J. Am. Soc. Mass Spectrom. (2015) 26:1643–1644
DOI: 10.1007/s13361-015-1234-7

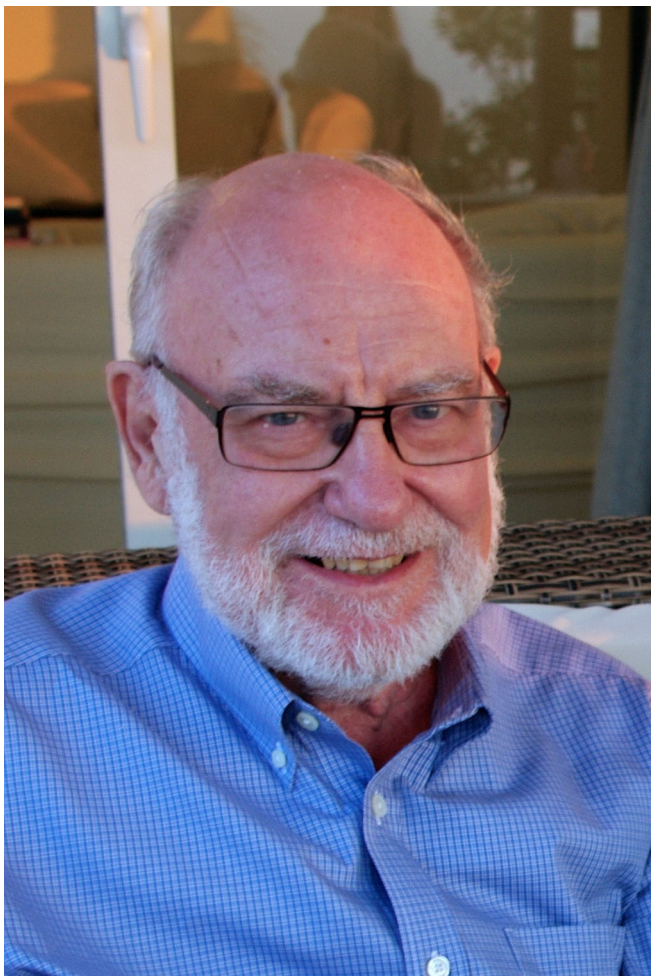
OBITUARY

Peter Henry Dawson, May 28, 1937–June 12, 2015

Peter Dawson had a remarkable career, with publications on gas kinetics, chemistry of low-pressure plasmas, surface science, thin films, and microstructures. To readers of this journal, he is most famously known for his many original contributions to mass spectrometry, especially the uses of 3D and linear quadrupole devices. His 1976 book, *Quadrupole Mass Spectrometry and its Applications* (Elsevier, Amsterdam 1976), remains the classic text on quadrupoles and was reissued in 1995 by the American Institute of Physics.

Peter was born in Melbourne, a village near Ashby de la Zouch, England. He received his B.Sc. at the University of London in 1958 and his Ph.D. in 1961 at King's College, working with A. J. B. Robertson. His post-doctoral fellowship was spent with A. W. Tickner in the Division of Applied Chemistry at the National Research Council in Ottawa. This work involved mass spectrometric characterization of ions in glow discharges. In 1963 he joined the Electron Physics section of General Electric in Schenectady, New York, as a Research Scientist. His first work on 3D traps appeared at that time. In 1969 he moved to Centre de Recherches sur les Atomes et Molécules at Laval University, where he studied vibrational energy transfer of diatomic molecules but continued to write papers on radio frequency (rf) mass analyzers. In 1974 he moved to the Division of Physics at the National Research Council of Canada (NRC) in Ottawa, where he spent much of his career and where much of his work in mass spectrometry was done. He moved up through the ranks, becoming the Director-General of the Institute for Microstructural Sciences in 1990.

Peter's major contributions to mass spectrometry were largely concerned with innovative investigations, both theoretical and practical, in what were at the time radically novel mass analyzers. His first patent in 1970 (filed in 1968), with co-inventor N. R. Whetten at GE, described an improved version of the original 3D quadrupole mass analyzer described in 1960 by Paul and Steinwedel. This was the first description of mass analysis with ion ejection from the trap. To obtain high sensitivity, it was necessary to increase the ionization (and hence storage time) and, thus, the number of rf cycles imposed on the ions. This also increased the mass resolution. In the method devised at GE, ions of a given *m/z* value were first selectively stored and then ejected



and measured. The mass spectrum was built up by isolating ions of different *m/z* values stepwise, measuring each one individually. This approach replaced earlier detection methods, for example resonant absorption of an auxiliary excitation rf as used independently by Fischer and Rettinghaus. The GE method is slow and is no longer used, but has the advantage of reduced space-charge effects. This early instrument received an IR100 Award (now known as the R&D Awards) in 1968, and was also promoted as a residual gas analyzer and ion gauge. This work was later expanded to a series of papers, including the 1969 construction of a large trap with z_0 = 2.0 cm and accurately machined hyperbolic electrodes that achieved a mass resolving power of 1000. These two authors also collaborated on factors controlling peak shapes in linear quadrupole and monopole

Electronic supplementary material The online version of this article (doi:10.1007/s13361-015-1234-7) contains supplementary material, which is available to authorized users.

