OFF THE BEAT

Does the Buck Stop at the Quark?

For thousands of years natural philosophers have sought a basic understanding of the structure of matter. Theory has changed and changed and changed again. We no longer think much of Aristotle's physics. On the other hand, the Pythagorean preoccupation with numbers, geometric figures and resonant relationships has amusing parallels to the modern physicist's search for mathematical salvation in symmetry groups.

Yet however opinion has veered, however the past has been rejected or accepted, progress has been made on the reductionist path laid out long ago by Demokritos of Athens: From the complex to the simpler to the simpler still. Ultimately, he hoped, there would come a simplest, the *atomos,* the unstructured simplicity that is no longer divisible.

That quest is now at an end. Or so one might come to believe from listening to a number of physicists at the recently held Twentieth International Conference on High Energy Physics, which was held at the University of Wisconsin at Madison. We have the theory that explains the basic structure of matter, they say. It is called quantum chromodynamics. The objects with which this theory deals, the quarks and the gluons, are, in a very sophisticated way, the *atomos* of Demokritos. The symmetry patterns on which quarks and gluons depend, and which depend on them, would cause overtones of joy in the heartbeat of Pythagoras. One of these physicists even remarked that he is already looking for something else to do when physics is over.

That's not to say that there is not yet a good deal that needs to be found out. There is. But that, in the words of another physicist, is "for chemists." A physicist, in this man's definition, is an extreme reductionist, someone who is interested in the simplest idea behind a collection of phenomena. Once that idea is known, the physicist loses interest in the phenomena. He or she is no longer interested in the complex relations and reactions among the phenomena. A physicist cut according to this archetype would tell you that we know all we need to know about chemistry, the usual kind of chemistry, that is. The average chemist would respond to such a statement with growls of outrage. It depends on your point of view. It depends on what it is you want to know.

It seems now that some particle physicists are ready to turn over particle physics to the chemistry-minded. These people, met here and there in the corridors as a large meeting was going on, are hardly a random sample of particle physicists. Here there is no Gallup poll. In fact, if the Gallup organization were to poll particle physicists, they might find it easier to dispense with the sample and simply mail ballots to everybody involved in the science. There are not that many more particle physicists in the world than the number of people Gallup interviews to determine whether President Carter's popularity rating is 28 or 31 percent this week.

The views expressed here may be those of a minority. It is nevertheless significant that physicists of some reputation would express such views out loud and without demanding that they be off the record. And these attitudes are supported by a general complacency that seemed to pervade the meeting, becoming almost as deep as the Marianas Trench.

It may be a bit difficult to express the change in mood from past years. Quantum chromodynamics, as well as related and parent theories such as Higgsism and the Weinberg-Salam theory, have been around for several years. Enthusiasm for this complex of "gauge field theories" or "gauge symmetric theories" (which collectively go toward making up the long-sought "unified field theory") has been quite high for a long time. They have received commendation after commendation, including several Nobel prizes, both for theory and for experiment.

Yet in time past people questioned whether these theories were in fact the last word. (Did quarks have internal structure, for example?) Physicists waited expectantly to see whether experiment would confirm the theoretical predictions. They wondered where a breaking point might come that would necessitate some serious amendment. Then they passed to expecting that experiment would confirm theory but leaving room in their minds for the possibility of an overthrow. Now they seem toweringly confident.

Mention, for example, that experiment has not yet found the last of the six varieties of quark that the quantum chromodynamics theory demands, and the response is: "Give us more energy, and we'll find it." Not even a bit of a "what if not." Reported observations of the interrelations of two families of particles closely identified with quantum chromodynamics, the charm particles and the upsilons, show that they conform most closely to the predictions. The talks generate no wild scenes of enthusiasm — nor any controversy — only a calm pleased acceptance.

This may be the end of a long road. On the other hand, a breaking point may come or may already have come. Physics was declared closed at least once before, and the most complacent declarations were heard after some of the breaks had already come. The determination that the speed of

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light was the same in all unaccelerated frames of reference gave classical electrodynamics something of a nasty problem, but Professor Einstein fixed that with his special relativity. Quantum processes, which are the distinguishing mark of modern physics, were found, but they seemed to be regarded as a curiosity. It was when physicists had to face the structure of the atom, and find a theory for it, that it was widely understood there was trouble. Classical physics failed egregiously. Classical electrodynamics, even as amended by Einstein, predicted the swift collapse of the atom, a disaster that manifestly did not happen. Physicists reached for quantum processes to hold the atom up, and the revolution was on.

Physics may be over. Or it may be in the doldrums waiting for a new storm to blow up. We may already have seen the first catspaw winds of that new storm, but we may not know it yet. We could be in for 20 years of complacency in physics, during which all the bright young minds go into chemistry. Or a hurricane could strike next week.

—Dietrick E. Thomsen

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