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Special Issue Preface

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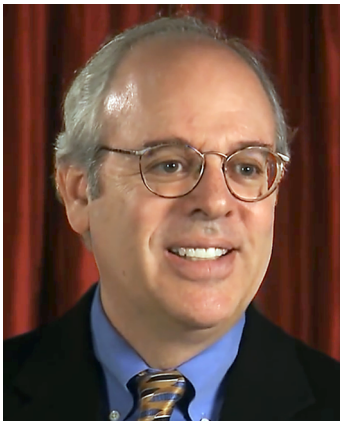
A Tribute to Steven J. Sibener



It is a great privilege to introduce this special issue celebrating Steven J. Sibener's numerous innovative and influential scientific achievements. Steve has been a major contributor in the quest of developing a molecular-level understanding of surface chemistry through careful studies of structures, motions, and reactions at solid surfaces. He has a wonderful knack for asking fundamental questions that have pervasive significance, and he designs innovative experiments to address them that provide definitive and insightful atomic-scale pictures. Steve's interpretations have proved to be profound and have withstood the test of time.

Steve carried out his Ph. D. studies at the University of California, Berkeley, from 1975 to 1979, under the tutelage of the master of molecular beam chemistry, Yuan T. Lee. There was great excitement and success at this time in unraveling the dynamical pathways followed by individual atoms during reactive encounters between elementary gas-phase species. Indeed, the 1986 Nobel Prize in Chemistry was awarded for this achievement to Yuan Lee, shared with Dudley Herschbach and John Polanyi. Steve's construction of a beam source that produced excited (singlet) oxygen atoms and his application of this technology to study reactions of singlet oxygen atoms with hydrogen and other species were notably among the first molecular beam studies of excited-state chemical reactions. Using this beam source Steve also elucidated the correct atomic-level mechanism for the reaction of ground-state (triplet) atomic oxygen with benzene, the model system for understanding oxygen atom−aromatic ring hydrocarbon reactions. Here he demonstrated that the primary bimolecular reaction products could be unambiguously determined using crossed-beam collision experiments, clarifying longstanding mechanistic issues in combustion chemistry. Early in his career, Steve realized how discoveries in gas-phase systems could be translated to develop a similarly detailed understanding of heterogeneous chemical systems. He has been at the forefront of this evolution from that time on.

In order to extend his research beyond the gas phase, Steve accepted a postdoctoral position at AT&T Bell Laboratories to work with Mark Cardillo. At Bell Laboratories, Steve continued to exploit the advantages of molecular beams, but now impinging on solid surfaces to elucidate gas−surface interactions. At Bell Laboratories, Steve made major contributions toward developing helium atom diffraction from ordered surfaces, particularly highly corrugated surfaces, as a probe of surface structure and properties. He applied this technique to uncover the structure of the (110) surface of GaAs.

Steve then began his position of Assistant Professor of Chemistry at the University of Chicago in 1980, an appointment that he had accepted while still a graduate student at Berkeley. He has remained at Chicago ever since, over which time he has established an exceptionally productive program in research and education, with continuously evolving research directions. Steve extended surface helium atom scattering to investigate phonons, the vibrations of surface atoms. Among the systems he characterized in this way were rare gas monolayers and multilayers physisorbed on metal surfaces, as well as the surface dynamics of the unusual copper−gold alloy. Steve also extracted novel and valuable information through scattering of hydrogen molecules and its deuterium isotopologues from surfaces. His exquisite control of molecular beams allowed his group to discover and quantify rotationally inelastic bound-state resonances of HD transiently adsorbed to single-crystal platinum and silver surfaces—HD molecules that have transferred quantized amounts of translational into rotational energy such that they do not have sufficient translational energy to escape from the surface. This data provided much needed input for constructing accurate potential energy surfaces for the interactions of hydrogen with metal surfaces.

Steve's research focused on revealing the mechanisms of fundamental chemical reactions at surfaces with unprecedented clarity and detail using a unique modulated-beam scattering apparatus involving three molecular beams. He has utilized this facility for many important studies, including the development of the most complete picture to date of the oxidation of carbon monoxide on the rhodium surface. Other processes he has elucidated are the atomic-level transformations that control the low-temperature growth of silicon carbide, the mechanism of photodesorption of nitric oxide from condensed films, and the interactions of O_2, NO, and NO_2 with rhodium, including the onset of metal oxidation.

Steve's more recent adventures in surface science have incorporated complex, organic, disordered surfaces: "soft matter". Steve has led the way for this transformation, in part by augmenting his molecular beam facility with STM and AFM scanning probe microscopies. One intriguing result he discovered was an unusual pattern of erosion of the graphite surface by atomic oxygen, a result that has direct implications for erosion of surfaces in low earth orbit. He has also impinged hyperthermal rare gas atoms on self-assembled alkane-thiol monolayers on gold, uncovering energy, angle, and mass-dependent energy transfer as well as burrowing of atoms between alkane chains. Steve's discovery that domains of block

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copolymers can be accurately aligned has attracted a huge interest in the materials community. He has demonstrated that this alignment is due to preferential wetting and can be lithographically patterned on a template, promising widespread applications in research and technology.

Steve's colleagues recognized early on that Steve was not only a brilliant experimentalist but also an unusually selfless and wise leader. His service to the scientific community is remarkable: Steve has been the director of an NSF Materials Research Science and Engineering Center, a DOD Multi-disciplinary University Research Initiative, and a NSF Phase I Center for Chemical Innovation. During Steve's term as director of The James Franck Institute, the institute designed, constructed, and moved to a new building: The Gordon Center for Integrative Science. This facility replaced the old Research Institutes building that was constructed by Enrico Fermi and colleagues after WWII to house the then-new Institute of Nuclear Studies and the Metallurgical Laboratory. He has also chaired the committee that led to the creation of the University of Chicago Institute for Molecular Engineering, and he is currently Director of its new Water Research Initiative. Additionally, he has served as Chair of the Division of Chemical Physics of APS. Through these time-consuming efforts, Steve has forged lasting friendships and earned the heartfelt gratitude of a generation of scientists. For many of us, Steve has become *the* "go-to" person for consultation and advice about future directions in science.

Steve Sibener has set a truly admirable standard of integrity, creativity, and leadership for his colleagues and students. His influence has spread far as he has trained an extraordinary group of 6 high school researchers, 30 undergraduates, 43 graduate students, and 14 postdoctoral fellows, many of whom recently hosted a "SibenerFest" in Steve's honor in March of 2014 at The University of Chicago. We are proud to mark Steve's 60th birthday with this exciting collection of articles as a tribute to his enduring science and friendship.

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