

Bibliography for Suspended in Language
by Jim Ottaviani and Leland Purvis (Ann Arbor, MI: G.T. Labs, 2004)

Primary Sources

The value of having access to original sources such as these is self-evident, so I won't dilute my gratitude to the American Institute of Physics and the Niels Bohr Institute by editorializing about them:

Oral History Interview with Niels Bohr, 1962 October 31 to 17 November.
Oral History Interview with Margrethe Bohr, 1971 August 11.
Oral History Interview with Werner Heisenberg, 1962 November 30 to 12 July 1963 and 1970 June 16.
Oral History Interview with Betty Schultz, 1971 March 25 and 26.
All courtesy of the American Institute of Physics Niels Bohr Library and Archives.

The Niels Bohr Institute in Copenhagen has made the Bohr-Heisenberg letters, in all their glorious ambiguity, available at <http://www.nbi.dk/NBA/papers/introduction.htm> years earlier than planned.

The Institute has also made the series *Niels Bohr Collected Works* possible—these volumes (10 to date, published by North-Holland) provide published papers and facsimiles of original documents written by Bohr, along with many rare photographs.

The University of New Hampshire offers excerpts from Werner Heisenberg's diaries, letters, and reminiscences from his sons at <http://werner-heisenberg.unh.edu>. Of particular interest is a letter Heisenberg wrote to his wife Elisabeth while in Copenhagen. She dated it September, 1941. Beyond this being at odds with most other accounts that place the meeting in October, it doesn't clear things up much. If only we could hear him "...tell you everything that happened to me" as he promised to do at the end of this note to her...

Books

Faust and Journal of Jocular Physics volumes I-III
(Reprinted on the Occasion of the Niels Bohr's Centenary, October 7, 1985.)
This facsimile edition, given to me by Katy Hayes, provided anecdotes, laughs, and a feel for *der Kopenhagener Geist* of long ago.

The Niels Bohr Institute: October 7, 1965

This pamphlet, given to me by Felicity Pors during my visit to Copenhagen, commemorates the Institute's name change from the "Institute for Theoretical Physics of the University of Copenhagen" to the name it had unofficially for many years: "The Niels Bohr Institute." Plenty of pictures and a concise history made this the most helpful short course in the history of the Institute I found.

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Niels Bohr and the Development of Physics edited by Wolfgang Pauli
(New York: McGraw-Hill Book Co., 1955.)

An unusual *Festschrift*, in that its contributors actually made it a tribute to Bohr rather than using it as just another opportunity to add a line to their list of technical publications. For me, the most important article in it is Heisenberg's, which is simultaneously straightforward, difficult, and eloquent.

Niels Bohr: His Life and Work as Seen by His Friends and Colleagues, edited by Stefan Rozental
(Amsterdam: North-Holland Publishing Co., 1967.)

If you wanted to rank the books I relied on by the number of important passages I marked, this comes in at a close third to Pais' biography and French and Kennedy's omnibus volume. It falls somewhere in between them in terms of accessibility, but it's the most consistently personal of the three.

Niels Bohr Philosophical Writings, volumes I-IV by Niels Bohr
(Woodbridge, CT: Ox Bow Press, 1987, 1998.)

The subtitles (such as "Essays on atomic physics and human knowledge," and "Causality and complementarity") indicate the breadth of Bohr's published work outside of physics journals. You won't find these books of his popular writings on any best-seller lists, but dipping into them will give you a feel for Bohr's writing style without all that messy math stuff that you'd probably want to skip over anyway.

Niels Bohr: A Centenary Volume edited by A.P. French and P.J. Kennedy
(Cambridge, MA: Harvard University Press, 1985.)

I'll admit it: I initially bought this for the pictures. But beyond the photos, this book is full of anecdotes, sidebars, and science. No single volume I've seen gives a better overview of Bohr's life and work, so if you've enjoyed *Suspended in Language* please seek this out as well.

The Atomic Scientists: A Biographical History by Henry A. Boorse, Lloyd Motz, and Jefferson Hane Weaver
(New York: Wiley Science Editions, 1989.)

From Lucretius to C.N. Yang & T.D. Lee, thousands of years of physics history and personalities come to life in this essential reference.

The Character of Physical Law by Richard Feynman
(Cambridge, MA: The M.I.T. Press, 1965.)

An excellent introduction to the nature of modern physics, Feynman's discussion of the double-slit experiment is the clearest I've read.

In Search of Schrödinger's Cat: Quantum Physics and Reality by John Gribbin
(New York: Bantam Books, 1984.)

You can tell by the broken spine and smudged pages of my copy that this is still one of the best introductions to the unlikely ideas of quantum physics I've read. (No assembly, batteries, or math required!) Recommended without reservation.

