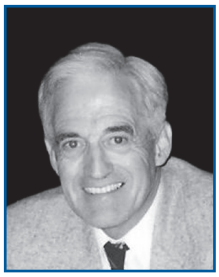
John Arthur Davies (1927-2016)



John Davies died on July 25, 2016, in Deep River, Ontario, Canada, his home for 60 years. He was a towering figure in the field of the interaction of energetic ions with matter.

His many awards include Fellow of the Royal Society of Canada and the Danish Academy of Sciences and Letters, the W B Lewis Medal of the Canadian Nuclear Society and others. In 2003, in Brazil, the Radiation Effects in Matter conference (REM3) was organized to honor John Davies for "his many and important contributions in the field of the ion beam interactions with matter, in particular, for his pioneering work regarding the channeling technique." To those of us in the field he was the epitome of an excellent experimentalist, constantly active, always involved and a wealth of knowledge and good science.

John was born 1927 in Wales and studied physical chemistry in England and Canada, where his family moved after World War II. He earned a PhD in electrochemistry from the University of Toronto and spent two years as a post-doctoral fellow at the University of Leeds in the UK before joining the Chemistry Division of Chalk River Nuclear Labs in 1956. He was also a Professor at McMaster University in Hamilton, Canada until his retirement in 1991. John maintained a strong Catholic faith throughout his life, and also was active in the community, serving on the local hospital board from 1974 to 1984, and on the local school board for a lesser time.

At Chalk River John's first task was to develop a technique to measure ranges of keV ions penetrating solids, so as to enable physicists to determine the energies of nuclear reaction products. The Davies ingenious solution was implantation of radioactive ions into a solid and layer-by-layer removal of the target material via electrochemical stripping, employing his chemistry expertise. This was the first demonstration of depth profiling, a prime task in micro-and nanotechnology, surface science and environmental science.

An intriguing feature in early measurements of ion range distributions was the occurrence of exponential tails of deeply penetrating ions, rather than the expected Gaussian distribution. This phenomenon found a surprising solution in a dialogue with Mark Robinson and Ordean Oen from Oak Ridge National Laboratory. In binary-collision simulations of ion penetration in single crystals, they found a pronounced dependence of nuclear stopping rates on the incident direction of the beam with respect to major crystalline symmetry directions. In a famous 1963 paper, Piercy, Brown, Davies and McCargo reported the application of the stripping technique to ions incident on a single crystal; thus the first experimental demonstration of channeling!

John had a special relationship with Scandinavia, particularly with leading groups in Stockholm, Sweden and Aarhus, Denmark. In 1964 he was appointed a visiting professor at Aarhus University, the home of the leading ion beam theorist, Jens Lindhard, who became interested in these single crystal results. In Lindhard's picture, the fundamental event was not the modified stopping power and range but the ion trajectory formed from the correlated scattering from a string of atoms, rather than a random array of single atoms. This led to the prediction of a drastic dip in the yield of nuclear reactions and other "close" (nuclear dimensions) collisions when the beam was incident along major crystalline direction. In a classic 1964 paper Bøgh, Davies and Nielsen demonstrated this for a p-Υ reaction in silicon.

In his contribution to a Festschrift for Jens Lindhard's 60th birthday John called 1964 the year of the channeling explosion. He writes: "From an Aarhus perspective, probably the most important event was that I had brought with me from CRNL the preprint of Geoff Dearnaley's pioneering experiment, confirming channeling for MeV proton energies; I had also brought a pocketful of W and Al single crystals." However, this is far too modest. John became a leading figure in the legendary 'Aarhus Saturday meetings' where experiments on channeling were critically discussed, and he became a mentor for a group of young physicists in Aarhus. In the following years young scientists from the physics institute in Aarhus and other laboratories active in channeling were invited to Chalk River, and the collaboration with John and the warm hospitality of the whole Davies family, in particular his wife Flo, led to lifelong friendships.

John recognized the power of the channeling technique for analyzing the structure of a crystal and its defects. A major breakthrough occurred on the formation of a collaboration with James W. Mayer, a pioneer in semiconductor materials and detectors. Together with Lennart Eriksson, a visiting scientist from Stockholm, this team developed channeling as a tool to determine lattice locations of impurities as well as damage profiles in semiconductor crystals. Thus John was a founding father of ion implantation and ion beam analysis of materials. This research led to a breakthrough in semiconductor science and technology. These ion beam processes have become essential components enabling the Si revolution.

John played an important role in almost all aspects of channeling, including the study of surface relaxation with Peter Norton at CRNL and measurements of very short nuclear lifetimes with Walt Gibson and others. He was a critical member

of numerous international collaborations that studied many basic and applied aspects of channeling. He also participated in studies of the channeling of very energetic heavy ions at the accelerator facility at CRNL and even in studies of positron channeling. Deservedly, he is internationally recognized as the leading figure in the development of channeling, from the pioneering range studies to a very broad field with important applications.

Beyond channeling John had a hand in almost every "ion beam interaction" innovation. These varied from new ways of doing materials analysis such as energy recoil spectroscopy to anomalies in ranges and "strange" sputtering in complex insulators. The latter work produced new insights into much discussed ion beam phenomena such as thermal spikes. In our field he knew his trade better than anybody (and he let us know it too). He was a walking library and a vocal and critical presence at conferences, workshops and in casual conversation.

Those of us in the ion beam community enjoy a special relationship. This has been fostered by many inter-laboratory visits, long and short, by attendance at family-involved Gordon conferences where we watched the kids grow and numerous personal involvements. John set the style for this. John and Flo generously opened their cottage first at Smoke Lake and later at Lyell Lake to our families. By way of the celebration of life's events, some sad, we became family. John's and Flo's warm hospitality, ability to engage colleagues, keen personal interest and friendship have kept our atomic collision physics community together and vibrant for over sixty years.

Jens Ulrik Andersen, Leonard Feldman, Frans Saris, Peter Sigmund, and Bruce Winterbon