Prediction of electric and magnetic form factors of $1/2^+$ octet hyperons and possible determination of their phase-difference

S. Dubnička

Institute of Physics, Slovak Academy of Sciences, Bratislava, Slovak Republic

E. Bartoš and A. Z. Dubničková

Dept. of Theor. Physics, Comenius University, Bratislava, Slovak Republic

Abstract

Starting from a specific universal 9 resonance model of electromagnetic structure for all members of $1/2^+$ baryon octet, dependent only on ρ-, ω-, ϕ- coupling constant ratios as a free parameters, then making a use of existing experimental information on nucleon electromagnetic form factors and SU(3) flavour symmetry, behaviours of electric and magnetic form factors of Λ, Σ and Xi hyperons and their phase-differences are predicted. The latters can be determined experimentally at the $e^+e^- \to Y\bar{Y}$ processes by measurement of y-component of the polarization $\vec{P}$ of one of the final hyperons, whereby the y-axis is orthogonal to the plane of the reaction.

Electromagnetic structure of $\mathbf{Y}$= $[\Lambda^0]$, $[\Sigma^+, \Sigma^0, \Sigma^-]$ and $[\Xi^0, \Xi^-]$ is completely described by two FF's $\mathbf{G_E^Y(t)}$, $\mathbf{G_M^Y(t)}$ or $\mathbf{F_{1Y}(t)}$, $\mathbf{F_{2Y}(t)}$ ($t = -Q^2$), which are mutually related

$$\begin{aligned}
\mathbf{G_E^B(t)} &= \mathbf{F_{1B}(t)} + \frac{t}{4m_B^2}\mathbf{F_{2B}(t)} \qquad (1)\\
\mathbf{G_M^B(t)} &= \mathbf{F_{1B}(t)} + \mathbf{F_{2B}(t)}.
\end{aligned}$$

Though we know a number of theoretical properties of hyperon FF's, like

- normalization
- asymptotic behaviour
- analytic properties
- reality condition
- unitarity condition

- saturation by vector mesons with quantum numbers of photon, following from the fact of a creation of vector mesons in $e^+e^- \to hadrons$ processes,

there is **almost zero experimental information** on $\mathbf{G_E^Y(t)}$, $\mathbf{G_M^Y(t)}$.

QUESTION:

At such a situation, is it possible to predict a behaviour of $\mathbf{G_E^Y(t)}$ and $\mathbf{G_M^Y(t)}$?

YES, IT IS:

by a utilization of

- exp. information on $G_E^p(t)$, $G_M^p(t)$, $G_E^n(t)$, $G_M^n(t)$
- specific universal 9 resonance model of electromagnetic structure for all members of $1/2^+$ baryon octet, depending only on ρ-, ω-, ϕ- coupling constant ratios as free parameters
- SU(3) flavour symmetry

NOTE:

The most suitable FF's for a construction of **specific universal model of elm structure of** N**,** Λ**,** Σ**,** Ξ are isoscalar and isovector parts of the Dirac $\mathbf{F_{1B}(t)}$ and Pauli $\mathbf{F_{2B}(t)}$ FF's