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Copenhagen by Michael Frayn
(New York: Anchor Books, 1998.)

See this play if you ever have the opportunity. (There's also a PBS adaptation of it for television, available on DVD.) Though it takes dramatic liberties, it is, after all, a drama, and a terrific one. The interest it sparked in the Bohr-Heisenberg wartime meeting contributed to the Niels Bohr Archive releasing Bohr's unfinished letters years earlier than they had intended.

Introducing Quantum Theory, by J.P McEvoy and Oscar Zarate
(Cambridge: Icon Books, 1996.)

A helpful introduction to quantum theory which works well in tandem with Gribbin's book. Oscar Zarate's caricatures of famous physicists are particularly good.

Niels Bohr: The Man, His Science, and the World They Changed by Ruth Moore
(New York: Alfred A. Knopf, 1966.)

An accessible biography of Bohr, written in a somewhat breathless style that may not satisfy serious historians but makes it worth seeking out for the rest of us.

Niels Bohr's Times in Physics, Philosophy, and Polity by Abraham Pais
(Oxford: Clarendon Press, 1991.)

The most comprehensive book about Bohr I know of. Pais was a first-rate physicist as well as a friend and confidant of both Einstein and Bohr. His insights into their personalities and science are singular...as is the structure of the book, (What was he thinking?) Anyway, if you can get past the odd narrative, between this and French and Kennedy's volume you'll get a complete and compelling picture of Niels Bohr as scientist and *mensch*.

Thirty Years that Shook Physics: The Story of Quantum Theory by George Gamow
(Garden City, NY: Doubleday & Company, 1966.)

A great source of anecdotes about all the superstar physicists of the early 20th century. Gamow was one of them too, but lives on mostly via his cartoons and humorous writing—he was a frequent contributor to the *Journal of Jocular Physics*, and the illustrator of “Copenhagen Faust.”

The Atomic Scientists by Boorse, Motz, and Weaver (New York: Wiley, 1989)

This collection of articles introduces all of the major players in the development of our view of the world below.

A Dictionary of Scientists (Oxford: Oxford Paperback Reference Series, 1999)

Brief overviews of the careers of 100s of scientists

History of CERN (Volume I) by Hermann, Krige, Mersits, and Pestre (Amsterdam: North Holland, 1987)

This detailed history of the early days of CERN covers both the physics and the politics of creating the quintessential international laboratory

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The Timetables of History by Bernard Grun (New York: Touchstone/Simon & Schuster, 1982)

All of world history (with a European tilt to it) on a multi-track timeline covering history, politics, literature, theater, religion, philosophy, learning, visual arts, music, science, technology, growth, and daily life.

The Scientific Companion by Cesare Emiliani (New York: Wiley, 2nd Edition, 1995)

Like the dictionary above, Emiliani's book isn't really something you read, but it's good to have handy when you're calculating things like the odds of successful teleportation.

Physics and Philosophy (New York: Harper Brothers 1958) & *Physics and Beyond* (New York: Harper and Rowe, 1971) by Werner Heisenberg

Heisenberg's memoirs give a fine look inside this brilliant mind.

Hitler's Uranium Club by Jeremy Bernstein (Woodbury, New York: American Institute of Physics, 1996)

What did the German atomic scientists really know, and do, during the war? The British tried to find out, and did a remarkably good job of it!

Atoms in the Family (Chicago: University of Chicago Press, 1954) by Laura Fermi

Very personal and a whole lot of fun—the spouses of genius don't always get their say.

A Tale of Two Continents: A Physicist's Life in a Turbulent World by Abraham Pais (Princeton, NJ: Princeton University Press, 1997)

Also very personal, though just a little less fun—the scientist in the company of genius gets his say. An excellent book by he who was so wise.

The nice thing about most non-fiction books is the titles make their contents obvious. (Quick: If you only had *To Kill a Mockingbird* or *Ulysses*—the one by Joyce!—to go on, what would you say they're about?) So the following books come with recommendation but without comment: *Uncertainty: The Life and Science of Werner Heisenberg* by David Cassidy, *Mr. Tompkins in Wonderland* (OK, maybe not all titles are obvious!) and *Mr. Tompkins Explorers the Atom* by George Gamow, *Schrödinger: Life and Thought* by Walter Moore, *Inward Bound: Of Matter and Forces in the Physical World* and *Subtle is the Lord: The Science and Life of Albert Einstein* by Abraham Pais, *Heisenberg's War* by Thomas Powers, *The Making of the Atomic Bomb* by Richard Rhodes (yes, I recommend this book every time), *Einstein for Beginners* by Joseph Schwartz and Michael McGuinness, *Lise Meitner: A Life in Physics* by Ruth Lewin Sime, and all three volumes of *The World of Physics*, edited by Jefferson Hane Weaver.

