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Philosophical reflections on string theory (2007-2010)

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Background

Physics claims to be the most fundamental science, at least in the sense that all changes in the world supervenes on physical state changes. Many takes the further step of believing that ultimately all facts are identical to physical facts. Thus physics not only helps us make predictions but also provides us with a scientific world view. This is one reason why philosophers are interested in what fundamental physics has to say.

There are two fundamental theories about the world, viz., quantum theory and general relativity. Quantum theory has been developed towards what is now called the standard model, a (nearly) complete account of all of micro physics. At the other end of the size scale general relativity is thought to be a correct theory of the large scale structure of space-time and of gravitational phenomena. But the large-scale structure of the universe is built up by smaller parts. The ultimate building blocks of the world are thought to be quarks and leptons. So it ought to be possible to unite the theory about the micro world and the theory about the large-scale structures into one unified theory. This was for a long time Einstein's desire. So far, this goal has not been fulfilled. The latest attempt to construct a unified theory about the world is string theory and the proponents seem to be fairly optimistic.

The goal of string theory could be summarized as:

i) To unite quantum theory and general relativity

ii) To derive from basic assumptions a number of physical constants, which cannot be derived in the standard model but must be decided empirically.

iii) To explain why all elementary particles are grouped into precisely three families.

iv) To give a unified description of all kinds of physical interactions, i.e., to construe 'a theory of everything'.

The basic assumption in string theory is that the ultimate constituents of reality are a kind of strings, i.e., one-dimensional objects. These strings can have different kinds or resonances, which produce different energy states. These resonance states can now be identified as different elementary particles. Furthermore one can interpret collisions in which some particles are destroyed and others are produced, as changes of resonance states of these strings. Thus strings are the fundamental substance out of which all different elementary particles are built up.

Many physicists are critical of string theory. The main argument is that no variants of the theory is empirically testable, hence string theory is strictly speaking not physics, but metaphysics. The proponents have used two strategies in their defence. The first is to make historical comparisons; several well-known physical theories were, when first presented, not testable. Only much later when technology had advanced further, were they tested and there is substantial hope that string theory also will be testable in the future.

The other line of defence is more fundamental. It is claimed that the consistency requirements, together with the requirement that goals i) to iv) cited above, are sufficient to sort out one single theory.

Specific goals

The goal of this project is to discuss string theory from a philosophical perspective. We will in particular probe into the following seven questions:

1. Justification of string theory; lacking empirical constraints the common view that empirical researchers propose hypotheses and nature shouts ’yes’ or ’no’, is not applicable. But then, how is it justified?
2. Concept formation; the usual picture is that theoretical concepts get their sense by being integrated into a theory which has empirical consequences. Although indirectly, theoretical concepts have an empirical meaning. But if string theory is not testable? What empirical meaning could be given to the concepts used? The critics could argue that string theory is just a piece of pure mathematics without any physical content. Are they right?
3. There are several versions of string theory and one naturally asks to what extent are these versions different theories or only different formulations of one and the same theory? This question is part of the general question about identity criteria for theories and underdetermination of theory by data (purported cases of underdetermination

presupposes that different theories are shown to be really different theories.) We aim to discuss the general issue as well.

4. Symmetry requirements are frequently used in physical arguments. What is the justification for these symmetry requirements? In string theory it is required that the theory is invariant under conformal mappings? Why? A common justification is that the symmetry demands selects particularly simple and 'beautiful' theories. That might be the case, but isn't that an illegitimate introduction of a human perspective in physics, otherwise thought to give a purely objective descriptions of the world? We think there is a better justification for at least some symmetry demands, viz., that symmetry demands are consequences of demands on invariance under changes of arbitrary parametrisations, but this must be argued in detail.
5. In order to unite the four fundamental forces of nature in string theory one has introduced a number (presently seven) of extra spatial dimensions. These dimensions are 'curled up' and can therefore not be observed. One might say that the price paid for unification is very high; a critic might say that if you allow yourself almost anything you can explain anything. It could plausibly be argued that an explanation must be such that explanans do not contain any assumptions not previously accepted, since if not, the explanation is a case of 'obscurum per obscurus'. It is obvious that the defenders of string theory think that unification of the forces of nature is so compelling that brave moves are defensible. We suspect that the very strong pull of unification is an expression of world view and will probe deeper into this issue. Can it be shown that unification is a consequence of certain epistemological and ontological views?
6. What ontological status have the extra curled up spatial dimensions? It is clear that they can't be Kantian 'Anschaungsformen'. Could they be incorporated into a Leibnizian view of space as merely relations among things? The discussion about the nature of space is given new impetus by these proposed extra dimensions and we want to investigate how it can affect the debate.
7. String theory appears to be a prime example of what Lakatos called a progressive research programme; it is a succession of theories held together by a set of common assumptions and the evolution of new theories are driven by theoretical demands, not by empirical findings. A historical comparison with other periods in physics within the framework of Lakatos' philosophy might be illuminating.