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Hanoch Gutfreund and Jürgen Renn (eds).

Dialectical Materialism and Quantum Physics: The Unpublished 1957 Lectures of David Bohm in Israel.

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This review is about the recently discovered unique lectures of the famous physicist David Bohm, delivered in Hebrew during his stay in Israel in 1957. Bohm challenged the hegemonic interpretation of quantum mechanics with his causal interpretation, from an implicit Marxist point of view. Bohm, also furthered the discussion on the dialectics of physical theories in contradistinction to others, who just tried to declare quantum mechanics a direct expression of dialectics. The 21 sections are divided into two parts: Philosophical questions raised in a new approach to the quantum theory and, General philosophical problems in the light of the infinity of nature and the unity of opposites. To make Bohm's lectures part of the ongoing studies of dialectics as a way to understand nature, the editors, both acclaimed experts in the history and philosophy of physics, painstakingly comment and explain the lecture notes and Bohm's outreach in most readable details. Hence, the book is also valuable for non-physicists.

Below, I first introduce Bohm, who is little known as a Marxist thinker. Some background information is given about quantum mechanics, in order to inform the reader in what context Bohm's materialist dialectics can be understood and why it is important for a broader discussion. Subsequently, I deal with Bohm's emphasis of various layers in physics as an expression of the unity of opposites, in this case the opposition between a deterministic particle view of nature and a probabilistic quantum wave model.

David Josef Bohm (1917–1995) was one of the most remarkable post-WWII physicists. In 1951 Bohm wrote a textbook, *Quantum Theory*, which upon publication was an immediate success.¹ The book follows carefully the orthodox interpretation of quantum mechanics, known as the Copenhagen interpretation. However, while this name, which is linked to the research group of Niels Bohr, might suggest a monolithic approach, this is certainly not the case.² According to the Copenhagen interpretation, quantum theory is complete in its mathematical structure. No new elements can be integrated unless the very structure of the theory is changed. In the literature, this is known as the non-existence of hidden variables—a questionable term, as it suggests that even if there are extra variables, by definition they cannot be measured (observed).

In his textbook, Bohm is already seen to be questioning this assertion and in 1952 he published two famous papers in which he shows that a different approach is possible *contra* the orthodox theory that stipulates that quantum states—that is to say, the situations in which quantum objects can be described by a 'wave function'—are intrinsically probabilistic. This is the basis of the endless discussions on Werner Heisenberg's (1901–1967) indeterminacy or uncertainty principle, which stipulates that we cannot measure both the position and the momentum of a quantum object with the same precision. The important issue is that we can handle particles in three-dimensional space, whilst the wave function, named after Erwin Schrödinger (1887–1961), 'lives' in an abstract mathematical, N-dimensional vector, known as Hilbert, space. In a Marxist materialist approach, we have to solve the question why an abstract elaborate mathematical theory works in our real material

¹ Bohm, David. 1989 [1951]. *Quantum Theory*. Dover Books on Physics and Chemistry.

² Howard, Don. 2004. 'Who Invented the "Copenhagen Interpretation"? A Study in Mythology'. *Philosophy of Science* 71 (5): 669–82. <https://doi.org/10.1086/425941>.

Beller, Mara. 1999. *Quantum Dialogue: The Making of a Revolution*. University of Chicago Press.

life.

This book review is not the place to dig deep into this conundrum, which is a topic of ongoing debate. For many mathematical, theoretical physicists, reality is in the formulae, but for a materialist, this remains an open question, since it allows for all kinds of idealistic or religious interpretations.

Bohm constructed a new quantum theory, which he named the Causal Interpretation. In Bohm's approach, the only real physical object is the particle and its path (trajectory). Note that the motion of a particle can be measured, but time as such is not a physical, tangible, entity, contrary to change. We cannot measure time, but only change measured by a clock.³

Bohm was a communist and well-versed in works such as Engels' *Dialectics of Nature* and Lenin's *Materialism and Empirio-Criticism*. Under political pressure he was refused a tenured position at Princeton University and escaped, with recommendations from Albert Einstein, to São Paulo, Brazil, where he started reading what was to become his favourite book, Hegel's *Logic*. Two years later he moved to Israel, and henceforth, until his untimely death, to London. In biographic studies of Bohm, it is often suggested that he left Marxism after Khrushchev's 1956 speech and the Soviet invasion of Hungary in 1956.⁴ However, in his ground-breaking popular book of 1957 *Causality and Change in Modern Physics* all Marxist elements can be found.⁵ Bohm, however, never mentioned Marx, Engels, or Lenin—possibly due his dramatic experiences with McCarthyism back home.

While the power of the book under review is that it is written in precise and clear language without mathematical excursions, during the same period Bohm also produced very technical papers. At various international conferences Bohm explained his 'heretic' view in clear language.⁶ In May 1967, Bohm delivered a series of lectures (in Hebrew) to a group of Marxist physicists at the headquarters of the secular left socialist Hashomer Hatzair Kibbutz movement. Only recently, a cyclostyled copy of the lecture notes was found. Although the lectures are more complex than that of *Causality and Change* (not least as the audiences were predominantly physicists), they offer further proof that Bohm was still fully a Marxist who tried to advance dialectics in the light of the conundrums with which quantum mechanics confronts us.

Bohm was a very intuitive researcher who, as his former graduate student Jeffrey Bub writes, changed topics frequently: 'Bohm's method of working through new ideas, which he produced with astonishing frequency, was entirely informal. He had a remarkable physical intuition and was dismissive of mathematical proof, which he felt obscured rather than illuminated informal thinking—a recurring theme in the letters. As I recall, he was never wrong.'⁷

Later, Bohm changed tack and became interested in infinity of wholeness in relation to Eastern philosophy, a field in which he garnered more public success. While still in Brazil, he started a

³ Kircz, Joost. 2022. 'Time=Money: The Notion of the Ideal Applied to Physics'. *Marxism & Sciences* 2 (1): 1. <https://doi.org/10.56063/MS.2301.02101>.

