

論文内容の要旨

Search for invisible particles beyond the standard model using radiative decay of J/ψ and ψ' mesons in e^+e^- collisions

(電子陽電子衝突実験における J/ψ , ψ' 中間子の輻射崩壊を用いた標準理論を超える見えない粒子の探索)

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A search for invisible particles beyond the context of the standard model using radiative decay of J/ψ and ψ' mesons is executed. The used data are corresponding to 5.5×10^7 events of J/ψ decay and 9.4×10^6 events of ψ' decay taken on the peaks of their resonances respectively with the BES-II detector in e^+e^- collisions at the BEPC collider in the period between 1999 and 2001.

In the analysis, event selections for signal candidates are based on the distinctive topology with only single photon shower in the whole detector and the shower profile compared with the true photons from radiative Bhabha events. A new reconstruction algorithm is developed as the needs for some delicate information not included in the public data. Background events from cosmic rays and long-lived neutral baryon processes are almost excluded by the event selections. The remaining backgrounds in Monte Carlo are anti-neutron showers from $J/\psi(\psi') \rightarrow n\bar{n}$ process. Photons and anti-neutrons in Monte Carlo simulation are validated by analysing the shower profiles of photons and anti-protons in the data.

After the selections, nine events are observed for J/ψ runs and one event is observed for ψ' runs. The production ratio of invisible pseudoscalar particles from radiative J/ψ and ψ' decays are measured from the distribution of the observed events comparing with Monte Carlo backgrounds. The amount of these observed events and the kinematical distributions of their showers are consistent with Monte Carlo. Hence these observed events are regarded as backgrounds. The upper limits are computed including statistical and systematical uncertainties using a profile likelihood approach on the $\ln \mathcal{L} + \frac{1}{2}$ method. The following results are obtained

for invisible particles having mass less than $100 \text{ MeV}/c^2$,

$$\begin{aligned}\text{Br}(J/\psi \rightarrow \gamma X) &< 3.9 \times 10^{-7} \quad (90\% \text{ C.L.}), \\ \text{Br}(\psi' \rightarrow \gamma X) &< 1.7 \times 10^{-6} \quad (90\% \text{ C.L.}).\end{aligned}$$

The upper limit on the branching ratio of invisible radiative J/ψ decay is improved about one order than the previous limit by the Crystal Ball experiment in 1982. Furthermore the branching ratio of invisible radiative ψ' decay is measured for the first time.

The upper bound on the coupling strength of invisible pseudoscalar particles with fermions is obtained from the result. If the coupling strength is assumed to be universal among quark flavors, the coupling constant g_{Xff} for pseudoscalar particles having mass less than $100 \text{ MeV}/c^2$ is constrained as

$$g_{Xff}^2 < 6.0 \times 10^{-7} \quad (90\% \text{ C.L.}),$$

which is one order lower limit than the previous measurements from the J/ψ and upsilon decays.