The Fading Charm of Pandamonium

In the longstanding sibling rivalry between experimental and theoretical physicists, theorists often take a certain wry satisfaction in predicting what the experimenters don't seem to be able to find. Conversely, when experimenters are finding things that theorists don't predict, the *schadenfreudliche* expression is apt to be on their faces. In the matter of the J or psi particles, those recently discovered, heavy, exotic, weird new particles, the smile is now on the face of the experimental tiger.

The J-psi's (one Brookhaven experimenter, R. B. Palmer now refers to them as gypsies, combining Brookhaven's designation J and Stanford's psi) are heavier than any previously known particles, and present a number of intriguing questions. As soon as their discovery was announced, theorists by the dozen jumped into the pool, the majority with variations on one basic suggestion.

The J-psi's, it was said, are made up of a quark and an antiquark that possess a newly hypothesized property called charm, the first experimental manifestation of that quality. The new particles do not exhibit charm themselves because the pairing of quark and antiquark, charm and anticharm, adds up to zero, but do carry hidden charm, as they say. They call the J-psi's "charmonium" (SN: 1/25/75, p. 58).

At last week's meeting of the American Physical Society in Washington, experimenters gathered for several symposia on the new particles and related topics, and their consensus indicates that the theorists may have gone off the deep end. Things are not coming out in detail as the theoretical prediction would have them. A whole charmonium spectrum should appear, a series of particles with increasing masses, but efforts to find the series have produced only two (and possibly a third). Heavier charmonium was supposed to decay to lighter charmonium through a series of quantized energy levels that would give off a characteristic spectrum of gamma rays. R. B. Hofstadter of California Institute of Technology reported an experiment that sought (but failed) to find that spectrum. "The data tend to show that the models do not seem to be consistent with what we are finding," he concludes.

Whether it be exactly as the theorists have laid out, everyone seems to agree that a new quantum number is necessary to explain the J-psi's. A quantum number is a quality that physicists assign to particles to explain why certain decays and other events happen while others do not. With a quantum number comes a conservation law. The law says that the amount of the quality that exists before an event must continue to exist after it. Only events that do not change the sum of the particular quality, be it charm, baryon number, a lepton number, or electric charge, can happen.

You can call a quantum number anything you like. Charm is just a word —nuanceless. (We almost said "colorless," but don't dare. Color has become a technical term too—the physicists are sprinkling semantic boobytraps throughout the language.) You might, as Martin B. Einhorn and C. Quigg of the Fermi National Accelerator Laboratory do, call it "panda." "We chose this name because of the panda's well-known shyness and tendency to stay among his own kind," they say. (It might be worth pointing out that pandas of the zoological variety seem to interact only weakly with other pandas, a possible contradiction to the physics as now written down.) The result of all this zoomorphism is that you can call the J-psi's "pandamonium."

It seems a long fetch for a wisecrack, but pandamonium is an accurate description of the situation. First of all, the existence of the J-psi's is readily confirmed. It seems that anybody who tunes in can turn on to them. They were first found in electron-positron collisions in the SPEAR storage ring at the Stanford Linear Accelerator Center and in proton collisions with fixed-target protons at Brookhaven National Laboratory. Since then they have been found in electron-positron collisions in the West German storage ring DESY and in the Italian Adone, and in proton-proton collisions in the CERN Intersecting Storage Rings.

The J-psi's can be made in certain other ways too. A suspicion that they are vector mesons, related to the known vector mesons, a group of particles that appears to embody the force of the strong interaction that binds atomic nuclei together, and the photon, which embodies electromagnetic forces, led to attempts to make them by photoproduction. In photoproduction a high-energy photon turns itself into a J-psi under the influence of a target body that helps the J-psi materialize itself. The experiment has been done at FermiLab, where the target was beryllium nuclei, and at SLAC with proton targets, a SLAC—University of Wisconsin collaboration. Similar success is also reported from Cornell University and West Germany.

A Northeastern University group working at FermiLab has also produced J-psi's by bombarding targets with pi mesons. The gathering evidence fuels a growing conviction that the J-psi's are closely related to the strong interaction and possibly representatives of a new group of vector mesons.

There are also other things around, relatives, not J-psi's but particles that seem to have unpaired charmed quarks in them and thus exhibit overt rather than hidden charm.

CERN has one of these. Brookhaven does too. Just one. "They mulled over that one event for six months," says a non-Brookhaven colleague, before they got up the nerve to make a claim for it. It illustrates the rarity of such things, and it causes consternation. Palmer, in announcing Brookhaven's claim, met a couple of strident critics who tried in vain to make him recant. Two experiments at FermiLab also have charmed-particle candidates. All these things are produced in one way or another by neutrino beams, and all seem to have masses around 2,500 million electron-volts, smaller than the J-psi's.

The Northeastern experiment reports a bump in the data at about 4,000 million electron-volts. This is about the right spot to produce something else—a charmed and anticharmed pair of particles. But the Northeastern scientists are not yet making a claim, says Roy Weinstein, because they need about five times their present statistics to be convincing.

There are many mysteries. Samuel C. C. Ting of MIT, one of the first J-psi discoverers, is puzzled that the J-psi production rate at 20 billion electron-volts is only 10 percent of what it is at 30 billion electron-volts. The steepness of the change is "very strange." Weinstein can't understand why production of J-psi's by pions is five times as great as that by protons. Theory just doesn't anticipate this. And then, among the many mysteries of the CERN proton-proton collisions are the unpaired electrons. There are conservation laws that require electrons produced in such events to come in electron-positron pairs, but some are coming off single. Ten percent can be explained as products of decay of J-psi's, but the rest are an enigma.

"We have all these unanticipated mysteries," says Michael Tannenbaum of Rockefeller University, speaking specifically of the CERN experiment, and he says it with a tone of glee in his voice. When experimenters confirm a neat theory, everybody says what a beautiful piece of work it is and drinks a toast. But the *real* fun is discovering unexpected things. And they certainly are finding them. ☐