Reading list for the philosophy of quantum mechanics

This is a fairly thorough reading list on philosophy of QM; it contains more material on each topic than is practical for a weekly tutorial, but it may serve as a basis for constructing tutorial reading lists, as a source for further reading or revision, or as a starting point for anyone considering writing a thesis on one of these topics.

Contents

General texts

Introductory

D. Albert, *Quantum Mechanics and Experience*, (Harvard University Press, 1994)

A. Rae, *Quantum Mechanics: Illusion or Reality?* (Cambridge, 2004)

E. Squires, *Conscious Mind in the Physical World*, (Adam Hilger, 1990)

Slightly more advanced

J.S. Bell, *Speakable and unspeakable in quantum mechanics*, (Cambridge, 1987)

R.I.G. Hughes, *The Structure and Interpretation of Quantum Mechanics*, (Harvard University Press, 1989)

M. Redhead, *Incompleteness, Nonlocality and Realism*, (Clarendon Press, 1989)

D. Home, *Conceptual Foundations of Quantum Physics*, (Plenum,1997)

D. Wallace, "Philosophy of Quantum Mechanics" (available on Weblearn)

Formalism of quantum mechanics

A handout to accompany the Intermediate Philosophy of Physics lecture course is available on Weblearn.

Some physics textbooks which present the formalism at a suitable level are:

P.A.M. Dirac, *The Principles of Quantum Mechanics*, 4th edition (Clarendon Press, 1958).
A classic; still relevant and readable.

J.S. Townsend, *A Modern Approach to Quantum Mechanics* (McGraw-Hill, 1992.)

C. Cohen-Tannoudji et al, *Quantum Mechanics* (Wiley, 1977).
A bit dry, but more technically careful than some.

S. Gasiorowicz, Quantum Physics (3rd edition). Wiley, 2003.

Mathematically more careful (but more challenging) presentations may be found in

L.E. Ballentine, *Quantum Mechanics* (Prentice Hall, 1990).
Beware of Ballentine's strong views on the 'true' interpretation of QM, which are not distinguished from the mathematics!

C.J. Isham, *Lectures on Quantum Theory: mathematical and structural foundations* (Imperial College Press, 1995).
Unfortunately rather hard to find in Oxford libraries.

K. Hannabuss, *An Introduction to Quantum Theory* (Clarendon Press, 1997).
Aimed at undergraduate mathematicians.

A. Peres, *Quantum Theory: Concepts and Methods* (Kluwer, 1993).
Again, beware of the author's strong opinions about the right interpretation!

For a really systematic reference (albeit one rather short on physical insight) see the first few chapters of:

R.I.G. Hughes, *The Structure and Interpretation of Quantum Mechanics* (Harvard, 1989)

or

R. Clifton, "Introductory Notes on the Mathematics Needed for Quantum Theory", available online at http://philsci-archive.pitt.edu/archive/00000390/.

For formal details of the mathematics used, shorn of any physical interpretation, try:

P. Halmos, *Finite-Dimensional Vector Spaces* (Springer- Verlag, 1958).

N. Young, *An Introduction to Hilbert Space* (Cambridge, 1988).

The measurement problem

Introductory accounts

D. Albert, *Quantum Mechanics and Experience* (Harvard University Press, 1992), Chapter 4 (pp. 73-79) and part of chapter 5 (pp. 80-92).

J.S. Bell, "Quantum Mechanics for Cosmologists", in *Quantum Gravity 2,* C. Isham, R. Penrose and D. Sciama (ed.) (Oxford, 1981), pp. 611-637. Reprinted in J.S.Bell, *Speakable and Unspeakable in Quantum Mechanics* (Cambridge, 1987), pp. 117-139. Sections 1-3.

R. Penrose, *The Emperor's New Mind* (Vintage, 1990), chapter 6, up to the section "Objectivity and Measurability of Quantum States", and from the section "Schrodinger's Cat" to the end (page numbers vary between editions, sorry!)

E Squires, *Conscious Mind in the Physical World* (Adam Hilger 1990), chapter 11, pp. 177-203.

More advanced discussions

D. Home, *Conceptual Foundations of Quantum Physics: an overview from modern perspectives* (Plenum, 1997). Chapter 2.

M.L.G. Redhead, *Incompleteness, Nonlocality and Realism*, (Clarendon Press, 1989) Chapter 2 (pp. 44-70).

