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Cassirer's Theory of Physical Principles and the Route to Schrödinger's Undulatory Mechanics

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In this paper I will analyse Cassirer's conception of physical principles in order to argue that (i) they are *universal*, meaning that they do not entail any definite content belonging to a particular phenomenon or a specific region of physical domain, rather they refer to the algebraic operations according to which we decipher and understand classes of physical phenomena; (ii) physical principles prove to have a *heuristic* value in the construction of physical theories, namely, a capacity to orient the inquiry towards the derivation of physical laws for a normative determination of empirical domains; (iii) finally, the function of physical principles is grounded in the capacity of '*synopsis*', i.e., the functional connection that is made possible between different phenomena and regions of physical domains. Then I will argue that the characteristics of physical principles and their function allow to shed light on the process of theory construction as a theoretical development independent from any ontological commitment of the underlying physical theory.
In this regard, I will apply Cassirer's conception of physical principles to the historical development of Schrödinger's undulatory mechanics, in order to argue that, on the one hand, Schrödinger sought after an undulatory mechanics by means of a generalization of Hamilton's principle, and on the other hand, the undulatory ontology results as a by-product of the constitution of the theory itself. I will focus on Schrödinger's first and second papers on undulatory mechanics: *Quantization as a Problem of Proper Values* (Ger. *Eigenwert*) (Part I) and *Quantization as a Problem of Proper Values* (Part II). In the first paper Schrödinger reflects on the derivation of the whole quantum numbers in the case of nonrelativistic hydrogen atom, by treating quantization as a *variational principle*. In the second paper, Schrödinger pursues further the formulation of undulatory mechanics by deepening Hamilton's mechanical-optical analogy.
Hamilton formulated an analogy between Fermat's principle of least time of light rays and Maupertuis's principle of least action of mechanical systems, by working on the extremal laws for geometrical optics and classical particle mechanics. I will show that Hamilton's analogy between physical principles allowed Schrödinger to gain two argumentative strategies for the *justification* of undulatory mechanics. This is because, Hamilton's analogy provided Schrödinger with two formal levels of analogy, i.e., according to variational principles and differential equations. With respect to variational principles, Hamilton's theory is grounded in the analogy between Fermat's principle and Maupertuis's principle. According to the differential equations, it is based on the analogy between the eiconal equation and the Hamilton-Jacobi equation for the characteristic function W.
In conclusion, I will argue that the reflection on the functions of physical principles, and not the search of a wave picture of nature, originally paved the way for the construction of Schrödinger's undulatory mechanics.

Keywords: Cassirer; Physical Principles; Schrödinger; Hamilton's Analogy; Undulatory Mechanics.

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