

This is an English translation of an article of a popular-science magazine *Parity* in **September 1986**.

“Superstring theory” syndrome

Noboru Nakanishi

Recently, superstring theory is extraordinarily fashionable among the researchers of elementary-particle physics. The sales point of this theory is anomaly-free (the absence of anomaly), but the way of its fashion cannot be said to be anomaly-free.

While the standard theory consisting of electroweak theory and quantum chromodynamics is steadily establishing its footing, various attempts at going beyond the standard theory are frustrated one after another. It seems that any of grand unified theories, supersymmetry, supergravity, Kaluza-Klein theory, and Kaluza-Klein supergravity do not go well. This frustration seems to have made people jump at the superstring theory which appeared in good timing. But this phenomenon looks unreasonable, because the superstring theory should be regarded as an extension of these unsuccessful theories. Ordinary development of natural science goes to the direction in which the theory has been successful. But this time people are making *the theory develop further just because it has been unsuccessful*.

From outsider's eyes, it looks that the people working in the superstring theory are afflicted with a strange malady called “superstring syndrome”. In what follows, I will enumerate its symptoms.

Scale frigidity

When learning quantum theory, students are required to drum the essential difference between macroscopic and microscopic laws into their head. When considering on the basis of the microscopic time, the macroscopic time is regarded as infinitely long. Indeed, the S-matrix which describes the reactions of elementary particles is defined in this manner. However, the ratio between macroscopic and microscopic scales may be at most 10^{10} or so. But the people of scale frigidity regard the super-super-microscopic scale called “Planck scale”, which is 10^{20} times smaller than the size of the atomic nucleus, as the scale of daily life. According to them, ordinary geometry holds perfectly in such a super-super-microscopic world.

How large the 10^{20} is can be seen from the fact that the 10^{20} -times enlarged atom is much larger than the sun. The reason why the physicists who should have the keen sense of scales have lost it seems to be a sequela of the grand unified theories, which cheaply introduced the tremendous energy which is 10^{10} times greater than the energy attainable by accelerators.

It is called *extrapolation* to apply the law established in a certain scope to the case beyond that scope. While the extrapolation is an effective means for the development of science, its uncritical application often brings us such a totally stupid consequence as used as a dope of joke. The people of scale frigidity do not mind such a thing at all and make the extraporation of any order at a breath.

Kaluza-Klein symptom

Everybody knows that the space in which we live is 3-dimensional. Relativity showed that we must consider a 4-dimensional spacetime by adding time, but since the existence of time has already been known from time immemorial, this fact does not imply the increase of the number of dimensions.

Quite surprisingly, however, the people affected by the Kaluza-Klein symptom, working in the superstring theory, believe that the spacetime in which we live is 10-dimensional (or 26-dimensional). For this, there is a historical background concerning the domestic circumstances of particle physicists. In 1920s, Th. Kaluza and O. Klein proposed the so-called unified field theory of the gravitational field and the electromagnetic field by introducing a 5-dimensional spacetime. Stimulated by the recent success of gauge theories in particle physics, the Kaluza-Klein theory revived in extended forms more than fifty years later. The Kaluza-Klein supergravity theories (particularly, the maximally extended ($N = 8$) supergravity, whose formulation was based on the 11-dimensional spacetime) were welcome with great applause. Although, after all, these theories turned out to be unsuccessful, they played the role of getting rid of the psychological suppress against considering higher-dimensional spacetimes. Of course, even if one claims that the spacetime is 10-dimensional, the actual world *is* 4-dimensional; they must therefore dispose of the extra 6 dimensions. Then they are forced to suppose that these 6 dimensions are of the Planck scale so as to become invisible. It seems that the people affected by the Kaluza-Klein symptoms can accept such a fantastic assumption without hesitation.

One may not be able to prove the non-existence of such hidden dimensions. But if the 10-dimensional spacetime splits into our 4-dimensional spacetime and a 6-dimensional space, which plays the role of the internal space characterizing the intrinsic degrees of freedom of elementary particles, then it is natural to suppose that the structure of the 6-dimensional space varies point by point in our spacetime. If so, an elementary particle created at a particular spacetime point will not be able to move to another spacetime point having the internal space of different structure. Therefore, in order not to conflict with phenomena in the actual world, the splitting into the 4-dimensional spacetime and the 6-dimensional space must be supposed to be done idealistically completely so as not to leave the slightest traces of the internal variety. The people affected by the Kaluza-Klein symptom believe in such a great miracle.