S. Saunders, "What is the problem of measurement?", available at http://users.ox.ac.uk/~lina0174/Harvard.htm

Nonlocality: the EPR argument and the Bell inequality

Core Reading

M. Redhead, *Incompleteness, nonlocality and realism: a prolegomenon to the philosophy of quantum mechanics.* (Clarendon, 1987). Chapter 3 (pp. 71-81).

J. S. Bell "Bertlmann's socks and the nature of reality". *Journal de Physique,* Colloque C2, suppl. au numero 3, Tome 42 (1981), pp. C2 41-61. Reprinted in J.S.Bell, *Speakable and Unspeakable in Quantum Mechanics* (Cambridge, 1987), pp. 139-158.

M. Redhead, *Incompleteness, nonlocality and realism: a prolegomenon to the philosophy of quantum mechanics.* (Clarendon, 1987). Chapter 4 (pp. 82-118), esp. sections 4.1, 4.5, 4.6.

R. I. G. Hughes, *The Structure and Interpretation of Quantum Mechanics* (Harvard, 1989), sections 6.2, 6.3, 6.7, 8.6.

Further Reading

J. N. Butterfield, "Bell's Theorem: What it takes", *British Journal for the Philosophy of Science 43* (1992), pp. 41-83. Available online via TDNet.
A careful classification of exactly what the Bell result does and does not show.

T. Maudlin, *Quantum non-locality and relativity: metaphysical intimations of modern physics.* (Blackwell, 1994), especially chapters 1 (pp.6-28), 5 (pp.125-161), 7 (pp.189-222).
A detailed account of Bell's theorem (ch.1) and its implications for causality (ch.5) and for Lorentz covariance (ch.7).

Original sources

A. Einstein, B. Podolsky and N. Rosen, "Can Quantum-Mechanical Description of Reality be Considered Complete?", *Physical Review 47* (1935), pp. 777-80. Available online via TDNet. Reprinted in J. A. Wheeler and W. H. Zurek (eds.), *Quantum Theory and Measurement* (Princeton, 1983), pp. 138-41.

N. Bohr, "Can Quantum-Mechanical Description of Reality be Considered Complete?", *Physical Review 48* (1936), pp. 696-702. Available online via TDNet. Reprinted in J. A. Wheeler and W. H. Zurek (eds.), *Quantum Theory and Measurement* (Princeton, 1983), pp. 145-51.

Dynamical-collapse theories

Core Reading

G. Ghirardi, "Collapse Theories". *The Stanford Encyclopedia of Philosophy (Spring 2002 Edition)*, Edward N. Zalta (ed.),
http://plato.stanford.edu/archives/spr2002/entries/qm-collapse/.

D.Albert, and B. Loewer, "Tails of Schrodinger's Cat", in *Perspectives on Quantum Reality: non-relativistic, relativistic, field-theoretic*, Rob Clifton (ed.) (Kluwer, 1996). Available online at
http://philosophy.rutgers.edu/FACSTAFF/BIOS/PAPERS/LOEWER/loewer-schroedingers-cat.pdf

P. J. Lewis, "Interpreting Spontaneous Collapse Theories", 2004. Available online from http://philsci-archive.pitt.edu (search for "Lewis")

Further Reading

J.S. Bell, “Are there quantum jumps?”, in *Schrodinger: Century of a Polymath* (Cambridge, 1987). Reprinted in J.S.Bell, *Speakable and Unspeakable in Quantum Mechanics* (Cambridge, 1987), pp. 201-212. Sections 1-3 and 5.
(An alternative presentation of the GRW collapse theory)

D. Home, *Conceptual Foundations of Quantum Physics: an overview from modern perspectives.* (Plenum, 1997) pp. 97-118.
Rather more technical detail about the GRW theory and its successors, including an overview of Pearle’s modification of the GRW program.

Leggett, A. J. (2002). “Testing the limits of quantum mechanics: Motivation, state of play, prospects”. Journal of Physics: Condensed Matter 14, R415–R451.

T.Maudlin, *Quantum non-locality and relativity: metaphysical intimations of modern physics.* (Blackwell, 1994). Chapter 7 (pp. 189-222).

W. Myrvold, “On peaceful co-existence: is the collapse postulate incompatible with relativity?”, *Studies in the History and Philosophy of Modern Physics 33* (2002), pp. 435-66. Available online via TDNet.
(Two viewpoints on the possibility of Lorentz-covariant collapse theories.)