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analyzers (a selected list of Peter's publications is presented as Supplementary Information).

His subsequent investigations in mass spectrometry at NRC were many and varied, and only some of the highlights can be mentioned here. In the early days of linear quadrupole mass analyzers, fringe fields at the analyzer extremities were regarded as a nuisance leading to ion losses. With characteristic flair, Peter showed that in fact, counter-intuitively, they could be manipulated to *increase* transmission provided that the residence time of ions in the fringe field is controlled correctly. In the same general vein, he also studied the often-ignored higher stability zones that are currently of interest because of the ability to obtain higher resolution, for example to separate $^{3}He^{+}$ from HD^{+} in fusion-reactor studies or to separate $^{56}Fe^{+}$ from ArO^{+} in ICP MS. A notable contribution with far-reaching consequences was his application of phase-space concepts from accelerator physics to permit calculation of the acceptance of linear quadrupole mass filters. These studies immediately explained why raising the gas pressure over a certain range in a linear ion guide increases transmission into a downstream quadrupole mass filter, first discovered ca. 1989 and published in 1992 by Douglas and French.

Peter's expertise in linear devices was essential for the ion optical design of the first commercial triple quadrupole (Sciex TAGA 6000, introduced in 1980). This system was unique in that it used large or no apertures between the quadrupoles and, crucially, with the rf of all three quadrupoles phase-locked. These innovations were patented by Barry French and Peter in 1981/82, and formed the basis of Sciex triple-quadrupole instruments for many years. The prototype in Peter's laboratory was used in the work leading to the first LC APCI MS/MS paper, with Jack Henion and Bruce Thomson in 1982. (Curiously this paper has been largely ignored, cited only four times plus in a book on quantitative mass spectrometry).

He also turned his mind to the problem of how to set the rf level on q2 (collision cell) of a triple-quadrupole. If it is scanned together with the rf applied to Q1, precursor ions will always be well confined in q2, but lighter fragment ions will suffer increased losses as the q2 rf increases. If it is scanned together with the Q3 rf, fragment ions will always be well confined but when low mass fragment ions are mass analyzed in Q3, the heavier precursor ions are less well contained. Eventually, it was found that scanning the q2 rf along with that of Q3 was the best compromise. This was largely Peter's work.

He was also responsible for many of the first papers on the fundamentals of ion dissociation in triple-quadrupoles, an interest that he pursued further for several years. Over this period he also published many studies of the effects of field distortions on the performance of quadrupole mass filters. Typically these studies included investigations of what seemed at the time to be mere curiosities (e.g., quadrupole mass filters with varying Mathieu parameter, and those with bent or bowed rods). One of these curiosity-driven investigations turned out to have significant commercial applications. The principles of the rf-only mass analyzing linear quadrupole were proposed by Brinkman in 1972 and later by others, but in 1985 Peter made more detailed studies and additional improvements. Eventually this led to mass-selective axial ejection from linear traps, used in the Q-Trap instruments marketed by Sciex.

Peter's long association with Sciex dates from his early collaborations with Barry French, then a Professor at the University of Toronto Institute for Aerospace Studies. (Sciex was founded by Barry and co-workers in the mid-1970s). Over the years, Peter also acted as a consultant for other manufacturers, including Thermo Scientific and Agilent.

In his role as leader of NRC's Institute for Microstructural Sciences, he became deeply involved in thin film technology. He became the first leader of a multi-company consortium that was involved in solid-state optoelectronics and worked with NRC to pioneer applications of wavelength division multiplexing technologies. In the early 1990s the NRC group had developed a fully automated manufacturing process for the deposition of complex optical coatings, and in 1997, demonstrated its ability to make prototype 200-GHz telecom filters. In 1998 after Peter had left NRC, he, together with his colleague Brian Sullivan, founded the private company Iridian Spectral Technologies, a model example of a highly successful spin-off from a government laboratory. After the difficult initial years in which NRC helped the new company get established, they increased their market share in telecom filters and diversified into other application areas and wavelength regions. As chairman of the company, Peter undertook a re-education in best practices for industrial management.

Peter had many interests other than science and technology. Together with two Iridian colleagues, he rescued "Books on Beechwood", a friendly neighbourhood bookstore on a street not far from the NRC building where he had spent so many fruitful years. The bookstore sponsors discussion groups on a range of subjects. Similarly, he was a supporter of the "Leading Note Foundation", an Ottawa group devoted to sponsoring musical education for children from all backgrounds, inspired by the famous El Sistema in Venezuela. He was also a devoted husband, father, and grandfather. For the present authors, he was an inspirational and supportive collaborator and colleague.

Acknowledgement: We thank Dr. Dawson's family for their permission to write this obituary and for making available information that would otherwise have been inaccessible. We also thank his former colleagues at Iridian for their assistance.

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