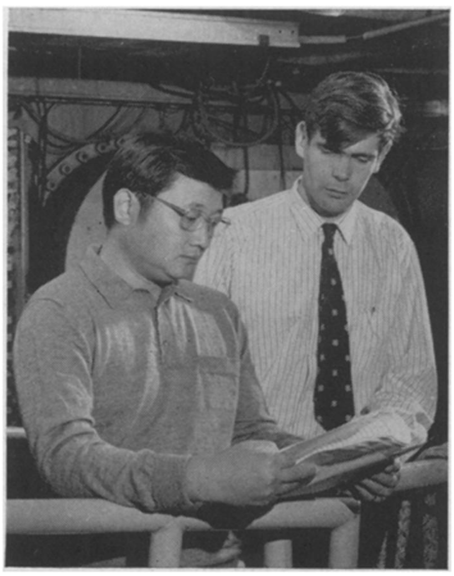
One Little, Two Little, A_2's

A particle thought to be one becomes two and threatens to upset theory

by Dietrick E. Thomsen



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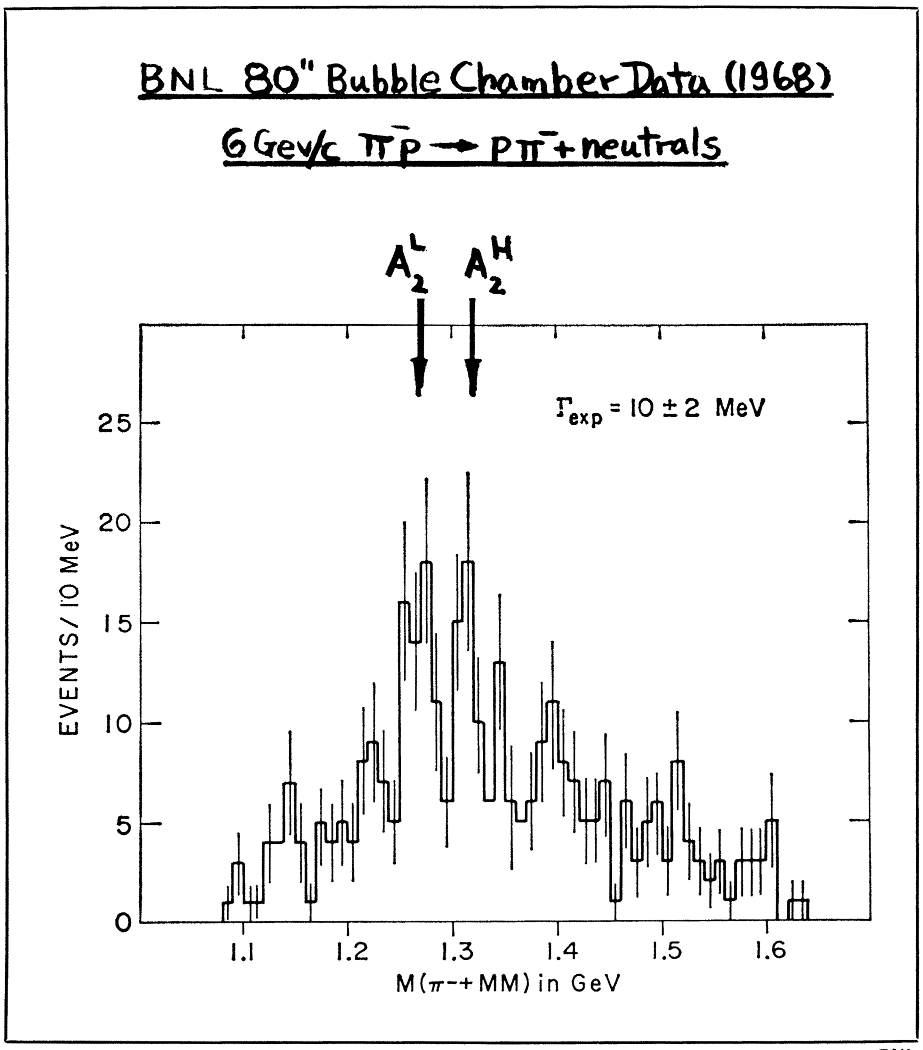
Drs. Lai and David Crennell study A_2.



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Two A_2 peaks: The graph shows the number of particles with indicated mass.