$$\mathbf{F^s_{1B}(t), F^s_{2B}(t), F^v_{1B}(t), F^s_{2B}(t)} \tag{2}$$

related to $G_E^B(t)$, $G_M^B(t)$ as follows

$$\begin{aligned}
\mathbf{G_E^{p,n}(t)} &= [F^s_{1N}(t) \pm F^v_{1N}(t)] + \frac{t}{4m^2_{p,n}}[F^s_{2N}(t) \pm F^v_{2N}(t)] \\
\mathbf{G_M^{p,n}(t)} &= [F^s_{1N}(t) \pm F^v_{1N}(t)] + [F^s_{2N}(t) \pm F^v_{2N}(t)] \\
\mathbf{G_E^{\Lambda}(t)} &= F^s_{1\Lambda}(t) + \frac{t}{4m^2_\Lambda}F^s_{2\Lambda}(t)\ , \mathbf{G_M^{\Lambda}(t)} = F^s_{1\Lambda}(t) + F^s_{2\Lambda}(t) \\
\mathbf{G_E^{\Sigma^+,\Sigma^-}(t)} &= [F^s_{1\Sigma}(t) \pm F^v_{1\Sigma}(t)] + \frac{t}{4m^2_{\Sigma^+,\Sigma^-}}[F^s_{2\Sigma}(t) \pm F^v_{2\Sigma}(t)] \\
\mathbf{G_M^{\Sigma^+,\Sigma^-}(t)} &= [F^s_{1\Sigma}(t) \pm F^v_{1\Sigma}(t)] + [F^s_{2\Sigma}(t) \pm F^v_{2\Sigma}(t)] \\
\mathbf{G_E^{\Sigma^0}(t)} &= F^s_{1\Sigma}(t) + \frac{t}{4m^2_{\Sigma^0}}F^s_{2\Sigma}(t)\ , \mathbf{G_M^{\Sigma^0}(t)} = F^s_{1\Sigma}(t) + F^s_{2\Sigma}(t) \\
\mathbf{G_E^{\Xi^0,\Xi^-}(t)} &= [F^s_{1\Xi}(t) \pm F^v_{1\Xi}(t)] + \frac{t}{4m^2_{\Xi^0,\Xi^-}}[F^s_{2\Xi}(t) \pm F^v_{2\Xi}(t)] \\
\mathbf{G_M^{\Xi^0,\Xi^-}(t)} &= [F^s_{1\Xi}(t) \pm F^v_{1\Xi}(t)] + [F^s_{2\Xi}(t) \pm F^v_{2\Xi}(t)]\ .
\end{aligned} \tag{3}$$

whereby

$$\mathbf{G_E^B(0)} = Q_B, \quad \mathbf{G_M^B(0)} = Q^B + \mu_B, \tag{4}$$

Q_B and μ_B are charge and anomalous magnetic moment of B.

The **specific universal 9 resonance unitary and analytic model of the elm. structure of B**, unifying all known theoretical properties of baryon FF's, is given by the following expressions

$$\begin{aligned}
\mathbf{F^s_{1B}[V(t)]} \quad &= \left(\frac{1-V^2}{1-V_N^2}\right)^4 \left\{ N^s_{1B} \cdot \prod_{n=\omega'}^{\omega''} H^1_n(V) + \right.\\
&+ \left[L^1_\omega(V) H^1_{\omega''}(V) \frac{(C^1_{\omega''} - C^1_\omega)}{(C^1_{\omega''} - C^1_{\omega'})} - L^1_\omega(V) H^1_{\omega'}(V) \frac{(C^1_{\omega'} - C^1_\omega)}{(C^1_{\omega''} - C^1_{\omega'})} - \right.\\
&- \left. \prod_{n=\omega'}^{\omega''} H^1_n(V) \right] (\mathbf{f^{(1)}_{\omega BB}/f_\omega}) + \\
&+ \left[L^1_\phi(V) H^1_{\omega''}(V) \frac{(C^1_{\omega''} - C^1_\phi)}{(C^1_{\omega''} - C^1_{\omega'})} - L^1_\phi(V) H^1_{\omega'}(V) \frac{(C^1_{\omega'} - C^1_\phi)}{(C^1_{\omega''} - C^1_{\omega'})} - \right.\\
&- \left.\left. \prod_{n=\omega'}^{\omega''} H^1_n(V) \right] (\mathbf{f^{(1)}_{\phi BB}/f_\phi}) \right\}
\end{aligned} \tag{5}$$

$$\begin{aligned}
\mathbf{F^v_{1B}[W(t)]} \quad &= \left(\frac{1-W^2}{1-W_N^2}\right)^4 \left\{ N^v_{1B} \cdot L^1_{\rho'}(W) H^1_{\rho''}(W) + \right.\\
&+ \left[L^1_\rho(W) H^1_{\rho''}(W) \frac{(C^1_{\rho''} - C^1_\rho)}{(C^1_{\rho''} - C^1_{\rho'})} - L^1_\rho(W) L^1_{\rho'}(W) \frac{(C^1_{\rho'} - C^1_\rho)}{(C^1_{\rho''} - C^1_{\rho'})} - \right.\\
&- \left.\left. L^1_{\rho'}(W) H^1_{\rho''}(W) \right] (\mathbf{f^{(1)}_{\rho BB}/f_\rho}) \right\}
\end{aligned} \tag{6}$$

