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Inconsistent Reasoning in the Sciences and *Strategic*-Logical Pluralism

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ABSTRACT: This paper submits a novel approach to contradictions in science. My main concern here is methodological, namely: to respond to the question *how can we study and explain cases of inconsistent science from an inferential point of view without ending up being a monist regarding a particular type of logical consequence?* In order to do so, here I present a novel type of paraconsistent approach to inconsistent reasoning and argue that such an approach could help to deepen our understanding of sensible reasoning in inconsistent contexts. In this paper, I argue that a *Paraconsistent Reasoning Strategies Approach* could constitute a methodological pluralistic alternative for the understanding and explanation of the inferential processes involved in inconsistency toleration in the sciences.

1. Introduction

Principle of Explosion is one of the most characteristic principles of classical logic (and of any other explosive logic), it says that any (explosive) theory will trivialize if it contains at least one contradiction. A *contradiction* is a pair of propositions, where one is the negation of the other - sometimes contradiction is defined as the conjunction of both propositions. A theory is *trivial* if it is possible to derive any proposition from it. Therefore, any inconsistent (explosive) theory will be trivial.

In light of the above, an important question in the philosophy of science is whether science could be inconsistent and non-explosive at the same time; this is, *can science be inconsistency tolerant?* If science could in fact be tolerant to contradictions, philosophers of science should also address the questions *how it is possible to make sense of*

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the use of inconsistent theories in science and *is such use an indication of scientific irrationality*. It has been argued that to understand contradictions as an epistemic phenomenon and to provide a formal analysis of sensitive inconsistent reasoning in science could be crucial in the search for a general theory of scientific rationality (Carnielli and Coniglio 2016). Unfortunately, large part of the philosophical projects that aimed at addressing the possibility of sensible inconsistent scientific reasoning lost sight of the original goal and ended up exclusively "proposing alternative logics that *might* lurk in the background of scientific reasoning" (Brown and Priest 2015: 299. My emphasis.).

Logical pluralism is, sometimes, understood as the recognition that "different kinds of situations, and different logics (or consequence relations) may be appropriate for *reasoning* about them—in the sense that if you know (or assume) that certain things hold in these situations, the logic is guaranteed to give you other things that hold in the situation" (Priest 2015: 331. My emphasis). All this in the absence of the assumption that a single correct approach to the reasoning exists.

Considering the apparent failure of many philosophical programs when explaining sensible inconsistent reasoning in the sciences, this paper submits a novel approach to the analysis of inconsistency in science. My main concern here is methodological, namely: to respond to the question *how can we study and explain cases of inconsistent science from an inferential point of view without ending up being a monist regarding a particular type of logical consequence?* In order to do so, here I present a novel type of paraconsistent approach to inconsistent reasoning and argue that such approach could help to deepen our understanding of sensible reasoning in inconsistent contexts.

In order to do so, here I introduce a paraconsistent approach to reasoning, namely, the *Paraconsistent Reasoning Strategies Approach* (PRSA); and I argue that the PRSA could, in the long run, ground a theory of scientific rationality and that is, at first, compatible with different views on logical consequence. The plan for this paper goes as follows: First, in Sec. 2, I briefly describe the phenomenon of inconsistency toleration in science and I will enunciate some of the most important requirements for its philosophical understanding. In Sec. 3, I briefly introduce a case study that illustrates inconsistency toleration in empirical sciences. Sec. 4 is devoted to characterize the formal approach to inconsistent reasoning, and to present the PRSA and defend that it can account for inconsistent scientific reasoning. Finally, I draw some conclusions.

2. Inconsistency toleration in science

While consistency in science has been untiringly pursued and inconsistency has often been understood through its negative connotation, the history of science has shown that, at some point in their development, many of our most important theories have been inconsistent. Some of the most famous examples of this are: Aristotle's theory of motion, the Early Calculus, Bohr's theory of the atom, and Classical Electrodynamics.

Considering the above, philosophers, historians and logicians of science have pointed out that contradictions are safely ubiquitous in the scientific activity, this is frequent without threatening the scientific enterprise (Lakatos 1970, Laudan 1977, Smith 1988, Meheus 2002, Carnielli and Coniglio 2016). Thus, nowadays, there is a common agreement about not every contradiction in the scientific reasoning being malign. So, contrary to what the traditional views might suggest, inconsistent theories do not always have to be rejected.

