Toward a dynamic theory

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Dirac: High energy must conform

In the years since it was introduced as a method of organizing the many subnuclear, apparently elementary particles into groups of those having similar characteristics, the Eightfold Way, also called the Theory of Unitary Symmetry, has been extraordinarily successful. There is any number of instances in which a new particle, predicted by the theory, has been discovered, with just the properties it should have to fit the pattern.

Despite the success, the theory is losing favor among physicists.

When the theorists of high energy physics gathered at the University of Miami in Coral Gables, Fla., from Jan. 22 to 24, this successful unitary symmetry theory was conspicuous by its almost total absence from the discussion.

In the one paper that dealt explicitly with it, Prof. Bernard T. Feld of the Massachusetts Institute of Technology reviewed the way in which quark combinations can account for the masses of all particles subject to the strong nuclear force. He drew little response.

No physicist has ever seen a quark, and after eight years of looking many are growing bored with the whole idea. California Institute of Technology theorist Murray Gell-Mann, who named them and who insists that quarks don't have to be real to be useful, is now more interested in particles that are not strongly interacting.

Prof. Gell-Mann dropped his announced topic, classification of strongly interacting particles, which presumably would have had to do with symmetry theory, and talked about problems in the balance of matter and antimatter in weak interactions.

"The symmetry business is at a standstill," says Prof. Richard Eden of Cambridge University. "The excitement now is in the analytical part."

That is, physicists are now talking about ways to understand and to describe, both verbally and mathematically, what it is that happens to particles as they collide with one another or decay spontaneously into other particles. This is in contrast to the symmetry approach, which tries to put the particles into static categories.

This desire for mathematical analyticity, for mathematical expressions that give continuous descriptions of what is happening in particle collisions and that can be applied as general principles to large classes of phenomena, leads another Cambridge professor, P. A. M. Dirac, to suggest that high energy physics needs equations of motion. These are predictive, dynamic mathematical formulas that tell how an object or group of objects under the influence of a given force will act from time to time. They are cornerstones of theory in the disciplines of classical physics, solid state physics and low energy atomic physics.

Ultimately, says Prof. Dirac, "high energy will have to conform to the rest of physics and allow itself to be based on equations of motion. If you try to teach high energy physics without equations of motion, you will see how hopeless it is."

But, he points out, experimenters, as opposed to theorists, could dispense with equations of motion since they involve quantities that are not closely connected to experimental measurements even though they may be philosophically important.

Meanwhile, he says, "theoretical people should find some equation of mathematical beauty" and not "cook up [mathematical elements] to fit experimental results."

High energy theorists have found their problem so complex that they have not attempted to reach such general all-describing mathematical statements, but have launched their attacks piecemeal, making theories to fit what parts of the problem seemed likely to yield success.

One of Prof. Dirac's examples of cooked-up theory involves not particle physics but the gravitational theory of the solar system. Isaac Newton's gravitational theory is based on just such equations of motions as Prof. Dirac argues for, and they say that the gravitational force between two bodies is inversely proportional to the square of the distance between them.

For a long time, however, astronomers have known that the planet Mercury does not move exactly as Newton's theory would have it. In the 19th century some astronomers proposed that Mercury's motion would come out correct if the force were inversely proportional to the 1.934 power of the distance instead of the second power.

Although this is the sort of adjustment that particle theorists would make, in gravity theory, says Prof. Dirac, "no one believed it. It was too ugly." Instead they waited until Einstein came along and derived a completely new formulation of gravitational theory that was general, complete and mathematically elegant.

Now, in the spirit of analyticity and mathematical elegance, theorists are beginning to apply this Einsteinian gravity theory to elementary particles, bringing the theory out of what Prof. Joseph Weber of the University of Maryland calls "its 50 years of isolation from the rest of physics."

And, from its newfound position in the main stream, Prof. Weber proposes some gravitational problems for his high energy colleagues: "Do we know," he asked during the meeting, "that inertia [a body's response to accelerations] is the same in all directions?" There might be discrepancies on the order of a few parts in a hundred thousand billion billion (10^{23}). He goes on to ask whether bodies with negative mass can exist, and points out that bodies whose inertial and gravitational mass were equal (SN: 6/1, p. 532) might participate in different kinds of reactions from those whose inertial and gravitational masses were not equal.

And Prof. John Wheeler of Princeton University points out that study of gravitational theory tends to show that "the masses of elementary particles are not something put into the machine at the beginning [as other theories tend to assume] but are relics of the history of the universe. A different history would have different masses."

A history that made the mass of electrons in an iron atom different from its present value by one part in 10^{55}, says Prof. Wheeler for example, might have caused the earth to collapse by now. By this time such electrons would have made about 10^{55} orbits, and would almost certainly have dropped into the innermost orbits of the iron atom. The iron atoms would thus collapse and the earth with them.

The problem before physicists, as Prof. Wheeler sees it, is to explain why electrons and other particles have the masses they do and not some others. The quark model may be able to predict the actual masses, but it does not explain why they are not something else.