

Various reasons for liking Niels Bohr

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I have been asked to say some light after-dinner words about one of my heroes, Niels Bohr. Please be warned, I shall not be scholarly. I am relying on my own memories from up to 60 years ago and on anecdotes that I have heard or read.

My title is: “Various reasons for liking Niels Bohr”.

My first reason for liking Niels Bohr is that he was a great encourager. I learnt this as an undergraduate, from my tutor, Heinrich Gerhard Kuhn, who completed his doctorate in Göttingen in 1926: a rather exciting time. He told me that: “Bohr liked young people with crazy new ideas. He encouraged them to be even more bold.”

Not only was Bohr an encourager, he was in many cases a life-line. He got funds from Rockefeller and Carlsberg for scientists to come to Copenhagen. Then he went on trips to USA to “sell Jewish refugee physicists”, in the vivid words of Viki Weisskopf. Thanks to such efforts by Niels Bohr, Harald Bohr, Frederick Lindemann, Leo Szilard and many others, Britain and North America were greatly enriched by a fine array of talent fleeing persecution by Adolf Hitler.

Here I should like to draw a parallel with the effect on British music of the Jewish diaspora, recounted by another of my heroes, the fine mezzo-soprano Janet Baker. She has explained how music-making in Britain was galvanized by the rigour, skill and dedication brought by refugees from continental Europe.

My next reason for liking Niels Bohr is that he had a sense of fun. I very much like his dictum: “Es gibt Dinge die eben sind so ernst, dass man darüber nur scherzen kann.” There are things that are so serious that one can only joke about them. Here I recall my time in the CERN theory group, which had been founded in Copenhagen before the first accelerator was built in Geneva. Later, in the mid 70s, some of us younger physicists felt that the theory group showed less joy than we had recently been used to in California. So we set up the “People’s Communication Collective”, which Leon Vanhove called “CoCo the Clown”. Our manifesto was simple: “no sniping in seminars; a coffee machine for chat by the pigeon holes; everyone, great or small, to give a 3-minute description of their current interests”.

CoCo was quite successful and led, I like to think, towards the theory-group Christmas plays, where everyone was able to enjoy making fun about everything, with even Vanhove volunteering to play the dinosaur. These plays followed the tradition of the Niels Bohr Institute where, for example, on 12 April 1932 young people put on a play called the “Copenhagen Faustparodie” with Niels Bohr portrayed as God, who seemed unable to finish any coherent sentence. I read about this in 1966, thanks to a lively English translation of the play, by Barbara Gamov.

I am also reminded of a description of Bohr, aged 50, running up the Institute’s staircase to get to the library, so as to be first to reach the table tennis table, where he could beat almost everyone. He did however ban the use of books as table tennis bats.

Another reason that I like Niels Bohr is that he did some of his best work in my home town, Manchester, the birthplace of James Prescott Joule’s mechanical equivalence of heat, of the Bohr-Rutherford atom, and of Henry Moseley’s elucidation of the periodic table by nuclear charge. Incidentally, Joule’s work, like Bohr’s, was funded by a brewery. But in Joule’s case his family’s brewery made real top-fermented ale, while Bohr had to make do with bottom-fermented lager from his sponsor, Carlsberg.

At the time of Bohr’s death, on 18 November 1962, I was a keen 15-year-old student of physics at the Manchester Grammar School. But there was a strange unwritten rule: quantum theory was X-rated material, deemed to be unsuitable for any person under the age of 18. When I took my Oxford entrance examination at 17, there were no questions on quantum theory. I knew the heat equation and was taught how to use complex numbers. But I was not supposed to know that Schrödinger’s wave equation is a complex version of the heat equation. I knew about matrices, but was not supposed to know about spin or the quantization of angular momentum.

Yet I was rescued from ignorance by a chemistry teacher who talked – rather vaguely – about s and p levels and something called sp^2 hybridization, which was supposed to explain how a double bond in the benzene molecule is neither in one place nor the other, but somehow both. It was all rather confusing: like learning the facts of life from illicit sources. Things were made clearer by Linus Pauling’s “Nature of the Chemical Bond”, which had a lot to say about Bohr.

I also like Bohr for being a pipe smoker. Between school and university I taught for 9 months in Central Africa. My students in Zambia were older than I was. So I decided to grow a beard and smoke a pipe.

There is an interesting book “The Fly in the Cathedral” by Brian Cathcart, about Cockcroft and Walton in Cambridge. They were worried that when Rutherford came into their lab he would knock out his pipe dangerously close to their apparatus. However, he never caused any damage. Of course, smoking is a bad habit. Yet I have been addicted to it for 57 years. So I show you now my best Meerschaum, which I shall light up outside, after this banquet, in memory of the pipe-smokers’ model of the atom, by Niels Bohr and Ernest Rutherford.

More seriously, another reason for liking Niels Bohr is that he was, first and foremost, a thinker: a natural philosopher. For him concepts were more important than equations. I admire this, because for me it has often been the other way around and there I am the loser. Here I give 3 extracts, in translation, from letters between Niels and his fiancée Margrethe Norlund, 110 years ago.

23 January 1912: Margrethe to Niels, then in Cambridge:

“How nice that you are going to Manchester for the next term, and I quite quite agree with you that it is best and most sensible to go just there.”

27 May 1912: Niels, now in Manchester, to Margrethe:

“It may be that it is very silly and that it amounts to nothing at all, as usual; but I believe that perhaps I have found out a little bit.”