Inconsistency toleration is an epistemic and inferential phenomenon which takes place once epistemic agents who believe contradictions are malign are able to identify a contradiction in a relevant part of their reasoning and still reason sensibly from them, this is, they are still able to distinguish between the (inferential) products of their reasoning that are sensible given a particular context from those that are not (Meheus 2002, Carnielli and Coniglio 2016).

Inconsistency toleration does *not* necessarily involve any of the following: (a) the final solution of the contradiction, nor (b) a *real* contradiction 'in action'. One the one hand, when facing a contradiction, scientists could be trying to solve it and fail at doing so, and we can still call this 'inconsistency toleration'. Additionally, they also could be using an inconsistent set of propositions without focusing on the contradiction but, if they are aware of its presence and can still prevent triviality, we can keep calling it 'inconsistency toleration'. On the other hand, if, in a particular time (*t1*), a scientist identifies a contradiction in a particular set of propositions, regards it as not dangerous and remains capable of having sensible reasoning; later, in a time (*t2*), she discovers that the original set of propositions did not contain a *real* contradiction (but only apparent), we can still call the processes that she followed for the avoidance of triviality, in *t1*, 'inconsistency toleration'.

Philosophers of science have developed three different types of research programs for the study of inconsistency in science:

Historical programs: this type of programs have a deeply descriptive approach to contradiction in science, "which concerns the question whether inconsistencies commonly appear in science, and whether scientists sometimes accept and reason from inconsistencies" (Šešelja 2017: 2).

Logical programs: these programs have a more "normative perspective, which concerns the questions whether we can rationally reason from an inconsistent set of premises without ending up in a logical explosion, and if so, how" (idem)

Methodological programs: this type of programs have "a normative perspective, which concerns the role of the standard of consistency in evaluations of scientific theories" (ibid).

As a result of the most recent discussions on the possibility of inconsistent science (Vickers 2013, Davey 2014), it has become clear that any attempt for the philosophical understanding of the phenomenon of inconsistency toleration should allow to put all these programs together. Thus, a satisfactorily approach to inconsistency toleration should allow for a way to understand how it is possible to reason from inconsistent information in science without arriving at arbitrary conclusions, it should also allow for some insights about the status of consistency in science and finally, it should help us to describe and explain actual cases of inconsistency toleration in science (if any).

In what follows I introduce a case study from nuclear physics that illustrates inconsistency toleration, and I argue that cases like this one deserve an explanation in terms of inferential mechanisms that allow for *good* predictions despite inconsistency and for the avoidance of triviality despite the presence of a contradiction.

3. The (inconsistent) nuclear realm

Some preliminaries: The nucleus of an atom is the small region in which 99.9% of the total mass of the atom is located. The nucleus consists in protons and neutrons bound together. The behavior of the nucleus is explained by appealing to two different forces: the strong nuclear force and the weak nuclear force. The strong nuclear force is what binds nucleons (protons and neutrons) into atomic nuclei, while the weak force is responsible for the decay of neutrons to protons. The *binding energy* of a nucleus is what in large part determines the stability of the nucleus. Any atomic nucleus (of any chemical element) will exhibit binding between protons and neutrons and decay of neutrons and protons. Finally, our current nuclear physics has provided us with, at least, 31 nuclear models that allow us to, at least, describe, predict and measure this type of behavior of atomic nuclei. (Cf. Cook 2006, Morrison 2015: Chap. 5).[2]

On the one hand, the *Liquid Drop Model* (LDM) is one of the most successful nuclear models. It was formulated under the assumption that the nucleus of an atom exhibits classical behavior (protons and neutrons strongly interact with an internal repulsive force proportional to the number of nucleons). On the other hand, the *Shell Model* (SM) is a nuclear model according to which a shell represents the energy level in which particles of the same energy exist, and so, the elementary particles are located in different shells of the nucleus. According to the SM the nucleus itself exhibits quantum-mechanical behavior (Heyde 1994: 58); that is, for this model "nucleons are assumed to be point particles free to orbit within the nucleus, due to the net attractive force that acts between them and produces a net potential well drawing all the nucleons toward the center rather than toward other nucleons" (Morrison 2015: 185).