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Articles

“The Philosophy of Niels Bohr” by Aage Petersen, *Bulletin of the Atomic Scientists*, vol. 19., no. 7, September 1963, 8-14.

The first source I read the “suspended in language” quote in.

“Did Bohr Share Nuclear Secrets?” by Hans A. Bethe, Kurt Gottfried, and Roald Z. Sagdeev, *Scientific American*, vol. 272, no. 5, May 1995, 84-90; “The Scientist and the Statesmen: Niels Bohr’s Political Crusade during World War II” by Finn Aaserud, *Historical Studies in the Physical and Biological Sciences*, vol. 30, no. 1, 1999, 1-47; and “What Did Heisenberg Tell Bohr about the Bomb?” by Jeremy Bernstein, *Scientific American*, vol. 272, no. 5, May 1995, 92-97.

These are great pieces on the wartime intrigues Bohr found himself involved in.

“Quantum Teleportation” by Anton Zeilinger, *Scientific American*, vol. 282, no. 4, April 2000, 50-59 and “Trillions Entwined” by Graham P. Collins, *Scientific American*, vol. 285, no. 6, December 2001, 26.

A more thorough accounting of teleportation, entanglement, qubits and other spookiness. The first article even has a one-page comic strip—the mark of quality in any writing about science.

The following lectures/papers were presented at the “Copenhagen Symposium” held in Washington DC on March 2, 2002, sponsored by The Graduate Center of the City University of New York: “Notes on Comparing the Documents of Heisenberg and Bohr Concerning their Encounter in 1941” by Gerald Holton; “Frayn’s ‘Heisenberg’: Fact or Fiction” by Jochen H. Heisenberg; “The Drawing or Why History is Not Mathematics” by Jeremy Bernstein; “‘A Great and Deep Difficulty’: Niels Bohr and the Atomic Bomb” by Richard Rhodes; “The Bohr-Heisenberg Meeting from a Distance” by Finn Aaserud; “On the Copenhagen Interpretation of Quantum Mechanics” by John Marburger.

All are available at <http://web.gc.cuny.edu/ashp/nml/artsci/symposium.html> and provide accounts of Bohr and Heisenberg’s meeting, their troubled relationship with each other, and the history they made. Jochen Heisenberg’s memories of his father are particularly affecting.

“The Niels Bohr Archive” by Finn Aaserud, *Uppsala Newsletter*, no. 15, Spring 1991, 1-3 and “The Physical Tourist: Historical Sites of Physical Science in Copenhagen” by Felicity Pors and Finn Aaserud, *Physics in Perspective*, vol. 3, 2001, 230-248.

“Werner Heisenberg and Albert Einstein” by Gerald Holton, *Physics Today*, vol. 53, no. 7, July 2000, 38-42.

“The German Uranium Project” by Hans A. Bethe, *Physics Today*, vol. 53, no. 7, July 2000, 34-36.

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“Copenhagen Revisited” by Michael Frayn, *The New York Review*, March 28, 2002, 22-24.

“What Bohr Remembered” by Thomas Powers, *The New York Review*, March 28, 2002, 25-26.

“P.A.M. Dirac and the Beauty of Physics” by R. Corby Hovis and Helge Kraghe, *Scientific American*, vol. 268, no. 5, May 1993, 104-109.

“Heisenberg, Uncertainty and the Quantum Revolution” by David C. Cassidy, *Scientific American*, vol. 266, no. 5, May 1992, 106-112.

“The Top-Secret Life of Lev Landau” by Gennady Gorelik, *Scientific American*, vol. 277, no. 2, August 1997, 72-77.

“Quantum Philosophy” by John Horgan, *Scientific American*, vol. 267, no. 1, July 1992, 94-104.

“Bringing Schrödinger’s Cat to Life” by Philip Yam, *Scientific American*, vol. 266, no. 6, June 1997, 124-129.

“The Duality in Matter and Light” by Berthold-Georg Englert, Marlan O. Scully, and Herbert Walther, *Scientific American*, vol. 271, no. 6, December 1994, 86-92.

“A Historical Perspective on Copenhagen” by David C. Cassidy, *Physics Today*, vol. 53, no. 7, July 2000, 28-32.

“Faster than Light?” by Raymond Chiao, Paul G. Kwiat, and Aephraim M. Steinberg, *Scientific American*, vol. 269, no. 2, August 1993, 52-60.

Sites

Visit the terrific “Visual Quantum Mechanics” at <http://phys.educ.ksu.edu/> to see electron waves in action!

For something in a more classical mode, you can see a tippe-top simulation at <http://www.physik.uni-augsburg.de/~wobsta/tippetop/>, but you really should try and get a hold of one yourself. And you can (while supplies last) by visiting <http://www.gt-labs.com/>.