$$\begin{aligned}
\mathbf{F^s_{2B}[U(t)]} \quad &= \left(\frac{1-U^2}{1-U_N^2}\right)^6 \left\{ N^s_{2B} \cdot \prod_{n=\omega'}^{\phi'} H^2_n(U) + \right.\\
&+ \left[L^2_\omega(U) H^2_{\omega''}(U) H^2_{\phi'}(U) \frac{(C^2_{\omega''} - C^2_\omega)}{(C^2_{\omega''} - C^2_{\omega'})} \frac{(C^2_{\phi'} - C^2_\omega)}{(C^2_{\phi'} - C^2_{\omega'})} - \right.\\
&- L^2_\omega(U) H^2_{\omega'}(U) H^2_{\phi'}(U) \frac{(C^2_{\omega'} - C^2_\omega)}{(C^2_{\omega''} - C^2_{\omega'})} \frac{(C^2_{\phi'} - C^2_\omega)}{(C^2_{\phi'} - C^2_{\omega''})} + \\
&+ L^2_\omega(U) H^2_{\omega'}(U) H^2_{\omega''}(U) \frac{(C^2_{\omega'} - C^2_\omega)}{(C^2_{\phi'} - C^2_{\omega'})} \frac{(C^2_{\omega''} - C^2_\omega)}{(C^2_{\phi'} - C^2_{\omega''})} - \\
&- \left. \prod_{n=\omega'}^{\phi'} H_n(U)^2 \right] (\mathbf{f^{(2)}_{\omega BB}/f_\omega}) + \\
&+ \left[L^2_\phi(U) H^2_{\omega''}(U) H^2_{\phi'}(U) \frac{(C^2_{\omega''} - C^2_\phi)}{(C^2_{\omega''} - C^2_{\omega'})} \frac{(C^2_{\phi'} - C^2_\phi)}{(C^2_{\phi'} - C^2_{\omega'})} - \right.\\
&- L^2_\phi(U) H^2_{\omega'}(U) H^2_{\phi'}(U) \frac{(C^2_{\omega'} - C^2_\phi)}{(C^2_{\omega''} - C^2_{\omega'})} \frac{(C^2_{\phi'} - C^2_\phi)}{(C^2_{\phi'} - C^2_{\omega''})} + \\
&+ L^2_\phi(U) H^2_{\omega'}(U) H^2_{\omega''}(U) \frac{(C^2_{\omega'} - C^2_\phi)}{(C^2_{\phi'} - C^2_{\omega'})} \frac{(C^2_{\omega''} - C^2_\phi)}{(C^2_{\phi'} - C^2_{\omega''})} -
\end{aligned} \tag{7}$$

$$- \prod_{n=\omega'}^{\phi'} H_n^2(U)\Bigg] (\mathbf{f}^{(\mathbf{2})}_{\phi\mathbf{BB}}/\mathbf{f}_\phi)\Bigg\}$$

$$\mathbf{F^v_{2B}}[\mathbf{X(t)}] \quad = \left(\frac{1-X^2}{1-X_N^2}\right)^6 \Bigg\{N^v_{2B}\cdot L^2_{\rho'}(X)H^2_{\rho''}(X)H^2_{\rho'''}(X)+$$
$$+\Bigg[L^2_\rho(X)H^2_{\rho''}(X)H^2_{\rho'''}(X)\frac{(C^2_{\rho'''}-C^2_\rho)}{(C^2_{\rho'''}-C^2_{\rho'})}\ \frac{(C^2_{\rho''}-C^2_\rho)}{(C^2_{\rho''}-C^2_{\rho'})}-$$
$$-L^2_\rho(X)H^2_{\rho'}(X)H^2_{\rho'''}(X)\frac{(C^2_{\rho'''}-C^2_\rho)}{(C^2_{\rho'''}-C^2_{\rho''})}\frac{(C^2_{\rho'}-C^2_\rho)}{(C^2_{\rho''}-C^2_{\rho'})}+ \tag{8}$$
$$+L^2_\rho(X)H^2_{\rho'}(X)H^2_{\rho''}(X)\frac{(C^2_{\rho''}-C^2_\rho)}{(C^2_{\rho'''}-C^2_{\rho''})}\frac{(C^2_{\rho'}-C^2_\rho)}{(C^2_{\rho'''}-C^2_{\rho'})}-$$
$$-L^2_{\rho'}(X)H^2_{\rho''}(X)H^2_{\rho'''}(X)\Bigg](\mathbf{f}^{(\mathbf{2})}_{\rho\mathbf{BB}}/\mathbf{f}_\rho)\Bigg\}\ ,$$

where

B	N^s_{1B}	N^v_{1B}	N^s_{2B}	N^v_{2B}
N	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}(\mu_p+\mu_n)$	$\frac{1}{2}(\mu_p-\mu_n)$
Λ	0	—	μ_Λ	—
Σ	0	1	$\frac{1}{2}(\mu_{\Sigma^+}+\mu_{\Sigma^-})$	$\frac{1}{2}(\mu_{\Sigma^+}-\mu_{\Sigma^-})$
Ξ	$-\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}(\mu_{\Xi^0}+\mu_{\Xi^-})$	$\frac{1}{2}(\mu_{\Xi^0}-\mu_{\Xi^-})$

