ELEMENTARY PARTICLE

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ABSTRACT

In this paper we review some elementary particle.They are very important part of standard model.Such as π,K.Mass, Width, Angular momentum, Parity, Isospin are our point.They may interact through the strong electromagnetic weak or through some unknown force.The purpose of this review is to provide a guide for future searches what is known, what is not known. This is very necessary for the beginner.

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1 PARTICLE TREE

There are so many elementary particles, So the best way is classify them.All elementary particles are made up quarks.In this paper we just focus on the meson and baryon which composed of 2 or 3 quarks.

1. Light Unflavored Mesons
2. Strange Mesons
3. N Baryons
4. Δ Baryons
5. Λ Baryons
6. Σ Baryons
7. Ξ Baryons

1.1 Light Unflavored Mesons

What is light unflavored mesons? In the quantum mechanic, we can use some quantum numbers to describe a quantum system.For the elementary particles, we usually use S, C and B. Light unflavored mesons is $S = C = B = 0$.

Table 1: Light Unflavored Mesons

Particle	Mass(MeV)	Width	$I^G(J^{PC})$
$\pi^{\pm}$	139.57018 ± 0.00035	$(2.6033 \pm 0.0005) * 10^{-8}s$	$1^-(0^-)$
π^0	134.9766 ± 0.0006	$(8.52 \pm 0.18) * 10^{-17}s$	$1^-(0^{-+})$
η	547.862 ± 0.017	$1.31 \pm 0.05keV$	$0^+(0^{-+})$
η'	957.78 ± 0.06	$0.197 \pm 0.009MeV$	$0^+(0^{-+})$
ρ	775.26 ± 0.25	$149.1 \pm 0.8MeV$	$1^+(1^{--})$
ω	782.65 ± 0.12	$8.49 \pm 0.08MeV$	$0^-(1^{--})$
ϕ	1019.461 ± 0.019	$4.266 \pm 0.031MeV$	$0^-(1^{--})$

Some particles are not the C eigenstate, such as $\pi^{\pm}$. We also could use lifetime to express the width, because we have $\Gamma = \frac{\hbar}{\tau}$.

1.2 Strange Mesons

Strange mesons are $C = B = 0, S = \pm 1$.

Table 2: Strange Mesons

Particle	Mass(MeV)	Width	$I(J^P)$
$K^{\pm}$	493.667 ± 0.016	$(1.2380 \pm 0.0020) * 10^{-8}s$	$\frac{1}{2}(0^-)$
K^0	497.611 ± 0.013	-	$\frac{1}{2}(0^-)$
$K^{*\pm}$	892.66 ± 0.26	$46.2 \pm 1.3MeV$	$\frac{1}{2}(1^-)$
K^{*0}	895.81 ± 0.19	$47.4 \pm 0.6MeV$	$\frac{1}{2}(1^-)$

Koan is not G and C eigenstate. K^0 is not lifetime eigenstate, but K_L^0 and K_S^0 is.

1.3 N Baryons

N baryons are $I = \frac{1}{2}, S = 0$.
p and n are not G and C eigenstate.

Table 3: N Baryons

Particle	Mass(MeV)	Width	$I(J^P)$
p	938.272081 ± 0.000006	$2.1 * 10^{29} years$	$\frac{1}{2}(\frac{1}{2}^-)$
n	939.565413 ± 0.000006	$880.2 \pm 1.0s$	$\frac{1}{2}(\frac{1}{2}^-)$

1.4 Δ Baryons

Δ baryons are $I = \frac{3}{2}, S = 0$.

Table 4: Δ Baryons

Particle	Mass(MeV)	Width	$I(J^P)$
Δ^-	-	-	$\frac{3}{2}(\frac{3}{2}^-)$
Δ^0	-	-	$\frac{1}{2}(\frac{3}{2}^+)$
Δ^+	-	-	$\frac{1}{2}(\frac{3}{2}^+)$
Δ^{++}	-	-	$\frac{3}{2}(\frac{3}{2}^+)$

The pdg only give Breit-Wigner mass(mixed charges) = 1230 to 1234 MeV. And Breit-Wigner width(mixed charges) = 114 to 120 MeV.

1.5 Λ Baryons

Λ baryons are $I = 0, S = -1$.

Table 5: Λ Baryons

Particle	Mass(MeV)	Width	$I^(J^P)$
Λ	1115.683 ± 0.006	$(2.632 \pm 0.020) * 10^{-10}s$	$0(\frac{1}{2}^+)$

1.6 Σ Baryons

Σ baryons are $I = 1, S = -1$.

1.7 Ξ Baryons

Ξ baryons are $I = \frac{1}{2}, S = -2$.

