Observation of Υ particles in colliding electron-positron beams

I. I. Roĭzen

Usp. Fiz. Nauk 128, 711–712 (August 1979)

PACS numbers: 13.65. + i, 14.40.Pe, 13.40.Hq, 12.40.Cc

These experiments were carried out in the middle of 1978 in West Germany in the storage ring DORIS, after a certain change in the mode of operation carried out specifically to increase somewhat the energy and to make it sufficient for production of Υ particles. This work was motivated, of course, not so much by an attempt to repeat or check the results of the remarkable experiment of L. Lederman and his colleagues but by the fact that an experiment on production of Υ particles in e^+e^- collisions, being free of hadronic background, should provide significantly better resolution and in this way should provide more detailed information on the properties of these particles. The expectation was justified, and at the present time our knowledge of the of the Υ and Υ′ particles (the ground state and the first excited state) is illustrated by the following two graphs—Figs. 1 and 2[1)]—which were obtained in these experiments. In regard to the Υ resonance it has been established that its mass is 9460 ± 10 MeV. The height of the peak at the point of the Υ′ resonance is approximately a factor of three less than its height at the point of the Υ resonance. In regard to the width of this peak, it must be kept in mind that it is comparable with the energy spread of the particles in the colliding beams, so that the true width of the Υ′ resonance may turn out to be appreciably smaller.

In addition, it has also been possible to measure the electromagnetic decay width of the Υ particle, which turned out to be 1.3 ± 0.4 keV, i.e., approximately a factor of four smaller than the similar width for the J/ψ particle. This argues in favor of interpretation of the Υ particle as a bound state of a new quark and a new antiquark with electrical charges ±1/3.

The next excited state is already inaccessible energetically at DORIS. However, on the basis of the improved data on the Υ and Υ′ resonances mentioned above, Lederman and co-workers have been able to improve significantly the statistical reliability of the indications of the presence of a second excited state, the Υ″ resonance, as the result of a more unambiguous interpretation of the experimental data obtained by them in the FNAL accelerator. The mass of the Υ″ turned out to be 10.41 ± 0.05 GeV.

Considerable interest from the theoretical point of view is presented by the angular distribution of the hadrons produced as the result of e^+e^- annihilation. In the experiments discussed here, we obtained convincing indications that at energies of the order of 10 GeV, but in the nonresonance region, this distribution is predominatantly two-jet in accordance with the predictions of the quark model. However, it may be that the greatest is presented by the fact that in the region of the Υ resonance the distribution becomes more nearly spherical. This fact could become one of the critical checks of quantum chromodynamics as a whole, since the greater sphericity of the hadron distribution in this energy range indicates that these hadrons are created

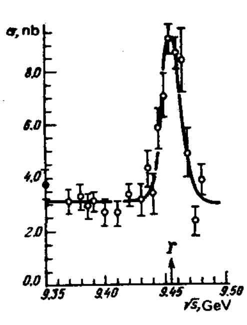

FIG. 1.

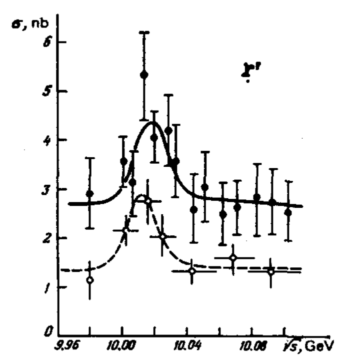

FIG. 2.

[1)] In Fig. 2 the preliminary data are shown. The curves were obtained by two groups who used detectors of different types.

 0038-5670/79/080654-02$01.10

not by two quarks (as in the case of two clearly expressed jets in the nonresonance region), but more likely by three gluons, which in turn should arise as the result of decay of the ϒ particle. Thus, this fact could in any case give the mysterious gluons the same degree of reality which is now given to the already completely accepted and necessary quarks.

Translated by C. S. Robinson