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# ЭТАПЫ ПОЗНАНИЯ ПРИРОДЫ НА ОСНОВЕ НАБЛЮДЕНИЯ ФИЗИЧЕСКИХ ЯВЛЕНИЙ

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**Резюме.** Физические теории - это общая сумма, которую мы – люди, ученые, физики – можем составить при интерпретации наших наблюдений за Вселенной. Мы являемся неотъемлемой частью Вселенной вместе с нашими наблюдениями, поэтому акты наблюдения также поддаются наблюдению и должны стать частью явлений, рассматриваемых теорией, особенно с учетом того факта, что произвольно выбранные способы наблюдений могут существенно определять эмпирические результаты.
Наблюдения и интерпретации являются актами отсылки, а самореференция возникает в физике всякий раз, когда наблюдатель признается частью наблюдаемой системы. Если самореференция появляется в физике по аналогии с теоремой Геделя, то неполнота в физике кажется неизбежной. В статье обсуждаются наблюдатели и наблюдения как ссылки в физике, кульминацией которых является понимание того, что они иерархически взаимосвязаны, так что универсальная физическая теория не может быть полной.

**Ключевые слова:** наблюдатели и наблюдения за собой; самореференция; самоотрицание; логические парадоксы; теория всего; участвующие наблюдатели.

# STAGES OF COGNITION OF NATURE BASED ON THE OBSERVATION OF PHYSICAL PHENOMENA.

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**Resume**

Physics theories are the sum-total that we – humans, scientists, physicists – can make in interpreting our observations of the universe. We are integral part of the universe, together with our observations, therefore acts of observation are also observables and should become part of the phenomena considered by the theory, especially in view of the fact that arbitrarily chosen modes of observations may essentially determine empirical results.

Observations and interpretations are acts of referencing, and self-referencing occurs in physics whenever the observer is recognized as being part of the observed system. If self-reference appears in physics in simile to G¨odel's theorem, then incompleteness seems unavoidable in physics. The article discusses observers and observations as referencing in physics, culminating with the understanding that they are hierarchically interrelated so that a universal physics theory cannot be complete.

**Keywords**: observers and observations; self-referencing; self-negation; logical paradoxes; theory of everything; participating observers.

Is it possible to arrive at an ultimate theory of the universe ? The belief that it is possible to arrive at a complete theory (sometimes known as "theory of everything" (TOE)) that fully describes the whole of the physical world – a theory that accounts, via few and simple first principles and inference rules, for all the phenomena already observed and that will ever be observed – has been, for many years and for most researchers, a fundamental tenet and the major drive for scientific research. A. Einstein put it very clearly : «It is the grand object of all theory to make these irreducible elements as simple and as few in number as possible, without having to renounce the adequate representation of any empirical content whatever».

In classical physics, till the end of 19th century, the common view was that the humanobserver-scientist is a separated, not involved, by-standing witness to all universal phenomena. But 20th century physics made us realize that in many instances the observer is capable of influencing the outcome of experiments. Therefore, also from the empirical point of view, the observer should be recognized as a full participant, an integral part of the observed system, with the acts of observation being also observables that should become part of the phenomena considered by the theory.

Observations and interpretations are acts of referencing. Whenever observers and observations are also part of the observed systems, participating in physical

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phenomena, with observers referring to their own observations, these are manifestations of self-reference in physics. Self-reference is also the core principle of G¨odel's incompleteness theorem, which implies that any rich enough consistent formal structure, based on a finite number of first principles and inference rules, cannot be complete. G¨odel's theorem concerns arithmetics and logic, but since physics theories use mathematics and are organized as formal structures then naturally comes the question: Does G¨odel's theorem apply to physics?

The applicability of G¨odel's incompleteness theorem to physics was initially discussed along these lines in. In the present article we elaborate on these ideas and further the study of the rˆole of referencing and self-referencing in physics. We start by discussing referencing and self-referencing in the light of G¨odel's theorem, then in physics theories formed from our observation of the universe. The questions that the article follows are "How to describe referencing in physics? Does self-reference lead to incompleteness in physics?"

It is argued that self-reference is found in physics in observations of observations. Moreover– in many instances the same physical phenomenon may be viewed in more than one way, so that the mode of the observation, freely chosen by the observer, determines its consequences. Self-reference and referencing in observations lead to identifying levels of observation, between observer and observations. Each level of observation requires a higher one for the former to be observed, thus creating a (potentially infinite) hierarchy of levels of observation.

Observations are followed by interpretations, therefore each higher level suggests a more profound insight which empirically implies an essentially new discovery, and together a potentially infinite hierarchy of levels of interpretation. New discoveries imply new first principles in the foundation of the theory, so the theory remains open and cannot be complete.