The A_2 meson is one of the short-lived particles called resonances. Resonances make fleeting appearances as intermediate steps in collision or radioactive decay processes that begin and end with other particles. They get their name because to physicists they have similarities to mechanical resonances like the sudden increase in motion that occurs when the person pushing a swing times his thrust to the swing's natural oscillation period.

There was nothing particularly unusual about the A_2 until it split. Early experiments, up to about three years ago, showed only one A_2 meson with a mass about 1,300 million electron volts (MeV). But starting about 1966 more discriminating detecting equipment began to find evidence that the early data had lumped together two distinct particles, one with 1,278 MeV of mass and one with 1,318. Further checks were run, and by the middle of this year it was fairly well established that there are two A_2 mesons.

The discovery has theorists in a state of concern because their most eminently successful theory, which they call the quark model, does not predict two particles at this point. One of the A_2's, probably the low one, is not playing according to the rules.

The rules arose from attempts to impose some order on the chaos of 100 or so subatomic particles that had been discovered. Physicists found that they could group the particles into families, or multiplets as they are called, according to certain of their properties. The groupings could be explained by supposing that there were three ultra-elementary particles called quarks and three ultra-elementary antiparticles, the antiquarks.

The theory explains the known particles by saying they are built of combinations of the basic six. Specifically, when a quark and antiquark unite, they produce a meson, and the different families of mesons with common properties can be explained by the different pairs that can be made. Members of the class of particles called baryons (protons, neutrons and a host of heavier ones) are made of three quarks each, and the families of baryons are explained by the arrangements possible in such trios.

The theory has served well in explaining the properties of various particles and predicting those that had not been found when the theory was devised. The theory's principles have not been violated—until now. Ironically, says Dr. Kwan Wu Lai of Brookhaven National Laboratory, the family that the A_2 belongs to fitted the theory especially well so long as the A_2 ap-

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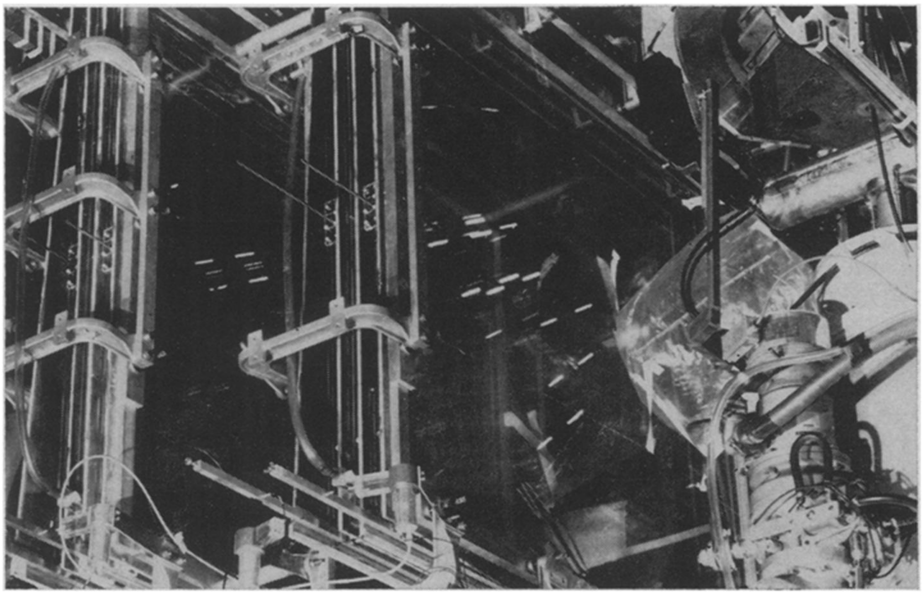
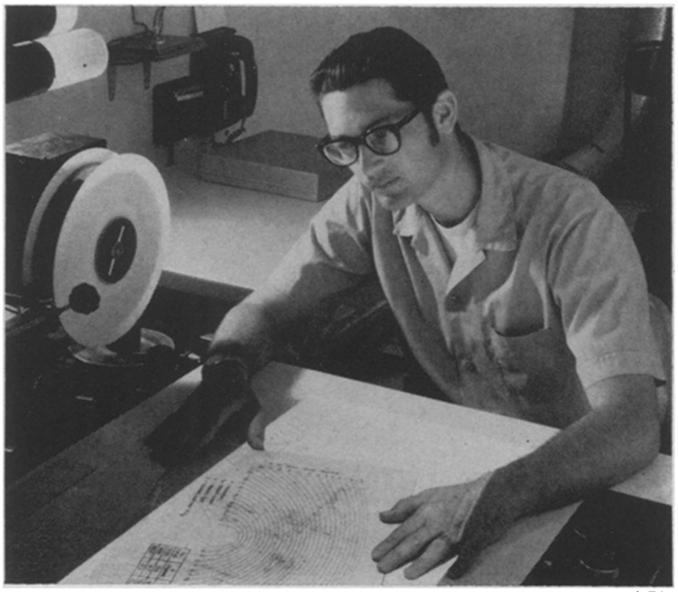


