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Intertheoretic relations, singular limits and emergence: a critical overview of the relation between classical and quantum mechanics

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An interesting issue in the history and philosophy of science concerns possible relations between scientific theories, in particular reductions of theories. According to Nickles [1], a possible notion of reduction is the physicist's one, according to which a theory is reduced to another theory by a mathematical limiting process on a parameter. When the correspondence relation between theories involves a singular limit, it may be more appropriate to speak of intertheoretic relations (Batterman) [2], since the notion of reduction is not applicable. The relevance of singular limits and their consequences have been pointed out by Berry [3], who recognized the role of singularities as a source of richness for the region of transition between two theories. In this respect, a paradigmatic example is the semiclassical limit of quantum mechanics which leads to the emergence of the classical world according to the correspondence principle [4]. Further problems arise when considering a quantum system whose classical counterpart is chaotic, because in this case also a long-time limit leading to a highly complex behavior is involved [4].
In this contribution we focus on the relation between classical and quantum mechanics [5] and give a critical and historical overview of the relevant results.

[1] Nickles T., 1973, "Two concepts of intertheoretic reduction", The Journal of Philosophy, 70: 181.
[2] Batterman R.W., 1991, "Chaos, quantization and the correspondence principle", Synthese, 89: 189.
[3] Berry M.V., 2002, "Singular limits", Phyiscs Today, 55: 10.
[4] Berry M.V., 2001, "Chaos and the Semiclassical Limit of Quantum Mechanics", in Quantum Mechanics: Scientific perspectives on divine action, R.J. Russell et al (eds), Vatican Observatory CTNS publications, pp. 41–54.
[5] Bokulich A., 2008, Reexamining the Quantum-Classical Relation, Cambridge University Press, Cambridge (UK).

Author: NADDEO, Adele (INFN, Sezione di Napoli)

Co-author: Dr DI MAURO, Marco (Dipartimento di Matematica, Università di Salerno)

Presenter: NADDEO, Adele (INFN, Sezione di Napoli)

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