RESENHAS
REVIEWS

FRENCH, Steven & KRAUSE, Décio. *Identity in Physics: a Historical, Philosophical, and Formal Analysis*. Oxford: Oxford University Press, 2006.

French and Krause write, in the first page of their book, that "[m]ost of us would agree that [...] many of the so-called 'everyday' objects we encounter can be regarded as individuals. How is this individuality to be understood?" On the other hand, there is a view (and both authors are very aware of this) that some physical objects (like those elementary particles usually studied in the context of quantum theories) seem to suffer some lack of individuality, in a sense to be made precise. This book is about this kind of problem, namely, the notion of (non)individuality as well as its related subjects like the concepts of identity and indistinguishability, among others. What is the meaning of individuality (hence, non-individuality)? What are the physical consequences of individuality? Is it reasonable to ask such a question? What kinds of philosophical questions can be raised about the issues of identity? But mainly, is it possible to talk about these concepts? What kinds of languages are we supposed to use in order to talk about such deep questions?

The book is very well written. The reading of this 438 pages book flows in an elegant, sophisticated and coherent way. In the introduction, some basic philosophical terminology is introduced concerning terms like "transcendental individuality", "self-identity", "distinguishability", "haecceitism", among others. Such a chapter prepares the reader for the remaining reading, by introducing some of the main concerns in the book. In the next chapter the authors make a historical and critical review on the concept of individuality in classical physics, with special emphasis on statistical mechanics and field theories. After all, there is an intriguing interweaving between statistical mechanics and the issues of non-individuality and indistinguishability, in the sense that one seems to entail interesting consequences on the other and vice versa. This discussion is extended in the third chapter, where it is discussed the fundamental role of quantum statistics in the problems of non-individuality among elementary particles.

Usually physicists consider that intrinsically indistinguishable particles are an exclusivity from the quantum world, and that individuals happen mainly in the classical framework for physics. Yet in the next chapter the reader will find a

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good deal of the state of art of individuality in the realm of quantum mechanics, including discussions about the possibilities that either classical particles can be considered as non-individuals or quantum particles can be understood as individuals. In the fifth chapter there is a careful discussion about the role of names among quantum particles, a world which seems to be a 'land of anonymity', despite the fact that physicists use labels to talk about specific quantum particles, which can be considered (and usually they are), in a sense, as non-individuals. Chapters 6 and 7 explore some proposals of possible mathematical frameworks to deal with non-individuality, like the so-called quasi-set theory (an extension of Zermelo-Fraenkel set theory that allows to talk about multiple collections of indistinguishable objects). Some interesting applications in theoretical physics are presented as well, like the deduction of quantum distributions. Chapter 8 is about non-reflexive quantum logics. Finally, the last chapter makes a very brief discussion about the status of particles within quantum field theories, which is a delicate subject, since it seems rather difficult to talk about particles within the scope of a field theory, although a *quantum* field theory.

This book is probably the most comprehensive document concerning the philosophical, historical, physical, and mathematical aspects of the notions of individuality, identity, indistinguishability and related subjects in theoretical physics, with its profound and yet well written discussions and its hundreds of classical and up to date references. But the most important is that this book surely can be used as a starting point for future research projects.

For example, from the philosophical point of view, one of the main difficulties faced by the authors (actually by all people who employ formal methods in philosophy of science) is the interface between formalism and the intuition (or common sense) usually expressed in natural language. They state, e.g., the infamous Principle of the Identity of Indiscernibles as it follows: "two objects which are indistinguishable, in the sense of possessing all properties in common, cannot, in fact, be two objects at all." This is like to say that the pink panther cannot be pink at all. A natural language like, e.g., English seems to be based on the intuition that it is impossible to talk about a plurality of indistinguishable objects. In order to talk about indistinguishable objects (note the plural) apparently we need a more appropriate language than English. This kind of problem raises fascinating philosophical issues, and some of them are discussed in a very detailed and clear way in this book. The quasi-set theory discussed by the authors seems to be an interesting alternative and formal way to "talk" about non-individuals. Yet a semantical side about this fascinating first order set theory without identity

seems to be an interesting research program to be developed, from a mathematical (logical) point of view, of course.

From the physical point of view, an interesting issue has to do with statistical mechanics. The authors explore very well the historical and physical aspects of the Boltzmann-Gibbs statistics, which is the standard classical approach to statistical mechanics. According to French and Krause, the ergodic hypothesis states that (page 38)"in the course of time a system will pass through every point on the energy hypersurface in Γ-space [the parameter space]. The fraction of time spent by the system in some region of this space will then be proportional to the volume of that region". Nevertheless, there are some generalizations of Boltzmann-Gibbs statistics that certainly should be explored in any discussions about individuality in physics. One remarkable example is the nonextensive (in the thermodynamical sense) Tsallis statistics, which allows to deal with physical systems subject to boundary conditions that are multifractal. For details see [Tsallis, C., "Nonextensive statistics: theoretical, experimental and computational evidences and connections", *Braz. J. Phys.* **29** 1–35 (1999)].

Other problems are raised by the authors themselves, which guarantees that this subject seems to be just starting, despite the huge literature available about this.

Some minor corrections should be made in the next editions of this book. For example, in page 7, it is asked "What confers individuality on physical individuals?", and the authors answer that this question "is actually an empty question since there is simply no need for any conferring 'Principle' if individuality is taken as primitive." That is fallacious, from the mathematical point of view, since even primitive concepts can be definable, according to standard theories of definition like Leśniewski's and Tarski's. A more careful text should be written on this. A suggestion is to replace the word "primitive" by "an undefinable primitive". There are other minor problems with the organization of the book, like, for example, footnote 43 on page 301, where the reader can find a definition for the rank of a set, although this term is used for the first time two pages before. Besides, the term "rank" does not appear in the index. But these are insignificant mistakes if we compare them to the extraordinary and original discussions along the whole book.

In summary, this book is recommended: (i) for the physicists who are unsatisfied with the naive intuitive notions of the issues of (non)individuality, identity, and indistinguishability mainly raised in the foundations of quantum theories; (ii) for the scientific philosophers who want to cope with different approaches (in-

cluding the formal ones) in order to get a better understanding on some aspects of the foundations of physical theories; (iii) for the scientific historians who want a comprehensive view of the dynamics of some philosophical ideas in physics; and (iv) for the mathematicians who want to boldly explore new worlds in set theory and mathematical logic.

Adonai S. Sant'Anna
Departamento de Matemática
UFPR
C. P. 019081
81531-990 Curitiba, PR
Brazil