of a good life are work and love. I am privileged to have had a life's work which I love, which is to me deeply meaningful and sustaining, an endless source of fascination, excitement and challenge. The best and most important part f this life's work is you, the people I have worked with. I take great pride in you and your lives; to me, you are a second family. You have enriched my life by working with me and now by coming back to gether again in a Reunion to celebrate ourselves and our years together.

There is a Quaker saying, "I'm holding you in the light". With people as well as molecules, Kent Wilson fulfilled this admirably in his life.

We are fortunate to have from Kent himself an autobiographical essay, "Summing Up", published last December in a special issue of the Journal of Physical Chemistry honoring him [2]. It is a poignant "love letter to posterity", with candid and wise observations on his life in science, his joys and regrets. I urge everyone concerned with science, whether a young person contemplating a career, a mature scientist concerned about better managing a research group, or a cultural scholar, to read Kent's essay. In this paper, I will augment portions of his essay and a brief obituary article [3]. Chiefly, I'll describe episodes from his graduate work with my group and his early years at San Diego. Now distant history, these stories may yet be instructive as harbingers of the enterprising, zestful style that emerged in his career and grew to a crescendo in his recent work.

2 Beginnings

Kent Wilson was born on 14 January, 1937 in Philadelphia and grew up, as he liked to say, "inside an experiment". This was located in a nearby village, Bryn Gweled Homesteads, a mostly Quaker community which his parents had helped to found, designed to foster communal living. Encouraged by prominent scientists in the village, Kent by the age of eight had made a rudimentary radio receiver. Later, his family spent winters in Washington, D.C., where his father headed a Quaker lobbying organization working for disarmament, civil rights, and combating poverty. Kent became an avid visitor to the Smithsonian Museums and the Library of Congress; he credited that with "saving my academic career from ruin" because he "did very little of the assigned homework in school".

At Harvard College, Kent began as a government major, focused on history and political science. However, he was captivated by a chemistry course given by the fabled Leonard Nash. That led Kent to switch his major to chemistry and physics. After completing a bachelor of arts degree in 1958, he went to the University of Strasbourg for a year and wrote a Diplome thesis in economics. Deciding then to pursue graduate study in chemistry, he came to the University of California at Berkeley. Susceptible to evangelical fervor, Kent joined my fledgling research group there soon after we began crossed molecular beam experiments of reactions of alkali atoms with halogen compounds [4].

Young scientists pursuing work with molecular beams now are blissfully unaware how rudimentary were the tools available back then, before the advent of lasers and modern computers and before vacuum chambers and all sorts of elegant gear could be ordered from a catalog. The prime detection method, limited to alkali atoms and alkali halide molecules, relied on surface ionization by hot filaments. This took advantage of a somewhat mysterious differential sensitivity (discovered by Sheldon Datz and Ellison Taylor). A tungsten filament ionized efficiently both nonreactively scattered atoms and reactively scattered halide molecules, whereas a platinum alloy filament responded almost only to atoms. Thus, the difference of readings taken on the tungsten and platinum alloy filaments (often small!), permitted measurement of the angular distributions of the alkali halide product. After initial success with reactions of alkali atoms with alkyl iodides (work of George Kwei, Jim Norris, and Jim Kinsey), however, my group encountered great difficulty in extending the experiments to analogous reactions with diatomic halogens and other molecules. Such molecules seemed to "poison" the platinum alloy filament, causing its signals to drift and fluctuate intolerably.

Kent undertook to improve the detection method in two ways. He built a quadrupole mass spectrometer (designed by Gilbert Brink) from scratch. It was a major job for a graduate student long before such instruments could be bought. He was justly proud of his instrument, as seen in the photo below. The motivation was to extend the chemical scope of surface ionization by mass analyzing the ions emitted by the filaments. Kent also built an auxiliary apparatus with which he carried out an extensive study of surface ionization efficiency for a wide range of filament materials and operating conditions. Both his mass spectrometer and ionization study proved quite valuable in later work. Here, I note just one aspect indicative of Kent's alert, questioning approach. In the literature on surface ionization, much ado was made of the fact that bursts of potassium ions emerge as background even from well-aged tungsten filaments in high vacuum, without exposure to incident beams. This was attributed to a similarity in the ionic radii of potassium and tungsten. Kent looked for and found other alkali ions were also emitted. He had the satisfaction of confirming that the relative yields did not correlate with ionic radii but simply matched abundances in the earth's crust, as he had suspected.

Another episode exemplifies Kent's characteristically optimistic outlook about what he might accomplish in the future. The summer following his first year in graduate school, he went off with a student group on a trip of 7 weeks or so to the Soviet Union, wanting to see first-hand how a communistic economy worked. After his return, box after box of books arrived at our lab. These contained more than a hundred classic texts of modern physics and chemistry, Russian translations that Kent had found he could buy very cheaply. He proudly assembled them in a large bookcase above his desk. Thereafter, I happened to come across a Russian article in need of translation. When I took it to Kent, I discovered he could not read Russian; he had blithely assumed that he'd learn how someday.

At the time my group moved to Harvard, in the fall of 1963, we were still struggling with detector poisoning. Fortunately, Kent's studies of surface ionization led him to a paper (by Eugene Toux and John Triscka) which showed us how to "immunize" the filament. Armed with such black art, Kent and others of my group were able to examine many more alkali reactions.