Many further references on the “counting anomaly” may be found in the paper by Lewis, above.

Reference

A. Bassi and G. C. Ghirardi, “Dynamical Reduction Models”. *Physics Reports 379* (2003), pp. 257. Available online via TDNet.

Original sources

G. Ghirardi, A. Rimini and T. Weber, “Unified Dynamics for Micro and Macro Systems”, *Physical Review D 34* (1986), pp. 470-91. Available online via TDNet.

P. Pearle, “Combining stochastic dynamical state-vector reduction with spontaneous localisation”, *Physical Review A 39* (1989), pp. 2277-2289. Available online via TDNet.

Hidden-variable theories

Core Reading

D. Albert, *Quantum Mechanics and Experience* (Harvard University Press, 1992), Chapter 7 (pp. 134-179).

D. Dürr, S. Goldstein, and N. Zanghì, "Bohmian Mechanics and the Meaning of the Wave Function," in Cohen, R. S., Horne, M., and Stachel, J., eds., *Experimental Metaphysics -- Quantum Mechanical Studies for Abner Shimony, Volume One;*

Boston Studies in the Philosophy of Science **193**, (Kluwer Academic Publishers, 1997). Available online at http://uk.arxiv.org/abs/quant-ph/9512031

J.S. Bell, "Quantum Mechanics for Cosmologists", in *Quantum Gravity 2,* C. Isham, R. Penrose and D. Sciama (ed.) (Oxford, 1981), pp. 611-637. Reprinted in J.S.Bell, *Speakable and Unspeakable in Quantum Mechanics* (Cambridge, 1987), pp. 117-139. Section 4.

Further Reading

On hidden variables and impossibility proofs in general:

H. Brown, 'Bell's other theorem and its connection with nonlocality. Part I' in *Bell's Theorem and the Foundations of Modern Physics*, A. van der Merwe, F. Selleri and G. Tarozzi (eds.), (World Scientific Publishing Company, 1992) pp. 104-116.
A philosophical analysis of the differing interpretations of the Bell-Kochen-Specker theorem.

A. Peres, *Quantum theory: concepts and methods* (Kluwer, 1993). Part II.

M. Redhead, *Incompleteness, nonlocality and realism: a prolegomenon to the philosophy of quantum mechanics.* (Clarendon, 1987). Chapter 5 (pp. 119-138).
(Two careful discussions of the Kochen-Specker paradox and its implications)

On the pilot-wave theory in particular:

J. S. Bell, "On the impossible pilot wave", *Foundations of Physics 12* (1982), pp. 989-99. Reprinted in J.S.Bell, *Speakable and Unspeakable in Quantum Mechanics* (Cambridge, 1987), pp. 201-212.
(Another presentation of the theory).

H Brown *et al*, "Cause and Effect in the Pilot Wave Interpretation of Quantum Mechanics", in J.T. Cushing *et al* (eds.), *Bohmian mechanics and Quantum Theory: An Appraisal* (Kluwer Academic Publishers, 1996).

H. Brown, and D. Wallace, "Solving the measurement problem: de Broglie-Bohm loses out to Everett". *Foundations of Physics 35* (2005), pp.517-540. Available online at http://uk.arxiv.org/abs/quant-ph/0403094

S. Goldstein *et al*, "Are all particles real?", *Studies in the History and Philosophy of Modern Physics 36* (2005), pp. 103-112. Available online via TDNet.
(These three papers are all concerned, in various ways, with the ontology of the pilot-wave theory and the apparent irrelevance of the corpuscles. Oddly, the rather powerful case against the theory in the third reference is made by one of its strongest advocates…)

J.T. Cushing, “Bohm’s causal interpretation of quantum mechanics”, in J.T. Cushing *et al* (eds.), *Bohmian mechanics and Quantum Theory: An Appraisal* (Kluwer Academic Publishers, 1996).
Historical discussion of the travails of the pilot-wave theory.

Michael Dickson, 'Antidote or Theory?', *Studies in History and Philosophy of Modern Physics*, **27B**, 229 (1996). Available online via TDNet.
A book review of two recent-ish discussions of the Bohm theory, with much useful background.

G. Ghirardi, “Bohm’s Theory versus Dynamical Reduction”, in in J.T. Cushing *et al* (eds.), *Bohmian mechanics and Quantum Theory: An Appraisal* (Kluwer Academic Publishers, 1996), pp. 353-377.
Comparison of the pilot-wave theory with dynamical collapse theories of GRW type.

