Abstract for 5th International Conference on the Nature and Ontology of Spacetime 2018

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Title : **The implication of Gödel's incompleteness theorem on our apprehension of the nature of space-time**

Abstract :

The central theme of this conference is the nature of space-time, and my question is : To what extent can such questions be answered ? Is it possible to arrive at a final statement regarding the nature of space-time ? Is it possible to encompass with a finite number of first principles and inference rules the full extent of the Universe ?

Gödel's incompleteness theorem implies that *in any consistent and rich enough formal structure, based on a finite number of first principles and inference rules, there will always be claims that may be formulated within this formal system but are undecidable* – questions that are not answerable, claims that cannot be either proved or refuted.

A close inspection of Gödel's theorem demonstrates that this impossibility arises when the claims are self-referential, or, more precisely, when the system asks to define itself in its own terms. This is very relevant to our case, since questions regarding the nature of space-time, the basic structure of the Universe, are asked from within it.

The way to remedy, in a sense, the non-answerability, is to add new first principles that allow an answer. Such first principles necessarily rely on new observations. But their addition creates a new theory, which in its turn produces new non-answerable questions.

In this way new insights, new knowledge, new information that are not derivable from old ones will be accumulated. The scientific research will produce, in a never-ending process, more and more insights, understandings and knowledge, within larger and larger theories.

This situation is certainly very familiar from the history of science, and I don't pretend to present in this sense any novelty. However, the fact that it is organically inherent in the nature of the scientific process, as is asserted by Gödel's theorem, is not realized by many, and if it is it seems to bring disappointment: Many people wish to arrive, hopefully in their life-time, to a theory that fully describes, with few and simple first principles, the whole of the physical world. This was certainly

the vision of Newton and Einstein. The realization of impossibility of such aspiration causes them much disappointment.

My view is different :

> The more we know then there is, and will be, even more to be known and reveal. The prospects to discover become larger, not smaller.
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> The "cake of knowledge and understanding" is not fixed, unchanging, but rather ever-growing. Thus there will always be more to be known, to be revealed, to discover, not less.
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> And indeed, if this were really the case (*i.e.*, that a theory that fully describes, with few and simple first principles, the whole of the physical world, is possible), then what new first principles will be left for the coming generations to reveal and discover ? What prospects would they have then ?

Not every question that lacks answers is Gödelean (*i.e.*, self-referential and non-answerable in the absence of appropriate first principles), but it is very reasonable that questions regarding the nature of space-time, like the theme of the conference, are Gödelean. I will attempt also to discuss, as much as possible, also the nature of such Gödelean questions, which is currently an evolving research.

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