Fig. 2. Kent Wilson as a gaduate student, with the mass spectrometer he had built; at Harvard, Spring 1964

By the next spring, we had established that reactions with diatomic halogens proceeded by a “stripping” mechanism, essentially opposite to the “rebound” process found three years before for methyl iodide. The paper reporting this, with Kent as first author, was submitted just a few weeks after a seemingly definitive theoretical paper, based on extensive classical trajectory calculations, had appeared with the conclusion that all reactions would go by a rebound mechanism.

Kent went on to survey reactions with carbon tetrachloride and several other polyhalide compounds. Thereby he mapped out generic aspects of a transition between the rebound and stripping limits [4]. This revealed how the reaction dynamics could be correlated with electronic structure of the reactant molecules. His doctoral thesis, completed in the fall of 1964, presented his abundant data and described in exemplary detail the design, construction, and operation of what was then state-of-the-art apparatus.

3 Career at San Diego

In 1965 Kent gladly returned to California and began teaching and building his own laboratory at San Diego. In his research, he tackled the challenging task of developing experiments to elucidate the dynamics of molecular photodissociation by observing the distributions in angle and velocity of the dissociation products. The techniques of ordinary spectroscopy put almost exclusive emphasis on stable excited states, but in molecules there exist many more dissociative excited states. Kent’s technique of photofragment spectroscopy opened up a vast lode of information about such states and repulsive intermolecular forces, thereby also contributing to understanding energy release in a large family of chemical reactions [4].

His success was hard won. The impetus for photofragment spectroscopy came from Dick Zare’s doctoral thesis, also done in my group in 1964, which treated the basic theory. However, feasibility estimates made by presuming use of the continuous light sources then available had discouraged us from undertaking photodissociation experiments. Kent realized that a pulsed light source offered substantial advantages and bravely set to work. In the reunion book [1], a superb chapter from the 1970 thesis of Kent’s first graduate student, George Busch, is reprinted. It describes the long series of failures confronted by Kent and his team, their inventive responses and their ultimate triumph, achieved only in late 1968 when a pulsed solid-state laser with decent conversion efficiency for doubling became available.

Although his later research explored quite diverse areas, Kent’s scientific leitmotif remained molecular dynamics. In the 1980s, by combining ultrafast laser experiments with computer simulations he was able to markedly advance understanding of reaction dynamics in solution, and bring out connections to gas phase dynamics. In the 1990s, his ultrafast x-ray laser apparatus revealed unanticipated dynamical aspects of the transition between solid and liquid phases, in a phenomenon termed “nonthermal melting”. In striving for his ultimate goal of “quantum control”, Kent arranged to conduct “conversations” with molecules via laser light pulses, thereby enabling the molecules to teach experimenters how to negotiate a desired chemical choreography of atomic motions.

For Kent, his teaching and mentoring were adventures in both intellectual and social dynamics. A unique part of his research group was dubbed by him the “Senses Bureau”. For this he recruited first-year undergraduates, “young enough so that they do not yet know the meaning of the word impossible”. Over 35 years, they created original software and hardware for computer animation and produced many educational films and interactive “virtual reality” devices used widely in high schools, colleges and medical schools. A classic film explicated protein synthesis with the aid of 200 dancers, poetry, and a jazz-rock band. The Bureau also had a large role in Kent’s studies of air pollution in California and Mexico, and in the use of chemical archaeology to elucidate trade routes in Africa.

In mid-career Kent became increasingly frustrated with the cost in time and tribulation of applying for grants to support his research. Too often, that prohibits work that requires building expensive, unprecedented apparatus. On a sabbatical leave in 1985, Kent came up with an extraordinary solution, discovering “a mapping between parts of physics and economics”. Boldly betting on his theory, over the next few years he invested in the stock markets of 25 countries, especially developing nations in financial chaos. This succeeded so well that he was able to resign all his federal grants, thereafter supporting from his own funds a sizable research group as well as equipping his laboratory with the finest laser and computer instrumentation he could buy or build.

4 Benediction

Late in 1998, Kent learned he had incurable, late stage prostate cancer. For the remaining 14 months of his life he dealt with this as his “most challenging experiment”, organizing a team of biochemists to work in collaboration with physicians pursuing new therapeutic approaches. With the support of his wife Lana and their daughters Tasha and Maya, and many friends, he maintained a “balance of hope and realism”, making arrangements for others to continue key lines of his research.

In the closing paragraph of his farewell essay [2], Kent describes his joy in visiting wildflowers along a favorite trail, akin to his pleasure in the blooming of his scientific projects and progeny. Late last August, he escorted me over that trail, happily introducing his favorite flowers. That was when I took the photo prefacing this article. With it, I wanted to hold Kent “in the light”. I also had in mind a poem by Max Planck [5]. It offers an apt benediction for Kent, who so earnestly pursued “that great central mystery of the connection of mathematics and physics to what happens in the world of matter". In a letter to another scientist, Planck wrote:

What you have picked, what I have picked
These we will bind together,
Entwining thus a fair bouquet
From gifts we give each other.

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