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From John Spence's Postdoc Time in Oxford to my Research on GaN and Graphene

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John Spence was arguably the greatest electron microscopist of his generation. I had the pleasure of spending three years with John when he came to Oxford as a Postdoctoral Research Fellow in 1973, which started my life-long friendship with him. In this paper I will explain the significance of these three years, which John told me were a major turning point in his life, and finish with describing my recent work on GaN and graphene.

Before coming to Oxford, John obtained his PhD in Melbourne, where he sat at the feet of two scientific giants: John Cowley and Alexander Moodie. In the 1950s and 1960s, John and Alec developed the multi-slice theory for interpreting electron microscope images. It used the concept of the incident electron beam travelling through many crystal slices of very small thickness and became known as the Cowley-Moodie theory. John Spence had numerous discussions with John and Alec about their complex theory during his PhD studies and thus finished his PhD with a high level of expertise in both experimental electron microscopy and in the multi-slice theory of image interpretation.

At the same time as Cowley and Moodie were developing their multi-slice theory, three scientific giants in the Cavendish Laboratory at Cambridge University, Hirsch, Howie and Whelan, were developing a very different theory of electron diffraction. Instead of mathematically slicing up the crystal into many very thin slices, they considered the electron beam being scattered by the crystal as a whole and solved the Schrödinger equation for the incident electron travelling through the crystal. Peter Hirsch and Mike Whelan moved from Cambridge to the Oxford Metallurgy Department in 1966, Peter being the inspirational Head of Department.

John Spence left Melbourne in 1973 for a three-year Postdoctoral Research Fellowship in the Department of Metallurgy at Oxford. These three years were of fundamental importance for John's future research because it was in Oxford that he learnt the dynamical theory of electron diffraction in terms of Bloch waves and dispersion surfaces. John's supervisor in Oxford was Mike Whelan, who gave him the challenging project of Single Atom Imaging, using the Department's JEOL 100B electron microscope with its top-entry stage. John shared an office with David Cockayne and Ray Egerton. I oversaw the Oxford 1 MeV electron microscope and had an office nearby. John worked on imaging heavy atom clusters on few-layer graphene films, cleaved from graphite using sticky tape, as instructed in TEM books on sample preparation. (The same method was re-discovered in 2004 for the preparation of graphene).

Alongside his experimental work, John studied electron diffraction theory, and he, David, Ray and I had a huge number of discussions about Bloch waves and defects in crystals, particularly dislocations, with John asking new thought-provoking questions almost every day. It was a wonderful and stimulating time. John published a paper in which he derived the Cowley-Moodie multi-slice equations from the Howie-Whelan equations for dynamical scattering, thus proving the equivalence of the two methods,

which was far from obvious. The year after he left Oxford, John wrote his classic textbook "High-Resolution Electron Microscopy", now in its 4th edition. John left Oxford with a deep understanding of the elastic and inelastic scattering of electrons by crystals and he was also a superb experimentalist. These skills underpinned and enabled all his future work.

John and I subsequently spent sabbatical leave periods at each other's labs and had a great friendship until his untimely death. For example, in 1984, I was working on channelling radiation using a semiclassical "wavon" theory, in which the lateral oscillations of the electrons travelling through the crystal due to Bragg diffraction give rise to monochromatic X-rays. John took sabbatical leave and joined me in Oxford, and together we produced a Bloch wave theory of the effect [2]. We discussed the possibility of using this effect for an x-ray laser, which may have seeded the idea of John later using an X-ray free-electron laser for his brilliant studies of the structure of proteins with Henry Chapman.

Electron microscopy was my main research theme until about the year 2000, when I moved into research on GaN for LEDs and power electronics. In 2015 I moved into graphene research, with the aim of making graphene useful for electronic devices. In my GaN and graphene research I have found electron microscopy to be essential, and I continue to benefit from the many discussions I had with John and from his superb books on electron microscopy. I will give examples in my presentation.

Finally, John was not only a world-leading electron microscopist, he was also an accomplished musician (piano, flute, guitar), and a keen pilot and sailor. His recent book, Lightspeed [3], is a masterpiece. John was remarkably gifted, very generous, and great fun!

Figure: John at his piano and with his flute.

References

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