16 July 1912: Niels, still in Manchester, to Margrethe:

“So many thoughts have rushed through my little head this year, and I have had so many visions; but in my hands there is but a dead treasure, for it is but indications of the most fleeting fantasy, which I cannot redeem, indeed scarcely even have the strength to hold back. But it is nevertheless the most valuable and only thing that I possess, and with that I come to you, and ask you, the largest and best and fullest human being, to redeem it for me, for us.”

I find that dialogue between Emil’s great-grand-parents very moving. I hear something of Goethe in the third extract and also the complementarity of intellectual and physical love.

Bohr’s enthusiasm for complementarity is a fine example of natural philosophy. No single picture can comprehend all situations. Matter and radiation propagate as waves, yet interact as particles. Momentum and position are complementary variables, each is vital to our understanding of nature, yet accurate specification of one entails less certainty of the other.

Another example: my tutor, Heine Kuhn, took great store from Bohr's correspondence principle, whereby quantum mechanics connects to classical physics in the limit of large quantum numbers. Here I shall recount a happy occasion were I made an utter fool of myself in a tutorial. Dr Kuhn was extolling the virtue of the correspondence principle. I went to his bookshelves, took down the book that he had written on Atomic Spectra, opened it at a place that I knew, with an ornate formula for hyperfine structure of atoms with a nuclear quadrupole moment, nuclear spin and active electronic spin and angular momenta.

"Surely, Dr Kuhn, you could never have obtained this from the correspondence principle. You must have needed Wigner's Clebsch-Gordan coefficients". His face lit up with joy. "Oh, Broadhurst, you make me so happy. You do not know how wrong you are. We guessed this from Bohr's correspondence principle, before Racah or Wigner could derive it properly."

Dr Kuhn sent me to work in Ottawa in the group of his distinguished friend and contemporary, Gerhard Herzberg. I was also fascinated by dinner talk with Heine's wife, Marie Bertha Nohl, cousin to Paul and Ludwig Wittgenstein, and daughter of a professor of philosophy at Göttingen, where she was befriended by Emmy Noether. After Heine's death in 1994 she let the Open University study his notes of lectures by Courant and Hilbert in Göttingen. Heine had told me why Heisenberg's "Dreier Männer Arbeit", the 3-man-work of 1926, needed three authors. Max Born knew that Pascual Jordan had also attended these lectures and so was much more familiar with matrices than Heisenberg was.

Bohr was instrumental in the links between Copenhagen and Göttingen. Heisenberg remarked, on Bohr's Göttingen lectures in 1922: "We could clearly sense that he had reached his results not so much by calculation and demonstration as by intuition and inspiration, and that he found it difficult to justify his findings before Göttingen's famous school of mathematics". Another example of complementarity, I suggest.

An amusing aspect of Bohr's life is his good luck. This has been attributed, apocryphally, to his possession of a horseshoe, because "they bring luck even to those who do not believe in them". In 1981 I had the privilege of a long conversation with Paul Dirac, who was unusually forthcoming about his own successes and failures. His great regret was that he had never made sense of the infinities of the point electron. Dirac was by then remote from, and sceptical about, the successes of the theory of quantum electrodynamics that he had founded.

I asked him how he regarded the amazing agreement between theory and experiment for the radiative corrections to the magnetic moment of the electron. Dirac replied, quite equably: “There are other examples of getting the right answer for the wrong reason”.

I understood this as an allusion to the fine structure of the hydrogen atom. Bohr had encouraged Paul Epstein, Karl Schwarzschild and Arnold Sommerfeld to extend his non-relativistic quantization of the hydrogen atom by including relativistic action-angle pairs for the radial and angular co-ordinates. This resulted in a formula for the fine structure, by Sommerfeld in 1916, that is identical, to all orders in the fine structure constant, to the much clearer result derived by Charles Galton Darwin, in 1928, using Dirac’s theory of electron spin. I can sympathize with Dirac’s frustration about this. It appears that the Bohr-Sommerfeld pseudo-derivation results from a lucky mistake: Sommerfeld used an azimuthal component of angular momentum where he should have used the magnitude of angular momentum.

Incidentally, Denmark is fortunate in having a distinguished historian of science, Helge Kragh, who has done much to chronicle the early days of both quantum theory and cosmology. I hope that he would excuse my choice of perhaps unreliable anecdotes.

I conclude by commending Niels Bohr for being tough-minded. In his dialogues with Einstein he clung tenaciously to the uncertainty principle. Our conference poster portrays rather well the respect that each had for the other. Albert may have been quicker in thought. Yet eventually Niels overcame the claimed counterexamples. On one notable occasion, at the Solvay Congress of 1930, Bohr was able, eventually, to refute Einstein’s argument by invoking the equivalence principle of general relativity.

Another example of Bohr’s tenacity concerns a claim, by Lev Landau and Rudolf Peierls, that quantum theory sets limits for uncertainties of determinations of electromagnetic fields. That was anathema to Bohr, who wanted to consider these fields as classical. Viki Weisskopf and John Heilbron have described rather vividly how fiercely Bohr sought to oppose Landau and Peierls and how pleased Bohr was when Leon Rosenfeld found an objection to their work.

I have missed out many other reasons for liking Niels Bohr. Please supply some of your own, from science, philosophy and human values.

Meanwhile, I invite you to stand, if you wish, to grab a glass and to join me in celebrating Niels Bohr’s humanity and scientific legacy.