⁴ Peat, David. 1997. *Infinite Potential: The Life and Times of David Bohm*. Helix Book, Addison-Wesley.
Freire Júnior, Olival. 2019. *David Bohm: A Life Dedicated to Understanding the Quantum World*. Springer Biographies. Springer.

Freire Junior, Olival. 2015. *The Quantum Dissidents: Rebuilding the Foundations of Quantum Mechanics (1950–1990)*. Springer Berlin / Heidelberg.

Talbot, Chris, ed. 2017. *David Bohm: Causality and Chance, Letters to Three Women*. SpringerLink Bücher. Springer. <https://doi.org/10.1007/978-3-319-55492-1>.

⁵ Bohm, David. 1957. *Causality and Change in Modern Physics*. Routledge & Kegan Paul Ltd.

⁶ Yourgrau, Wolfgang, and Allen D. Breck, eds. 1970. *Physics, Logic, and History*. Plenum Press.

Korner, S., ed. 1962 [1957]. *Observation and Interpretation in the Philosophy of Physics. With Special References to Quantum Mechanics*. Proceedings of the Ninth Symposium of the Colston Research Society Held in the Univ. of Bristol April 1–4. Butterworths Scientific Publications. Reprint, Dover.

Kožnjak, Boris. 2018. 'The Missing History of Bohm's Hidden Variables Theory: The Ninth Symposium of the Colston Research Society, Bristol, 1957'. *Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics* 62 (May): 85–97. <https://doi.org/10.1016/j.shpsb.2017.06.003>.

⁷ Bohm, David, Chris Talbot, and Jeffrey Bub. 2020. *David Bohm's Critique of Modern Physics: Letters to Jeffrey Bub, 1966–1969*. Springer. Page vi.

productive collaboration with the French communist activist and theoretical physicist Jean-Pierre Vigier. Later, in the 1980s, students of Bohm picked up the discussions and Peter Holland, who became an associate of Vigier, published the only textbook on the causal interpretation.⁸ It is important to mention that a group of theoretical physicists who follow purely statistical approaches call themselves ‘Bohmian’, although their work has nothing to do with David Bohm. Unfortunately, at present, this is often a source of confusion, as clearly explained in a paper by Del Santo and Krizek.⁹

The essential importance of Bohm’s lectures are his dialectical approach. Bohm tackles two fundamental problems: a) the use of socially accepted words and notions; and b) the intrinsic dialectical process of the understanding of these notions as used in physics. For Bohm, the two basic starting points were the unity of oppositions and the infinity of nature. Here he proves himself a conscientious student of Lenin. Bohm never tried to press the novel riddles of (sub-)atomic physics in the Procrustean bed of Stalinist Diamat and its iron laws. Taking as given the experimental measurements, executed with large measuring apparatuses that adhere to the world of classical mechanics, he developed a new understanding of dealing with the old antagonisms of, for example, continuous vs discrete, determinism vs indeterminism, subject vs object, etc.

Bohm starts with the notion of levels. Classical (Newtonian) mechanics is seen as a consequence of a lower level of quantum mechanical processes. On one level we are able to describe phenomena with a statistical approach in a wave model, while on another level they can be described in deterministic terms as particles. This explains that the opposition between a ‘wave picture’ of reality and a ‘particle picture’ are not complementary, as Niels Bohr postulates, but the expression of different levels of reality for which we, humans, need different theoretical models. In his lectures and in many talks, Bohm frequently fought Bohr’s idea that ‘at the end of the day’ we have to deal with words and notions in ‘classical mechanical’ terms, as we have and know them today.

Bohr’s complementary oppositions remain unsolved and mystical in the context of one, classical level. However, for Bohm, the buck does not stop here. By introducing various levels, including their own notions and laws, which are hierarchical as well as interpenetrating, we are able to develop level-specific (e.g., deterministic or statistical) theories that together enlarge our understanding of the reality of nature, of which we are a part. In this context, our human, limited, but ever progressing experimenting and theory building is indeed an expression of the infinity of nature and our evolutionary limitations of a complete understanding of nature, without the emergency brake of a religion. In the again lower level of elementary particle research, for example on quarks, we describe interactions that grow with distance in contradistinction with, for example, gravity and electromagnetic forces. While such findings can be modelled in formal quantum mechanical calculations, they also induce the notion that we again have reached another, deeper level of reality.

By reading Bohm’s lecture notes, non-physicists will also be stimulated to ponder the context dependence of physics theories in terms of levels as a metaphor for the fundamental historical-materialist notion of contextuality. The excellent and elaborate comments by the editors will certainly assist the non-professional natural scientist to advance the discussion on dialectics in nature, beyond Hegel, Engels, and the Diamat School.

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⁸ Holland, Peter R. 1993. *The Quantum Theory of Motion, An Account of the de Broglie-Bohm Causal Interpretation of Quantum Mechanics*. Cambridge University Press.

⁹ Del Santo, Flavio and Gerd Christian Krizek. 2025. ‘Against the “Nightmare of a Mechanically Determined Universe”: Why Bohm Was Never a Bohmian’. In: Oldofredi, Andrea, ed. 2025. *Guiding Waves in Quantum Mechanics: One Hundred Years of de Broglie-Bohm Pilot-Wave Theory*. Oxford University Press. Part II–6. See also <https://doi.org/10.48550/arXiv.2307.05611>