D. Home, *Conceptual Foundations of Quantum Physics: an overview from modern perspectives.* (Plenum, 1997) pp. 38-54.
Rather more technical detail about the pilot-wave theory.

References and anthologies

P. Holland, *The Quantum Theory of Motion: an account of the de Broglie-Bohm causal interpretation of quantum mechanics* (Cambridge, 1993).

J.T. Cushing *et al* (eds.), *Bohmian mechanics and Quantum Theory: An Appraisal* (Kluwer Academic Publishers, 1996).

Original source

Bohm, D. “A suggested interpretation of quantum theory in terms of ‘hidden’ variables. *Physical Review 85* (1952), pp. 166-193. Available online via TDNet.

The Copenhagen Interpretation

Core Reading

Peierls, R., in P.C.W.Davies and J.R Brown (ed.), *The Ghost in the Atom* (Cambridge, 1986), pp. 70-82.

Bub, J. *Interpreting the Quantum World* (Cambridge, 1997), chapter 7 (pp. 189-211), esp. section 7.1 (7.2 focusses on much more technical, formal results).

Cushing, J. *Quantum Mechanics: Historical Contingency and the Copenhagen Hegemony*, (University of Chicago Press, 1994) chapter 3 (pp. 24-41) & possibly also chapters 5-6 (pp. 90-122).

C. Fuchs and A. Peres, “Quantum Theory Needs No `Interpretation’”. *Physics Today 53(3)* (2000), pp. 70-71. See also the letters to the editor in *Physics Today 53(9)* and

Fuchs and Peres' reply (both available online at http://www.aip.org/pt/vol-53/iss-9/p11.html).

Further Reading

Peres, A. *Quantum Theory: Concepts and Methods* (Kluwer, 1993), pp. 353-357.
An expansion of Fuchs and Peres' discussion above.

Saunders, S. "Complementarity and Scientific Rationality", *Foundations of Physics* (forthcoming), available at http://users.ox.ac.uk/~lina0174/cushing.pdf.
Saunders provides a reconstruction of Bohr's thought more sympathetic than Cushing's.

Scheibe, E. *Logical Analysis of Quantum Mechanics*, (Pergamon Press, 1970); ch. 1 (pp. 9-49).
A careful exposition of what Bohr, in particular, actually thought.

Original Sources

An extensive collection of historical sources on the Copenhagen interpretation can be found in
J. A. Wheeler and W. H. Zurek, *Quantum Theory and Measurement* (Princeton, 1983).

The Everett interpretation

Core Reading

D. Deutsch, "Comment on Lockwood", *British Journal for the Philosophy of Science 47* (1996), pp. 222-8. Available online via TDNet.

D. Albert, *Quantum Mechanics and Experience* (Harvard University Press, 1992). First part of chapter 6 (pp. 111-119).

D. Wallace, "Everett and Structure", *Studies in the History and Philosophy of Modern Physics 34,* pp. 87-105 (2003). Available online via TDNet.

S. Saunders, "Time, Quantum Mechanics, and Probability", *Synthese 114* (1998), pp.373-404. Online at http://users.ox.ac.uk/~lina0174/part3.pdf or via TDNet.

D. Wallace, "Quantum Probability from Subjective Uncertainty: improving on Deutsch's proof of the probability rule", unpublished (2003). Online at http://xxx.arxiv.org/abs/quant-ph/0312157 .

Further Reading

J. Barrett, *The quantum mechanics of minds and worlds* (Oxford University Press, 1999), especially chapter 3 (and possibly chapter 6). What is essentially a precis of

chapter 3, with some added sections which precis other bits of the book, can be found in Barrett, Jeffrey, "Everett's Relative-State Formulation of Quantum Mechanics", *The Stanford Encyclopedia of Philosophy (Spring 2003 Edition)*, Edward N. Zalta (ed.), http://plato.stanford.edu/archives/spr2003/entries/qm-everett/ .
A clear exegesis of Everett's original paper and a variety of comments on later versions of the interpretation.

S. Saunders, "The quantum mechanics of minds and worlds", *Mind 110* (2001), pp. 1039-43. Available online at http://users.ox.ac.uk/~lina0174/barrett.pdf
Rather critical review of Barrett's book.

