Project "Fundamental ontological issues and contemporary physics"

Description for the general public

Ontology (also referred to as metaphysics) is the branch of philosophy that considers the most general questions regarding the fundamental nature of reality. Among these questions are such as "What are the basic constituents of the physical world?", "What individuates a particular object from the rest of the universe?", "What makes an object the same entity throughout changes?", "What is the connection between objects and the properties it possesses or relations that links it to other objects?" and the like. On the other hand, physics is an empirical science that aims at discovering the most fundamental principles governing the universe. Therefore there is a great deal of overlap between these two seemingly distinct areas of study. This particular project focuses on selected issues that connect two fundamental physical theories – quantum mechanics and the theory of relativity – with some philosophical discussions on the nature of objects in general. One of the central ontological concepts considered in this project will be that of individuation. Under one possible interpretation, to individuate an object is to discern it from the rest of the universe with the help of some qualitative properties or relations. As it turns out, quantum mechanics challenges the view that elementary particles can be individuated in this sense. This is supposed to be a consequence of the fact that the quantum-mechanical description of a system of many particles of the same type (many photons, electrons etc.) should possess certain mathematical features of symmetry. In the current project this claim will be thoroughly investigated, and it will be revealed that the non-individuality of quantum particles is by no means a foregone conclusion. It will be argued that quantum mechanics possesses the formal means necessary to distinguish even particles of the same type by their state-dependent properties.

Another philosophical interpretation of the concept of individuation is formulated in the framework of the philosophical theory of modality (necessity and possibility). The question asked here is how to identify a given object in various possible scenarios. Assuming that such identification should be done on the basis of some selected properties and/or relations (known as "essential"), we can now turn to physical theories in search for the appropriate properties/relations to do the individuation of the fundamental objects of these theories. In quantum mechanics essential properties will be found among the so-called state-independent properties (mass, electric charge, spin), uniquely characterizing a given type of particles. On the other hand, physical theories of spacetime (such as the general theory of relativity) suggest that individual spatiotemporal points and regions are best individuated by their metrical relations (relations that, roughly speaking, reflect mutual distances between these points and regions). An interesting consequence of this assumption is that alternative mathematical models of spacetime and matter formulated within the general theory of relativity may refer to the same physical reality in spite of being mathematically distinct in some sense. This can help us better understand the ontological meaning of an important feature of general relativity known as covariance. On the philosophical side, the lesson from this case is that individuation of objects by relational structures they participate in (this can be seen as part of the doctrine known as ontic structuralism) is a reasonable assumption that modal metaphysicians should not easily dismiss. As seen in the above examples, the project should contribute both to the advancements of scientifically-oriented ontology, and to the foundational analysis of modern physical theories.