$\mathbf{f_{vBB}}$ are $v=\rho,\omega,\phi$ couplings to B,

$$\mathbf{f}_\rho = 4.9905 \pm 0.1089;\ \mathbf{f}_\omega = 17.0550 \pm 0.2990;\ \mathbf{f}_\phi = -12.8832 \pm 0.0030; \quad (9)$$

$$L^1_k[V(t)] = \frac{(V_N-V_k)(V_N-V_k^*)(V_N-1/V_k)(V_N-1/V_k^*)}{(V-V_k)(V-V_k^*)(V-1/V_k)(V-1/V_k^*)}, \quad k=\omega\ ,\phi$$

$$H^1_n[V(t)] = \frac{(V_N-V_n)(V_N-V_n^*)(V_N+V_n)(V_N+V_n^*)}{(V-V_n)(V-V_n^*)(V+V_n)(V+V_n^*)}, \quad n=\omega'\ ,\omega''$$

$$V(t) = i\frac{\left[(t^{1s}_{in}/t^s_0-1)^{1/2}+(t/t^s_0-1)^{1/2}\right]^{1/2}-\left[(t^{1s}_{in}/t^s_0-1)^{1/2}-(t/t^s_0-1)^{1/2}\right]^{1/2}}{\left[(t^{1s}_{in}/t^s_0-1)^{1/2}+(t/t^s_0-1)^{1/2}\right]^{1/2}+\left[(t^{1s}_{in}/t^s_0-1)^{1/2}-(t/t^s_0-1)^{1/2}\right]^{1/2}}$$

$$V_s = V(t_s) \quad ,t_s=(m_s-i\Gamma_s/2)^2, \quad s=\omega\ ,\phi\ ,\omega'\ ,\omega''\ ;V_N=V(t)\Big|_{t=0}$$

$$C^1_k = \frac{(V_N-V_k)(V_N-V_k^*)(V_N-1/V_k)(V_N-1/V_k^*)}{-(V_k-1/V_k)(V_k^*-1/V_k^*)}, \quad k=\omega\ ,\phi$$

$$C^1_n = \frac{(V_N-V_n)(V_N-V_n^*)(V_N+V_n)(V_N+V_n^*)}{-(V_n-1/V_n)(V_n^*-1/V_n^*)}, \quad n=\omega'\ ,\omega''$$

and similarly for $L^1_v(W)$, $H^1_v(W)$, C^1_v; $L^2_s(U)$, $H^2_s(U)$, C^2_s and $L^2_v(X)$, $H^2_v(X)$, C^2_v.

From the trace of $\mathbf{SU(3)_f}$ invariant Lagrangian

$$\begin{aligned} Tr(\mathbf{L_{VB\bar{B}}}) &= \frac{i}{\sqrt{2}}\mathbf{f^F}\left[\bar{B}^\alpha_\beta\gamma_\mu B^\beta_\gamma - \bar{B}^\beta_\gamma\gamma_\mu B^\alpha_\beta\right](V_\mu)^\gamma_\alpha + \\ &+\frac{i}{\sqrt{2}}\mathbf{f^D}\left[\bar{B}^\beta_\gamma\gamma_\mu B^\alpha_\beta + \bar{B}^\alpha_\beta\gamma_\mu B^\beta_\gamma\right](V_\mu)^\gamma_\alpha + \\ &+\frac{i}{\sqrt{2}}\mathbf{f^S}\bar{B}^\alpha_\beta\gamma_\mu B^\beta_\alpha\omega^0_\mu\ , \end{aligned} \quad (10)$$

and $\omega-\phi$ mixing, one obtains for ρ-, ω-, ϕ- coupling constants to B's the relations