A. Kent, "Against Many-Worlds Interpretations", online at http://xxx.arxiv.org/abs/gr-qc/9703089. This is a 1997 update of Kent's 1990 paper of the same name in *International Journal of Modern Physics A5* , pp. 1745-1762.
Critical survey of Everett-type interpretations from a physicist's perspective.

M. Lockwood, *Mind, Brain, and the Quantum: the compound "I"* (Oxford, 1989).

M. Lockwood, "'Many Minds' Interpretations of Quantum Mechanics", *British Journal for the Philosophy of Science 47* (1996), pp. 159-88. Available online via TDNet. (See also the many commentaries in the same issue).
Lockwood's version of the Everett interpretation, emphasising considerations from the philosophy of mind.

D. Albert and B. Loewer, "Interpreting the Many Worlds Interpretation", *Synthese 77* (1988), pp. 195-213.
Another version of the Many Minds theory.

D. Papineau, "Many minds are no worse than one", *British Journal for the Philosophy of Science 47* (1996), pp. 233-41. Available online via TDNet.
An argument that the probability problem is actually no worse in the Everett interpretation than in single-universe interpretations.

S. Saunders, "Relativism", in R. Clifton (ed.), *Perspectives on Quantum Reality* (Kluwer, 1996), pp. 125-142.

S. Saunders, "Time, Quantum Mechanics and Decoherence", *Synthese* 114 (1998), pp. 405-44. Available online at http://xxxx.arXiv.org/abs/quant-ph/0111047.

S. Saunders, "What is probability?", in A. Elitzur, S. Dolev and N. Kolenda (eds.), *Quo Vadis, Quantum Mechanics* (Springer-Verlag, 2005). Available online at philsci-archive.pitt-edu (search for Saunders).
More detailed presentations of Saunders' approach to the Everett interpretation.

D. Wallace, "Epistemology Quantized: Circumstances in which we should come to believe in the Everett interpretation", available online at http://users.ox.ac.uk/~mert0130/papers/epist.pdf.

More detail about the probability problem in the Everett interpretation.

Original sources

H. Everett III, "Relative state formulation of quantum mechanics". *Review of Modern Physics 29* (1957), pp. 454-462. Available online via TDNet. Reprinted in de Witt and Graham (below) and in J. A. Wheeler and W. H. Zurek, *Quantum Theory and Measurement* (Princeton, 1983).

B. de Witt and N. Graham (eds.), *The Many-Worlds Interpretation of Quantum Mechanics* (Princeton, 1973).

D. Deutsch, "Quantum Theory of Probability and Decisions", *Proceedings of the Royal Society of London A455* (1999), pp. 3129-3137. Available online at http://uk.arxiv.org/abs/quant-ph/9906015 .

H. Barnum *et al*, "Quantum Probability from Decision Theory?", *Proceedings of the Royal Society of London A456* (2000), pp. 1175-82. Available online at http://uk.arxiv.org/abs/quant-ph/9907024 .

(An exegesis of the above two papers can be found in D. Wallace, "Everettian Rationality: defending Deutsch's approach to probability in the Everett interpretation", *Studies in the History and Philosophy of Modern Physics 34* (2003), pp. 415-439, available online via TDNet.)

Decoherence and consistent histories

Core Reading

G. Bacciagaluppi, "The Role of Decoherence in Quantum Mechanics", *The Stanford Encyclopedia of Philosophy (Winter 2003 Edition)*, Edward N. Zalta (ed.), available at http://plato.stanford.edu/archives/win2003/entries/qm-decoherence/.

M. Gell-Mann, "A contemporary view of quantum mechanics: quantum mechanics and the classical approximation." Chapter 11 of *The quark and the jaguar*: *adventures in the simple and the complex* (Abacus, 1995), pp. 136-166.

J. J. Halliwell, "A review of the decoherent histories approach to quantum mechanics", *Annals of the New York Academy of Science 755* (1995), pp. 726-740. Available online at http://arxiv.org/abs/gr-qc/9407040

W. H. Zurek, "Decoherence and the transition from quantum to classical", online at http://arxiv.org/abs/quant-ph/0306072.

Further Reading

J. Bub, *Interpreting the Quantum World* (Cambridge, 1997), chapter 8, pp. 212-236. Rather critical discussion of the decoherence-based approaches.

M. Gell-Mann and J. B. Hartle, "Quantum mechanics in the light of quantum cosmology", in *Complexity, Entropy and the Physics of Information: Santa Fe Institute Studies in the Science of Complexity* vol. VIII (Addison-Wesley, 1991), pp. 425-458.
More technical account of Gell-Mann and Hartle's almost-but-not-quite-Everett interpretation.