CERN



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Sparks in Geneva wire chamber record A_2's as Flatté in California seeks K★, f_0 doubles.

peared to be only a single particle.

The extra particle, the interloper as some physicists are beginning to call it, may be an accident, that is, some sort of completely unrelated particle that just happens to have nearly the same mass as the A_2 and interferes with it in experiments of this kind that distinguish particles from each other mainly by their mass.

But, if the split is not an accident, says Dr. Lai, "we need new rules to play the game."

How the theory needs to be changed depends on what the properties of the two A_2's are, whether they are twins in all but mass or whether they are related particles with different properties.

If they are twins, then they may be a so-called dipole resonance one resonance piled on another, something like having a swing within a swing. That is something the quark theory—and all the rest of physics—would have trouble explaining. A dipole resonance, says Dr. Lai, "is a very funny thing. Why should a dipole exist? Do we really know there is such a thing as a dipole?"

If the A_2 should be a dipole, then physicists' belief in symmetry in the world of subatomic particles would lead them to expect similar doubling in other members of the A_2's family. One such is the meson called K★ (pronounced K-star). A group led by Dr. Stanley M. Flatté of the Lawrence Radiation Laboratory in Livermore, Calif., has looked for splitting of the K★. They report that they don't find any.

This, says Dr. Flatté, makes the idea that the A_2 is a double pole rather unlikely.

The other possibility is that the two A_2's are related particles with different properties.

In such a case one of them would have spin and parity properties not permitted to mesons under the current theory, and this has already led to a suggestion that the quark theory be rather seriously revised. Drs. K. E. Lassila and P. V. Ruuskanen of Iowa State University suggested that one of the A_2's might be a new kind of meson composed of two quark-antiquark pairs instead of the one pair allowed to ordinary mesons. Drs. Richard C. Arnold and J. L. Uretsky of Argonne National Laboratory have expanded this idea to propose a game in which any number can play.

Drs. Arnold and Uretsky propose that mesons can be built out of any number of quark-antiquark pairs. This greatly increases the number of possible meson families and permits some mesons to have properties that are not allowed under the original, simple rule of one quark-antiquark pair only.

This theory also predicts companions for the other members of the A_2's family, but the experiment of Dr. Flatté and his associates does not necessarily disapprove it. "We do predict that there will be companion particles to the K★," says Dr. Arnold, "but they might not be on top of K★." That is, the companions could be sufficiently different from the K★ in mass so as not to interfere with it.

Drs. Arnold and Uretsky suggest in addition that the class of baryons may be similarly increased by adding successive quark-antiquark pairs to the three quarks allowed to baryons in the simple form of the quark theory. This would produce particles made of 3, 5, 7, 9 and so forth subparticles, but no experimental data yet suggest their existence.

All this complicates the original theory seriously. It greatly increases the number of particles that can exist and the combinations of properties that they may have. And it makes some physicists unhappy. There are those who like their theories simple and prefer no explanation to a complicated one. There have been mutterings about throwing out the quark theory entirely.

But Dr. Arnold expresses an alternate view. Complexity is strictly a matter of degree, he says. If a simple theory doesn't work, you try the next most complicated model.

Experiments on the A_2 and related particles are continuing in various laboratories all over the world. Dr. Flatté and his associates are gathering more statistics on the A_2 and on the f_0, another member of the family. A current experiment at the CERN Laboratory in Geneva is designed to determine whether the two A_2's are twins. The CERN experimenters expect to complete their data analysis by early 1970. ◻