

*CPV caused by EDM in the Baryon-Antibaryon pair  
production in  $e^+e^-$  annihilation*

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# Outline

① *Amplitude*

② *Effect*

1 *Amplitude*

2 *Effect*

- ✓ The hadronic current, the red term violates the CP

$$K_\mu = \bar{u}(p_1) \left[ F_1 \gamma_\mu - \frac{F_2}{4M} (\gamma_\mu \cdot Q - Q \cdot \gamma_\mu) + (p_{1\mu} - p_{2\mu}) \eta \frac{G_M}{p_B} \gamma_5 \right] \nu(p_2) \quad (1)$$

- ✓ The amplitude

$$M = K_\mu \frac{-ig_{\mu\nu}}{q^2} j_\nu \quad (2)$$

# Source of CPV

- ✓ electric dipole moment
- ✓ CP violating  $Z - \Lambda$  coupling

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the EMD of  $\Lambda$  is  $d_\Lambda$

$$L_{dipole} = i \frac{d_\Lambda}{2} \bar{\Lambda} \sigma_{\mu\nu} \gamma_5 \Lambda F^{\mu\nu} \quad (3)$$

exchang a  $\gamma$  between  $\Lambda$  and  $c$  quark

$$L_{c-\Lambda} = -\frac{2}{3} \frac{g_V}{M^2} e d_\Lambda (p_1^\mu - p_2^\mu) \bar{c} \gamma_\mu c \bar{\Lambda} i \gamma_5 \Lambda \quad (4)$$

So

$$\eta = i \frac{2}{3} \frac{p_B}{G_M} \frac{g_V}{M^2} e d_\Lambda \quad (5)$$

where  $g_V = 1.25 \text{ GeV}$

1 *Amplitude*

2 *Effect*

✓  $\alpha_\psi$  will be small

$$\frac{dN}{d\Omega} \sim 1 + \alpha'_\psi \cos^2 \theta \quad (6)$$

$$\alpha'_\psi = \alpha_\psi - \frac{2(1 + \alpha_\psi)^2 |\eta|^2}{1 + 2|\eta|^2(1 + \alpha_\psi)} \quad (7)$$

✓ CPV term, where  $\eta = |\eta| e^{i\Delta\phi_\eta}$

$$\begin{aligned} & \eta \left( \sqrt{1 - \alpha_\psi^2} \left( -4 \sin^2(\theta) \cos(\theta_2) \alpha_{\bar{\chi}} \cos(\Phi - \Delta\phi_\eta) - 4 \alpha_{\Lambda} \sin(\theta_1) \sin(\theta_2) \sin^2(\theta) \sin(\Phi) \sin(\phi_1 + \phi_2) \alpha_{\bar{\chi}} \cos(\Delta\phi_\eta) + \right. \right. \\ & \quad 4 \alpha_{\Lambda} \sin(\theta_1) \sin(\theta_2) \sin^2(\theta) \cos(\Phi) \sin(\phi_1 + \phi_2) \alpha_{\bar{\chi}} \sin(\Delta\phi_\eta) - 4 \alpha_{\Lambda} \sin^2(\theta) \cos(\theta_1) \cos(\Phi - \Delta\phi_\eta) \left. \right) + \\ & \quad 4 \alpha_{\Lambda} (\alpha_\psi + 1) \sin(\theta) \cos(\theta) \alpha_{\bar{\chi}} \sin(\Delta\phi_\eta) (\sin(\theta_1) \cos(\theta_2) \sin(\phi_1) - \sin(\theta_2) \cos(\theta_1) \sin(\phi_2)) + \\ & \quad \left. \cos(\Delta\phi_\eta) (2 (\alpha_\psi + 1) \sin(2\theta) \sin(\theta_2) \cos(\phi_2) \alpha_{\bar{\chi}} - 2 \alpha_{\Lambda} (\alpha_\psi + 1) \sin(2\theta) \sin(\theta_1) \cos(\phi_1)) \right) + \\ & \eta^2 (4 \alpha_{\Lambda} (\alpha_\psi + 1) \sin^2(\theta) \alpha_{\bar{\chi}} (\cos(\theta_1) \cos(\theta_2) - \sin(\theta_1) \sin(\theta_2) \cos(\phi_1 + \phi_2)) + 4 (\alpha_\psi + 1) \sin^2(\theta)) \end{aligned}$$