To measure binding energies of different nuclei, physicists have always preferred LDM, as it is extremely simple and highly accurate. However, while this model is efficiently used for predicting binding energies and fission of many elements, LDM faces serious difficulties when addressing the behavior of atoms of Helium (He), Oxygen (O), Calcium (Ca), Nickel (Ni) and Lead (Pb). Such elements' nuclei are bound more tightly together than

[2] The diversity of models itself is not problematic; especially if "each model has its particular successes, and together they are sometimes taken as complementary insofar as each contributes to an overall explanation of the experimental data" (Morrison 2015: 179). However, the case study that I am presenting here illustrates how the basic assumptions required by one model contradict those required by another model.

predicted by the LDM depending on the number of nucleons that they possess. This is the so-called 'magic numbers' phenomenon. Yet, SM can predict binding energies of nuclei with magic numbers (and, oddly, only nuclei of magic numbers). So, if physicists want to measure binding energies of all elements' nuclei they have to, sometimes, see the nucleus as classical and, some other times, as a quantum object. As could be obvious to the reader, to assume that the atom is describable as a classical entity as well as a quantum object is at its best, problematic, and at its worst, inconsistent.

It is well known that nuclear physicists do not take both models as candidates for the partial truth, they only use them (and combine them) in order to get accurate predictions and measurements, but they do not believe that both models put together describe realistically the empirical domain they 'talk about'. Nonetheless, this case study demands an explanation about how an inconsistent combination of information –interpreted realistically or not- could *entail* accurate predictions and how scientists could avoid triviality at the same time. Cases like this one require then an analysis in terms of inferential procedures that are useful (or needed) for the avoidance of triviality while tolerating inconsistencies, i.e., an explanation in terms of logic.

With that in mind, in the following section I briefly describe two different ways for giving a formal account of inconsistency toleration in science.

4. Paraconsistent approaches

Logic understood from an epistemological point of view is mainly focused on increasing our understanding of human reasoning through the analyses of certain inferential patterns that agents could actually employ (Corcoran 1994). Such a view has provoked critical discussions on formal and philosophical level. On the one hand, some philosophers have been strongly skeptical regarding the normative role of formal logic in human reasoning (Margáin 1976), and some others have accepted that it is not clear if logic could describe and norm always human inferential processes, yet it could still be explicative of some common inferences (Harman 1984). On the other hand, some other logicians have sustained that certain (type of) logics could ground a theory of human rationality (Carnielli and Coniglio 2016). The latter approach consists in identifying a paradigmatic element of human rationality and analyzing the inferential patterns that are involved (which logical principles play a role in that particular type of reasoning, which logical principles are clearly avoided, and so on), the next step is to select a logic or a group of logics that can describe and explain such inferences. Ideally, the result of such analysis will provide us with, at least, a deeper understanding of human rationality (Carnielli and Coniglio 2016).

Following this intuition, some schools of paraconsistent logics have persistently aimed at providing logics that are supposed to describe and norm –actual- human reasoning in inconsistent contexts. Let's call this type of program the *Paraconsistent Logics Approach* (PLA). The PLA projects are mostly focused on the analysis of different types of logical consequence that could describe sensible reasoning in inconsistent contexts –as part of this approach one could recognize certain branches of the Adaptive Logics project (Batens 2002, 2017; Meheus 2002), the **LFI**s project (Carnielli and Coniglio 2016), among others. While this enterprise has produced many interesting formal results, it also has been accused of overlooking the actual phenomenon of handling inconsistency in human reasoning, partially because the type of analysis that it holds requires strong commitments with very peculiar logical consequences (that might not be part of human reasoning at all) and also because none of these projects has been able to provide a satisfactorily uniform explanation for inconsistent reasoning in science (while endorsing that uniform solutions are the ultimate goal of some of these projects).

In the majority of cases the PLA-explanations of cases of inconsistency toleration are habitually reinforced by specific applications of particular paraconsistent logics. And so, it has been argued that, the PLA draws the attention away from the actual premises and arguments offered by scientists by privileging discussions on which particular notion of logical consequence is more virtuous (Brown and Priest 2015). For instance, in Meheus (2002) the case of Clausius' derivation of Carnot's theorem is explained by stating that the logic that satisfactorily models this type of reasoning is an Adaptive Logic, in particular, the adaptive logic ANA. In a similar way, Priest (1987) analyzes the –physical- phenomenon of motion as a contradictory one and provides an understanding of it that suits the basic structures of some dialetheist logics. So, it is not surprising that these PLA-explanations face some harsh critiques from the history and philosophy of science. It has been constantly pointed out that the PLA that underlies the understanding of the inconsistency toleration episodes, tends to threaten the understanding of the actual phenomenon (as it was claimed for the case of the Priestian theory of motion, by Boccardi and Macias-Bustos (2017), and by Vickers (2013) for some other interesting cases of alleged inconsistency toleration).

