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Cover illustration
Electron density map of a portion of seryl-tRNA syntethase protein. Some 102 000 reflections were recorded at the ESRF using monochromatic radiation, allowing a 2.6 Å resolution (see page 81).

On Towers and Cathedrals

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Text taken from the opening presentation at the triennial seminar on *Future Perspectives in High-Energy Physics* (Hamburg, 3-7 May 1993) organized by the International Committee on Future Accelerators (ICFA).

I cannot give a picture of high-energy physics without describing perspectives for the main existing and future accelerators. I shall therefore try to set a framework in which discussions could be coherently perceived.

A natural basis for this framework was formulated by the late Soviet theorist M.P. Bronshtein in the early-30's. His scheme may be presented as a cube of theories. The present vision of our field is a sort of tower, 19 stories high (on a log scale) which is being built simultaneously from the ground and from the top. Some parts of the tower already exist and they are magically beautiful; some parts are still in scaffolding and look rather ugly. Or maybe our field is a cathedral, the difference being that a cathedral has no stories, just a large volume.

Up to now, with each new order of magnitude in energy, we discovered new principles. But maybe we were only in the basement of the cathedral. This is the great hope of many theoretical physicists. Anyway, we have to remember that the tower and/or cathedral exist in the space of theories, in the space of principles.

The builders from the top are inspired by the creation of general relativity early this century. Since then, many mathematical constants were created by pure thinking and then used to describe important parts of the real world. One of the best examples is Klein-Yang-Mills non-Abelian gauge symmetries. Maybe we are wrong, but we think that we know that the top floor of the tower is at the Planck scale of $\approx 10^{-19}$ GeV. At least it is at this scale where theorists are working. To the extent we understand our subject, the ground floor starts around 0.3 GeV for strong interactions (this is the scale of quantum chromodynamics confinement), and around 0.3 TeV for electroweak interactions (this is the Fermi scale).

The main principles of the tower are determined by the fact that it is quantum (h=1) and relativistic (c=1). But its concrete engineering and architectural realisation also use other principles, some of which we know, some of which we are guessing at, and some of which we are completely unaware of. Given the main rules, the physics is determined by the values of about 20, or 30, or more dimensionless constants. The constants are in fact not quite constant but functions of the momentum transfered q; they are running with q^2 along the tower.

The leading idea of the Creator, as it appears to us, is to use symmetries and to then conceal them or to break them. This breaking may in its turn be a manifestation of a deeper symmetry.

Scalar Particles are the Priority

The discovery of the Higgs particle is still problem number one in high-energy physics. Without this discovery the entire mechanism of gauge symmetry breaking and the origin of the masses will remain a mystery. Discovery of the Higgs will give us insight into the structure of the most simple and the most complex object in the universe — the vacuum. The next step would be to search for other scalar particles and to establish their nature: are they elementary or composite.

We are lucky that the lightest scalar is maybe light enough to be produced at CERN's LEP 200 in several years from now. But even in this case we cannot see the future of our field without the multi-TeV colliders SSC and LHC. The rôle of e^+e^- linear colliders is seen now as complimentary: to study in extremely clean conditions some of these particles in e^+e^- and other collisions.

Among the first candidates are supersymmetric partners of our particles ("sparticles"). There are several reasons to believe in the existence of light (< 0.3 TeV) sparticles; their discovery would have an enormous influence on the perception of the whole structure of physics. It would be like a moment when two teams drilling a tunnel from opposite directions finally meet each other.

The Danger

The main danger in these days of fast and global change is that the construction of the tower may stop, like at Babylon. I do not think that the many-language problem could be serious in the high-energy physics community. For many years, we have learned to understand each other, to help each other, and to work together in spite of national and professional differences. I am even not sure that languages were the main problem with Babylonian towers; the main problem, I suspect, was the lack of funding.

Now, when the cold war is over, more and more governments realise the necessity to stop and reverse the suicidal arms race. It would be tragic if progress in high-energy physics were to be be sacrificed under the pretext of more urgent needs.

In the course of this century, a unique team of accelerator-scientists, engineers, experimentalists, and theorists has been formed. This community, this team, can enormously widen and deepen our understanding of the main principles of the physical world. If high-energy physics is strangled, the team will irreversibly decay.