Individuality Through Relatedness: A Leibnizian Framework for Quantum Mechanics

The purpose of this paper is twofold. First, it aims at showing how Leibniz's ontology provides an understanding of Nature that crucially departs from the classical view of modern science, in which physical entities are defined by their separability and their intrinsic identity. Second, focusing on his metaphysics of relations, it aims at investigating the fruitfulness of Leibniz's ontology in approaching some core issues of Quantum Mechanics, especially those concerning holism and non-separability. In this context, a particular emphasis will be placed on the problem of the individuality and distinctness of physical entities within the interconnected Nature that both Leibniz and Quantum Mechanics portray.

In the first part, by way of introduction, I shall briefly outline the classical ontology underlying the Newtonian framework of modern science. Conceived on the model of particles, the basic entities constituting the world are, according to this picture, objects subsisting *per se* and existing apart from others: what is primarily real are indivisible, permanent and self-contained unities, upon which rests the reality of all compound things[1]. I refer to this view as the "atomistic" conception: regardless of the exact nature of the elements considered as fundamental (be they material points, or mathematical ones), these are conceived as being *discrete* entities possessing *intrinsic* qualities. Within this framework, the relations between physical entities are regarded as external to them, insofar as they are not essential to the related terms.

While Leibniz's ontology has often been associated with this classical view, by examining his theory of individual substances and his doctrine of universal connection, I shall argue in the second part of the paper that this is not the case. As a matter of fact, Leibniz explicitly rejects the idea of ontologically independent entities[2]. Crucially, he conceives of beings as relational entities, their nature being fully determined by their relations to all other beings. According to the structure of the divine decrees whose primary object is the harmonic unity of Nature, every single thing that exists in the universe is essentially dependent upon and related to the whole complex and to each individual entity constituting it[3]. Moreover, Leibniz also rejects the idea of intrinsic natures. On his view, an individual entity is primarily defined by its "mirroring" nature[4]: all its properties originating from its relation to the extraneous multiplicity, like a glass bead reflecting and enfolding the surroundings in itself, it has therefore nothing but relational properties. Indeed, it is one of Leibniz's most enduring and far-reaching theses, that *any* change in a relation between several individual entities necessarily modifies the *internal* properties of *all* the related terms[5].

In light of this, the parallel with entanglement phenomena – arguably the most distinctive feature of Quantum Mechanics[6] – does present itself. As is known, entanglement phenomena can generally be described as phenomena where the states of distinct entities cannot be fully specified without reference to each other and to the whole complex in which they enter. In such cases, it is not possible to assign an absolute value to one parameter, independently of the assignation we make to another related one –

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[1] See I. Newton, *Opticks or a Treatise of the Reflections, Refractions, Inflections and Colours of Light*, I. B. Cohen (ed.), New York, Dover, 1952, Quest. 31, p. 400.
[2] "All substances are co-requisites for each other" (A VI, iv, p. 1800).
[3] "There is no term which is so absolute or so detached that it does not involve relations and is not such that a complete analysis of it would lead to other things and even to all other things" (A VI, vi, p. 228).
[4] See for instance A VI, iv, p. 1542.
[5] See for instance A VI, iv, p. 1746.
[6] *Cf.* E. Schrödinger, "Discussion of Probability Relations Between Separated Systems", *Proceedings of the Cambridge Philosophical Society*, vol. 31, 1935, p. 555.

hence their non-separability. Yet, as I will have shown, likewise it is precisely a key idea of Leibniz's ontology that "a single state of a substance can be exhaustively described only if one takes into account the whole substantial series and the whole world, according to a corresponding law"[7]. In the third and final part of the paper, I shall thus propose a reconsideration of the issues of holism and non-separability in Quantum Mechanics in the light of Leibniz's ontology. To this end, I will use two major strands of contemporary philosophical interpretations that have been developed in the context of Quantum Mechanics: the so-called "Ontic Structural Realism" (M. Esfeld[8]) and "Quantum Holism" (J. Ismael and J. Schaffer[9]). While their arguments differ in some important aspects, both theories hold that the relational structure of reality has to be seen as fundamental, and consequently reject the idea of individuals ontologically independent and that of intrinsic natures.

By confronting these recent philosophical developments with Leibniz's ontology, my intention is not only to offer a new perspective on the Leibnizian approach with reference to these ontologies of Quantum Mechanics, but also to point out how Leibniz's thought can, in turn, highlight the renewed understanding of Nature yielded by Quantum Physics. Within this context, a particular attention will be given to the following questions: What is it for two related physical entities to be distinct? How can we account for their diversity within a holistic framework? Or, to put it another way, how can we reconcile their individuality with their non-separability? As an attempt to answer these questions, I shall argue in favour of a conception of individuality defined in terms of relatedness: the individuating feature of a physical entity is to be found in (and only in) its relational properties.

[7] S. Di Bella, *The Science of the Individual: Leibniz's Ontology of Individual Substance*, Berlin, Springer, 2005, p. 340.
[8] M. Esfeld, "Quantum entanglement and a metaphysics of relations", *Studies in History and Philosophy of Modern Physics* 35B, 2004, pp. 601-617.
[9] J. Ismael, J. Schaffer, "Quantum Holism: Nonseparability as Common Ground", *Synthese*, forthcoming.