Focusing on referencing and self-reference liberates us from the mathematical argument – it is not important any more what kinds of mathematics are used by physics.

In the basis of the scientific research is the expectation that it is possible to identify in the totality of observations common fundamental principles that can be grasped by human cognition. These fundamental principles form – as axioms – the basis of the theory, and from them are deduced properties, statements and conclusions corresponding to the object of the research. Then it is expected that the combination of logical inferences with the results of observations makes it possible to examine the correctness of these fundamental principles. But G¨odel's theorem challenges

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the co-existence of the two essential characteristics that are expected from any physics theory – consistency and completeness, both logically and physically:

• Logical consistency – that the theory does not produce conflicting predictions.

• Physical consistency – that the theory does not produce predictions that contradict physical observations.

• Logical completeness – that all the predictions of the theory are uniquely concludable.

• Physical completeness – that with given initial data, the future can be predicted with any desired accuracy.

The last feature is the requirement of determinism. In G¨odel's theorem self-reference allows paradoxical self-negation, that implies undecidability which leads to incompleteness. Accordingly, with self-reference being possible in physics, incompleteness seems unavoidable in physics theories that are large enough. In this way G¨odel's theorem casts doubt on the possibility of the existence together of these characteristics for sufficiently broad physics theories.

Any physics theory (or, more broadly, natural science theory) may be viewed as the conclusion and summing-up of our interpretations of our observations of nature. In an act of observation the observer refers to the observed phenomenon, hence observations are referencing in physics.

We may observe our own observations, thus any observation is also an observable phenomenon. Therefore, the act of observation is referencing in physics, and self-observation is self-referencing in physics. Classical physics is dominated by the view expressed by Victor Hugo who once said that Creation lives and evolves; the human is only a witness. This was the common view up until the 20th century. Now it becomes evident that we humans are not simply bystanders on the cosmic stage – we are active participants in the evolution of the universe, the cosmos being made real in part by our own participations. This is the viewpoint put forward by people like E. Wigner and J.A. Wheeler, referring to observations of quantum phenomena. It is certainly reminiscent of the ancient Jewish tradition, that the human is active participant in Creation.

The principle of relativity manifests the fact that measurements are observer-dependent. In quantum experiments the way the experiment has been set up and the chosen mode of observation may determine the outcome of the experiment – the very nature of the empirical end-result – whether the observed object is detected as a wave or a particle, or which path it follows in traveling from one point to another, etc..

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Then the observer is not a by-stander, uninvolved, separated witness of physical phenomena but an active participant involved in the physical occurrence. The mode of observation – arbitrarily chosen by the observer – determines, even in small, the way the universe evolves. When the act of observation, being influential in physical phenomena, becomes an integral part of the phenomenon, then with it, necessarily, also the human observers, which become participating observers. When the observer, the observation and the subject are all part of the physical phenomena, this is a manifestation of self-reference in physics.

Summing up, physics is our (human) interpretation of what we observe in the universe. We (humans) are part of the universe, therefore we are both observers and observed. If the physical process is independent of the observer then the observer seems to be only a witness. But if the observer intervenes with the physical process then the act of observation should be considered an active part of physical processes, therefore part of the subject matter of physics theories.

Observers are therefore active participants in the physical happening.

## Final notes

The results of G¨odel's theorem are used here as a lead to consider, in a sense, the future of physics theories. A universal point of view, beyond current physics, is proposed : We (humans) are part of the universe. Physics theories are formed of the interpretations that we make of what we observe in the universe. By our daily decisions, in the way we act and observe our actions, we take part in determining how the universe evolves. In particlar, by choosing the mode of observation in certain experiments we determine the nature of the outcome.

## Conclusion

An observation is therefore also an observable phenomenon, we are both observers and observed, and we and our observations should also be considered part of the subject matter of physics theories. A universal physics theory will ever be incomplete. First, for the very simple reason that no one can assure us that new facts, that require drastic changes in how we view the physical world, will never be discovered sometime in the future. New discoveries imply new first principles in the foundation of the theory, new insights that are not derivable from old ones. The scientific research will then produce, in the way it used to be and what seems to be a never-ending process, more and more insights, understandings and knowledge, within larger and larger theories.

Second, because our observations introduce referencing into physics. The foregoing discussion indicates that since we may observe our own observations, and from any level of observation it is possible to observe only lower-order observations, then the various observations must form some hierarchy. We interpret the world according to the results of our observations. Levels of observations imply levels of interpretations. Each level implies a more profound insight, associated with an essentially new discovery. Therefore, (at least in principle) an endless hierarchy of levels of interpretation.

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