1.8 Born in Lab

PION The invariant differential cross sections for inclusive neutral pion at mid-rapidity are measured in proton-proton collisions at $\sqrt{2} = 8TeV$ using the ALICE detector at LHC. The neutral pion is identified from the invariant mass of photon pairs detected by the PHOS detector covering $260 < \phi < 320$, and $|\eta| < 0.12$[1].

KAON A search for CP and P violation using triple-product asymmetries is performed with $\Lambda_b^0 \rightarrow pK^-\pi^+\pi^-$,$\Lambda_b^0 \rightarrow pK^-K^+K^-$ and $\Xi_b^0 \rightarrow pK^-K^-\pi^+$ decays. The data sample corresponds to integrated luminosities of $1.0fb{-}1$ and $2.0fb^{-1}$,

Table 6: Σ Baryons

Particle	Mass(MeV)	Width	$I^{(}J^{P})$
Σ^+	1189.37 ± 0.07	$(0.8018 \pm 0.0026) * 10^{-10}s$	$1(\frac{1}{2}^+)$
Σ^0	1192.642 ± 0.024	$(7.4 \pm 0.7) * 10^{-20}s$	$1(\frac{1}{2}^+)$
Σ^-	1197.449 ± 0.030	$(1.479 \pm 0.011) * 10^{-10}s$	$1(\frac{1}{2}^+)$
$\Sigma(1385)^+$	1382.80 ± 0.35	$36.0 \pm 0.7MeV$	$1(\frac{3}{2}^+)$
$\Sigma(1385)^0$	1383.7 ± 1.0	$36 \pm 5MeV$	$1(\frac{3}{2}^+)$
$\Sigma(1385)^-$	1387.2 ± 0.5	$39.4 \pm 2.1MeV$	$1(\frac{3}{2}^+)$

Table 7: Ξ Baryons

Particle	Mass(MeV)	Width	$I(J^P)$
Ξ^0	1314.86 ± 0.20	$(2.90 \pm 0.09) * 10^{-10}s$	$\frac{1}{2}(\frac{1}{2}^+)$
Ξ^-	1321.71 ± 0.07	$(1.639 \pm 0.015) * 10^{-10}s$	$\frac{1}{2}(\frac{1}{2}^+)$
$\Xi(1530)^0$	1531.80 ± 0.32	$9.1 \pm 0.5MeV$	$\frac{1}{2}(\frac{3}{2}^+)$
$\Xi(1530)^-$	1535.0 ± 0.6	$9.9^{+1.7}_{-1.9}MeV$	$\frac{1}{2}(\frac{3}{2}^+)$

recorded with the LHCb detector at centre-of-mass energies of $7TeV$ and $8TeV$, respectively. The CP- and P-violating asymmetries are measured both integrating over all phase space and in specific phase-space regions. No significant deviation from CP or P symmetry is found.[2]

η MESON We report the first observation of the doubly Cabibbo-suppressed decays $D^+ \to K^+\eta^-$ using a $791fb^{-1}$ data sample collected with the Belle detector at the KEKB asymmetric-energy e^+e^- collider. [3]

ρ MESON The production of the $\rho(770)^0$ meson has been measured at mid-rapidity ($|y| < 0.5$) in pp and centrality differential Pb–Pb collisions at $\sqrt{sNN} = 2.76TeV$ with the ALICE detector at the Large Hadron Collider. [4]

ω MESON The production of $\omega(782)$ meson has been measured at mid-rapidity in pp collisions at $\sqrt{s} = 7TeV$ with the ALICE detector at the Large Hadron Collider (LHC). The particles are reconstructed in the $\omega \to \pi^0\pi^+\pi^-$ decay channel. A data sample with an integrated luminosity of $6nb^{-1}$ has been used to measure the invariant differential cross section of the ω meson and the pT-differential ω/π^0 ratio in the transverse momentum range 2 < pT < 17 GeV/c. The measured cross section and the ω/π^0 ratio are found to be in agreement with predictions of PYTHIA and PHOJET events generators. Furthermore, the ω/π^0 ratio is consistent with previous measurements by other experiments at lower energies within uncertainties.[5]

ϕ MESON ϕ meson measurements provide insight into strangeness production, which is one of the key observables for the hot medium formed in high-energy heavy-ion collisions. ALICE measured ϕ production through its decay in muon pairs in Pb-Pb collisions at $\sqrt{sNN} = 2.76TeV$ in the intermediate trans- verse momentum range $2 < pT < 5GeV/c$ and in the rapidity interval $2.5 < y < 4$. The ϕ yield was measured as a function of the transverse momentum and collision centrality. The nuclear modification factor was obtained as a function of the average number of participating nucleons. Results were compared with the ones obtained via the kaon decay channel in the same pT range at midrapidity. The values of the nuclear modification factor in the two rapidity regions are in agreement within uncertainties.[6]

Σ BARYON We report on measurements of the inclusive production rate of Σ^+ and Σ^0 baryons in hadronic Z decays collected with the L3 detector at LEP. The Σ^+ baryons are detected through the decay $\Sigma^+ \to p\pi^0$, while the Σ^0 baryons are detected via the decay mode $\Sigma^0 \to \Lambda\gamma$[7].