First-principle amnesia

Originally, the string theory was a theory for hadrons. The dual resonance model was proposed as the theory satisfying both Regge behavior and duality, which were principles verified experimentally, and then the string theory was formulated as the quantum-theoretical basis of the dual resonance model. But, after all, hadron dynamics was seen to be successfully described by quantum chromodynamics based on the quantum theory of the Yang-Mills field, while the string theory was abandoned owing to its theoretical difficulties. Picking up this forsaken theory, some people reformulated it as the most fundamental theory of physics; this is the superstring theory. That is, it is a recycling of a theory; it is not energy-saving but “theory-saving”. But since this remodeled opening was made by making 10^{20} times scale-down, both Regge behavior and duality lost their meaning. Thus the most fundamental theory having no first principles appeared on stage.

The people of the first-principle amnesia believe that the gravity theory, which is constructed systematically from the first principles, can be derived from a theory having no first principles.

Perturbation-theory paranoia

The quantity which describes the reactions of elementary particles is the S-matrix or the scattering amplitude. But since it is impossible to calculate it exactly, various approximation methods have been invented. Among them, the most well-organized one is perturbation theory.

Among particle physicists, there are many people who overtrust perturbation theory. This is because the special-relativistic quantum field theory, such as quantum electrodynamics, has been brilliantly successful in the framework of the perturbation theory in which divergence difficulty was resolved by renormalization theory. They, however, do not understand at all the fact that the situation is completely different in quantum gravity, which is nothing but the quantum field theory of general relativity. In quantum gravity, since the spacetime structure itself has quantum uncertainty, it is conceptually incompatible with the perturbative approach in which the existence of the Minkowski space (or a particular curved spacetime) is postulated from the outset. Indeed, it is clear that the perturbative approach to quantum gravity is totally meaningless in the region smaller than the Planck scale. Nevertheless, the people of perturbation-theory paranoia firmly believe that such an academic problem as divergence difficulty, which arises from the infinitesimally small spacetime region, should be discussed within the framework of perturbation theory.

At the present stage of the superstring theory, almost nothing has been formulated about the non-perturbative approach. Although, in the superstring theory, it has been claimed that divergence problem is completely resolved and that it is an extension of supergravity, all such stories have been considered in the framework of perturbation theory. The people of perturbation-theory paranoia, however, feel supreme ecstasy in the matter itself that the “scattering amplitude” is calculable by means of perturbation theory, but they are totally indifferent to whether or not it is a really physically sensible concept.

Fashion toxicosis

Although I have criticized the superstring theory stringently in the above, it is certainly an interesting attempt. M. Green and J. Schwarz, who had diligently worked in it for the recent several years during which almost nobody showed interest on their work and then led it to the today's bloom, are worth being praised. But it is definitely an "eccentric theory", as was aptly mentioned by the Asahi Shinbun (one of the leading newspapers in Japan) reporting Green's talk made in the International Conference held in Kyoto in the summer of 1985. Indeed, since the superstring theory is a heresy theory which is beyond the well-established framework of quantum field theory and makes no experimentally verifiable predictions, it should, in the ordinary situation, be investigated by a small number of rather peculiar researchers helplessly. Nevertheless, it has now become the mainstream of the research in particle physics; the present situation is surely an extraordinarily abnormal one!

Recently, the fashion is too passionate in the "industry" of the particle-physics research. This phenomenon is not irrelevant to the worldwide chronic shortage of employment positions in this industry. The person who is working in a deep theory and makes a creative research (though, of course, what the worker himself only calls "creative" is merely self-importance) cannot easily get high appreciation nor a good position thereby. For getting a position, it is a cleverer way to make the research with which many people are familiar, that is, to work in the fashionable topic. Even a minor comment can be published as a paper if it is related to the topic in fashion, and also in the side of the journal, it is welcome by the publisher because such a policy helps acquiring more readers. In this way, the fashion is more and more accelerated.

The people of fashion toxicosis pursue the fashionable topic neither because they think it important nor because they are interested in it but *just because it is fashionable*. Anyway, at present, the superstring theory is not yet a theory which fits its ideas to real conditions. It is quite risky for young researchers who are going to fledge out to indulge in such a theory of still unknown quality. It is something like to imitating a painting of Picasso without learning basic skill of *dessin*.

The patients of superstring syndrome regard the superstring theory as the ultimate theory of physics. According to them, this is because there is no other candidate which can take its place. I do not understand, however, why the candidate of the ultimate theory must be found right now. It is quite unplausible that the ultimate door of the secret of Nature is opened so quickly.