In face of this kind of controversies, a more general type of formal approach to inconsistency toleration has been suggested: general formal tools that do "not focus on identifying or proposing alternative logics that might lurk in the background of scientific reasoning. Instead it focuses on a more directly observable feature of reasoning, viz., how and where different premises are invoked in the course of arguments" (Brown and Priest 2015: 299). The result is a type of analysis of inconsistency in (scientific) reasoning through the use of some reasoning strategies; let's call this approach *the Paraconsistent Reasoning Strategies Approach* (PRSA). Considering that this methodological view makes no assumptions about which is the underlying logic of scientific reasoning, it is considered to be 'minimal' (Brown 2017).

Paraconsistent Reasoning Strategies are specific technical procedures that help to achieve the avoidance of triviality in an optimal way –what is 'optimal' would depend on the own constrains of each of the cases that are being studied. These strategies suggests ways in which information could be chunked and transmitted. Even though these strategies often substantiate the general dynamics of certain logics; they are, most of the time, also logic-independent. Paraconsistent reasoning strategies do not necessarily focus on the structure of the scientific inconsistent theory (or model) itself, but they pay special attention to both, the information that epistemic agents often employ to identify the contradiction and the ways in which agents use such information in scientific problem solving and still avoid triviality from it. This minimal approach to inconsistent scientific reasoning was first sketched through the Rescher-Manor mechanisms (Rescher and Manor 1970) and is nowadays incarnated in the strategies that substantiate the dynamics of the so-called Adaptive Logics, *reliability strategy* and *minimal abnormality strategy* (Verdee 2009, Straßer 2014, Batens 2017), and in *Chunk and Permeate* (Brown 2016, 2017; Brown and Priest 2004, 2015; Friend 2013; Benham et al. 2014; Priest 2014).

5. PRSA logical pluralism

Usually *logical pluralism* is understood as "the view that there is more than *one correct logic*. Logics are theories of validity: they tell us, for different arguments, whether or not that argument is of a valid form. Different logics disagree about which argument forms are valid" (Russell 2019).

That considered, as the PRSA is mostly interested in analyzing general procedures that help to attain reliable information through the use of inconsistent data, and because paraconsistent reasoning strategies are -most of the time- also logic-independent, this allows for a logical pluralism of the following type:

> **Logical Pluralism PRSA**: exhibits the absence of the assumption that a single correct approach to the logical consequence that underlies the inconsistency toleration processes exists. The pluralist-PRSA view suggests that there is a finite number of equally successful paraconsistent strategies that help to handle contradictions in human reasoning. While these strategies guide very general procedures of information management, such as to *separate the information in maximally consistent sets*, or to *distrust certain type of results*, they are also compatible with different types of logical consequences (explosive or paraconsistent, among others).

Now, one could fear that this logical pluralism is actually a type of *logical relativism*; this is the view that there can be as many *correct* logics as inferential subjects (either individuals or collectives) (Baghramian & Carter 2018: Sec. 4.4). This, of course could diminish the normative component that, intuitively, logic possess. However, I think, that this might not be the case, as, while all PRSs could be abstractly compatible with extremely many and diverse logics, when being employed to model specific cases of scientific reasoning, only some of them would be relevant and suitable for doing this job –depending on the particular cases to be modeled. In addition, even if the different strategies that could be used for formally reconstructing specific cases of inconsistency toleration provide different reconstructions of the same phenomenon, it is very likely that such reconstructions reveal different components of the same episode of scientific rationality and while doing so, enrich our understanding of both, the reasoning that took place at that particular moment as well as the general phenomenon of scientific rationality.

Finally, considering that the PRSA takes into account general elements involved in the most common practices of inconsistency toleration in science, this approach also permits that, depending on the particularities of each case of inconsistency toleration, different logics are used in order to transmit, select and neglect certain type of information. In order to provide a successful approach to inconsistency toleration a paraconsistent reasoning strategy should describe the use of the most natural information-transmitting inferences into, at least, conditional operations (Meheus 2002), and if doing so, a PRSA could, in the long run, shed light on the basic elements of human rationality in inconsistent contexts.

6. Final remarks

Inconsistency toleration is a phenomenon that takes place once epistemic agents who, after identifying a contradiction, can still reason sensibly from it. It is possible to identify many instances of inconsistency toleration in science (one of them was presented in Sec. 3). There are two different formal approaches to inconsistency toleration in science: the *Paraconsistent Logics Approach* and the *Paraconsistent Reasoning Strategies Approach*, while the former faces many difficulties (one of them being to overlook the actual phenomenon of inconsistency toleration), the latter could, through a type of pluralism, maintain the virtues of the Paraconsisten Logics approach and at the same time, give account of the particularities of each case of inconsistent reasoning in science.

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