Ξ BARYON Measurements of hadron production in pp collisions at $\sqrt{s}$=0.9,2.36 and 7 TeV recorded with the CMS detector are reported. Transverse momentum, pseudorapidity and multiplicity distributions of charged hadrons are presented. For non-single-diffractive collisions, the average charged-hadron transverse momentum and pseudorapidity density reveal an increase in production rate not well matched by theory and models. Measured spectra of identified strange particles, K^0_S, Λ, Ξ^- and Ξ^+, reconstructed based on their decay topology, are also presented. The production rates for strange particles are observed to be in excess of those predicted by Monte Carlo models by up to a factor of three[8].

Λ BARYON Measurements of strange hadron (K^0_S, $\Lambda + \Lambda$, $\Xi^- + \Xi^+$, and $\Omega^- + \Omega^+$) transverse momentum spectra in pp and pPb collisions are presented in several center-of-mass rapidity (yCM) intervals[9].

Δ BARYON We carry out photoproduction experiments using linearly polarized photon beams with energies of 1.5-3 GeV at SPring-8/LEPS. The photoproduction of various mesons and baryons is important to understand hadron production mechanisms. We took the data for the $\gamma p \to \pi^-\Delta^{++}$ and $\gamma p \to \pi^+\Delta^0$ reactions at the forward π angles of $0.7 < \cos\theta_\pi^{c.m.} < 1$ with the same acceptance for π^- and $\pi+$. Precise comparison between the $\bar{u}u$ and $\bar{d}d$ productions in the final state is possible, which is expected to give important information on how hadrons are produced. Preliminary results of photon beam asymmetries, which are sensitive to reaction mechanisms, are reported. [10]

$\Sigma(1385)$ BARYON We present a study of the inclusive production of $K^*(892)$ and $\Sigma^\pm(1385)$ at 3.6 GeV/c from $\bar{p}p$ interactions.[11]

$\Xi(1530)$ BARYON The production of the strange and double-strange baryon resonances $\Sigma^\pm(1385)$, $\Xi(1530)^0$ has been measured at mid-rapidity ($|y| < 0.5$) in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ALICE detector at the LHC. Transverse momentum spectra for inelastic collisions are compared to QCD-inspired models, which in general underpredict the data. A search for the $\phi(1860)$ pentaquark, decaying in $\Xi\pi$ channel, has been carried out but no evidence is seen.[12]

MASS The mass of particle and antiparticle is strictly equal.Such as π^+ and π^-

2 DECAY MODEL

2.1 Strong Decay

ρ can decay by strong interaction:

- $\rho^\pm \to \pi^\pm\pi^+\pi^-\pi^0$
- $\rho^0 \to \pi^+\pi^-\pi^0$

ω can decay by strong interaction:

- $\omega \to \pi^+\pi^-$

ϕ can decay by strong interaction:

- $\phi \to K^+K^-$

η can decay by strong interaction:

- $\eta \to \pi^+\pi^-\pi^0$

$\eta^{'}$ can decay by strong interaction:

- $\eta^{'} \to \pi^+\pi^-\eta$

K^* can decay by strong interaction:

- $K^* \to K\pi$

The $\Sigma(1385)$,$\Xi(1530)$,Δ could decay by strong interaction, And the width of strong decay particle are about MeV. The difference comes from the mass difference.

2.2 Electromagnetic Decay

Kaon, pion, Λ, Σ, Ξ, Ω could decay by electromagnetic interaction. Their mean life are about $10^{-10}s$.

2.3 Weak Decay

The mass of π^0 , π^+ and π^- are so small.The only decay by weak interaction. The p is stable.n only have weak interaction.

3 PARTICLE IN THE DETECTOR

We know when $t = 3\tau$, only left 0.05. So pass through detector condition is:

$$ct\frac{\beta}{\sqrt{1-\beta^2}} = 3c\tau\frac{P}{m} > l \tag{1}$$

So the $\pi^{\pm}$, $K^{\pm}$, K^0, p, n, $Lambda$, Σ, Ξ, Ω could pass the detector. Λ^c, Λ^0_b, Ξ^0_c could be distinguished by the detector.

4 SUMMARY AND SUGGESTION

I learned many knowledge in the homework such as Feynman diagram, So i thought the homework should be more.It is very significant.

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