Evidence for a Glueball – $q\overline{q}$ filter*

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QCD predicts that particles composed of bound states of gluons should exist. Experiments WA76, WA91 and WA102 have performed a dedicated search for these states using the CERN Omega Spectrometer. Evidence for a glueball-$q\overline{q}$ filter is presented based upon a kinematical cut on the difference in transverse momentum of the exchanged particles, dP_T. It is shown that at small dP_T undisputed $q\overline{q}$ mesons are suppressed, whereas glueball candidates are enhanced.

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1. Introduction

QCD predicts that gluons will interact with other gluons to form mesons called glueballs. The best estimate for glueball masses comes from lattice gauge theory calculations. Current results show that the lightest glueball has $J^{PC} = 0^{++}$, and that its mass is predicted to be in the range 1500 – 1750 MeV/c [2, 3]. Thus the lightest non-$q\overline{q}$ states are predicted to have the same J^{PC} quantum numbers, and to exist in the same mass region as $q\overline{q}$ states. To search for glueballs one therefore needs to look for nonets with too many candidates and subsequently identify any non-$q\overline{q}$ members. If extra states are found then in order to isolate the likely non-$q\overline{q}$ member one can look for unusual branching ratios and for states preferentially produced in gluon-rich processes.

Interactions that have dynamics which create glue-rich regions are considered to be likely sources of glueballs. Three important mechanisms are central production, radiative J/ψ decays, and proton-antiproton annihilation.

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2. Evidence for a Glueball-$q\overline{q}$ Filter in Central Production

The WA102 central production experiment [4] is designed to study exclusive final states formed in the reaction $pp \longrightarrow p_f X^0 p_s$, where p_f and p_s refer to the fastest and slowest particles in the laboratory frame respectively, and X^0 represents the central system produced by double exchange.

The WA91 collaboration has published a paper [5] showing that the production of resonances depends on the azimuthal angle between the outgoing fast and slow protons. In order to understand this effect further Close and Kirk [6] proposed that the data be analysed in terms of the difference in transverse momentum between the particles exchanged from the fast and slow vertices. The difference in the transverse momentum vectors (dP_T) is defined to be

$$dP_T = \sqrt{(P_{y1} - P_{y2})^2 + (P_{z1} - P_{z2})^2}$$

where Py_i, Pz_i are the y and z components of the momentum of the ith exchanged particle in the pp centre of mass system.

It is observed that the production of undisputed $q\overline{q}$ states is enhanced at large dP_T and suppressed at small dP_T. A remarkable effect is seen when applying the dP_T criteria to channels containing glueball candidates. At small dP_T the glueball candidates are all more prominant than in the total mass spectrum. It is also interesting to note that the enigmatic $f_0(980)$, a possible non-$q\overline{q}$ meson or $K\overline{K}$ molecule state does not behave as a normal $q\overline{q}$ state.

The acceptance corrected mass spectra in three dP_T ranges has been fitted using the resonance parameters calculated from the fit to the total mass spectrum. From these fits the contribution of each resonance to the total as a function of dP_T has been found. The ratio of the number of events for $dP_T < 0.2$ GeV to the number of events for $dP_T \geq 0.5$ GeV for each resonance considered is shown in figure 1. It is seen that the undisputed $q\overline{q}$ states all have a small value for this ratio. This is in contrast to the glueball candidates $f_0(1500)$, $f_J(1710)$ and $f_2(1900)$, and the states $f_0(1300)$ and $f_0(980)$ which could have a gluonic component, which all have a large value for this ratio.

3. Summary

The results presented in this paper give evidence for a kinematical filter which selects glueball candidates from undisputed $q\overline{q}$ states in central production. All the undisputed $q\overline{q}$ states are observed to be suppressed at small dP_T, but the glueball candidates $f_0(1500)$, $f_J(1710)$, and $f_2(1900)$, together with the enigmatic $f_0(980)$, survive.

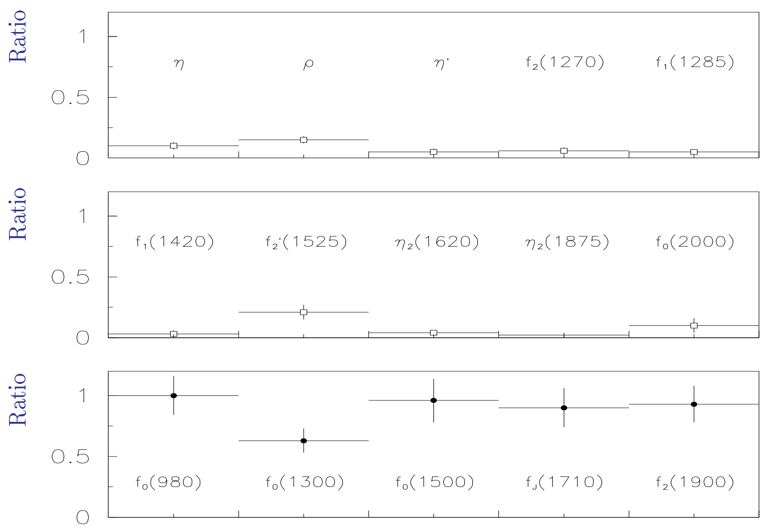

Fig. 1. Ratio of the number of events for $dP_T < 0.2$ GeV to the number of events for $dP_T \geq 0.5$ GeV for each resonance considered.

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