R. Griffiths, *Consistent Quantum Theory* (Cambridge, 2002), especially chapter 27 (pp. 36-370).
Full technical review of the consistent-histories formalism, together with the author's interpretational gloss on it.

A. Kent, "Consistent Histories and Bohmian Mechanics", in J.T. Cushing *et al* (eds.), *Bohmian mechanics and Quantum Theory: An Appraisal* (Kluwer Academic Publishers, 1996), pp. 343-352.
Influential criticism of the idea of using consistent histories as a solution to the measurement problem (the "Bohmian mechanics" part is incidental.)

R. Omnes, *The Interpretation of Quantum Mechanics* (Princeton, 1994), especially final chapter.
Another attempt to use consistent histories to solve the measurement problem.

W. H. Zurek, "Decoherence, einselection, and the existential interpretation (the rough guide)", *Philosophical Transactions of the Royal Society of London A356* (1998), pp. 1793-1820. Available online at http://uk.arxiv.org/abs/quant-ph/9805065.
A conceptually motivated account of environment-induced decoherence and its role in the interpretation of quantum mechanics.

References

E. Joos *et al*, *Decoherence and the Appearance of a Classical World in Quantum Theory*, 2nd edition (Springer, 2003).
An exhaustive survey.

W. H. Zurek, "Decoherence, einselection, and the quantum origins of the classical", *Reviews of Modern Physics 75* (2003), p. 715-775.
Review paper, covering a wide range of developments in environment-induced decoherence.

Other interpretations

Quantum logic

H. Putnam, "Is logic empirical?", *Boston Studies in the Philosophy of Science 5* (1969), pp. 216-41. Reprinted in H. Putnam, *Mathematics, Matter and Method: Philosophical Papers vol. 1* (Cambridge, 1979).

M. Dummett, “Is logic empirical?”, in H. D. Lewis (ed.) *Contemporary British Philosophy* (Allen and Unwin, 1976), pp. 45-68. Reprinted in M. Dummett, *Truth and Other Enigmas* (Duckworth, 1978).
Critique of Putnam.

M. Redhead, *Incompleteness, nonlocality and realism: a prolegomenon to the philosophy of quantum mechanics.* (Clarendon, 1987). Chapter 7 (pp. 153-167).

M. Dickson, “Quantum logic is alive ^ (it is true v it is false)” , *Philosophy of Science 68* (2001), Supplement: proceedings of the 2000 Biennial Meeting of the Philosophy of Science Association Part I: Contributed Papers, pp. S274-S287.

Modal interpretations

Dickson, Michael, "Modal Interpretations of Quantum Mechanics", *The Stanford Encyclopedia of Philosophy (Winter 2002 Edition)*, Edward N. Zalta (ed.), available at http://plato.stanford.edu/archives/win2002/entries/qm-modal/.

D. Dieks and P. E. Vermaas (ed.), *The modal interpretation of quantum mechanics* (Kluwer, 1998).

Information-theoretic interpretations

C. A. Fuchs, “Quantum Foundations in the light of Quantum Information”, available at http://uk.arxiv.org/abs/quant-ph/0106166.
Fuchs proposes a variant of the Copenhagen interpretation motivated by quantum information theory, in which the quantum state represents only our subjective knowledge about the results of measurements.

A. Hagar, “A Philosopher Looks at Quantum Information Theory”, *Philosophy of Science 70* (2003), pp. 752-775.
Critical assessment of the Fuchs proposal.

Consciousness-based collapse theories

E. Wigner, “Remarks on the Mind-Body Problem”, in I.J.Good (ed.) *The Scientist Speaks* (Heinemann, 1961), pp. 284-302. Reprinted in E. Wigner, *Symmetries and Reflections* (Indiana University Press 1967), pp. 171-84 and in J. A. Wheeler and W. H. Zurek, *Quantum Theory and Measurement* (Princeton, 1983).

H. P. Stapp, *Mind, matter and quantum mechanics,* 2nd ed. (Springer, 2004).

Uncertainty relations

M. Redhead, *Incompleteness, Nonlocality and Realism*, (Clarendon Press, 1989) ch 1.

J. Hilgevoord, “The uncertainty relation for energy and time. II”, *American Journal of Physics*, **66** (1998), pp 396-402.