$$\begin{aligned}
\mathbf{f}^{(\mathbf{1,2})}_{\rho\mathbf{NN}} &= \frac{1}{2}(\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}}+\mathbf{f}^{\mathbf{F}}_{\mathbf{1,2}})\\
\mathbf{f}^{(\mathbf{1,2})}_{\omega\mathbf{NN}} &= \frac{1}{\sqrt{2}}\cos\vartheta\mathbf{f}^{\mathbf{S}}_{\mathbf{1,2}}-\frac{1}{2\sqrt{3}}\sin\vartheta(\mathbf{3f}^{\mathbf{F}}_{\mathbf{1,2}}-\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}})\\
\mathbf{f}^{(\mathbf{1,2})}_{\phi\mathbf{NN}} &= \frac{1}{\sqrt{2}}\sin\vartheta\mathbf{f}^{\mathbf{S}}_{\mathbf{1,2}}+\frac{1}{2\sqrt{3}}\cos\vartheta(\mathbf{3f}^{\mathbf{F}}_{\mathbf{1,2}}-\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}})\\
\\
\mathbf{f}^{(\mathbf{1,2})}_{\omega\mathbf{\Lambda\Lambda}} &= \frac{1}{\sqrt{2}}\cos\vartheta\mathbf{f}^{\mathbf{S}}_{1,2}+\frac{1}{\sqrt{3}}\sin\vartheta\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}}\\
\mathbf{f}^{(\mathbf{1,2})}_{\phi\mathbf{\Lambda\Lambda}} &= \frac{1}{\sqrt{2}}\sin\vartheta\mathbf{f}^{\mathbf{S}}_{1,2}-\frac{1}{\sqrt{3}}\cos\vartheta\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}}\\
\\
\mathbf{f}^{(\mathbf{1,2})}_{\rho\mathbf{\Sigma\Sigma}} &= -\mathbf{f}^{\mathbf{F}}_{\mathbf{1,2}} \qquad\qquad\qquad\qquad\qquad\qquad\qquad (11)\\
\mathbf{f}^{(\mathbf{1,2})}_{\omega\mathbf{\Sigma\Sigma}} &= \frac{1}{\sqrt{2}}\cos\vartheta\mathbf{f}^{\mathbf{S}}_{1,2}-\frac{1}{\sqrt{3}}\sin\vartheta\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}}\\
\mathbf{f}^{(\mathbf{1,2})}_{\phi\mathbf{\Sigma\Sigma}} &= \frac{1}{\sqrt{2}}\sin\vartheta\mathbf{f}^{\mathbf{S}}_{1,2}+\frac{1}{\sqrt{3}}\cos\vartheta\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}}\\
\\
\mathbf{f}^{(\mathbf{1,2})}_{\rho\mathbf{\Xi\Xi}} &= \frac{1}{2}(\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}}-\mathbf{f}^{\mathbf{F}}_{\mathbf{1,2}})\\
\mathbf{f}^{(\mathbf{1,2})}_{\omega\mathbf{\Xi\Xi}} &= \frac{1}{\sqrt{2}}\cos\vartheta\mathbf{f}^{\mathbf{S}}_{1,2}+\frac{1}{2\sqrt{3}}\sin\vartheta(\mathbf{3f}^{\mathbf{F}}_{1,2}+\mathbf{f}^{\mathbf{D}}_{1,2})\\
\mathbf{f}^{(\mathbf{1,2})}_{\phi\mathbf{\Xi\Xi}} &= \frac{1}{\sqrt{2}}\sin\vartheta\mathbf{f}^{\mathbf{S}}_{\mathbf{1,2}}-\frac{1}{2\sqrt{3}}\cos\vartheta(\mathbf{3f}^{\mathbf{F}}_{\mathbf{1,2}}+\mathbf{f}^{\mathbf{D}}_{\mathbf{1,2}})\ .
\end{aligned}$$

PREDICTION OF $\mathbf{G^Y_E(t)\ G^Y_M(t)}$:

I.

$\mathbf{f}^{(\mathbf{1,2})}_{\rho\mathbf{NN}}$, $\mathbf{f}^{(\mathbf{1,2})}_{\omega\mathbf{NN}}$, $\mathbf{f}^{(\mathbf{1,2})}_{\phi\mathbf{NN}}$, on the left hand side of the first three lines in (11) can be **determined numerically** by a comparison of the model for nucleons with existing exp. data and $\mathbf{f}_\rho$, $\mathbf{f}_\omega$, $\mathbf{f}_\phi$ given by (9).

II.

Then the first three relations in (11) are **algebraic eqs.** for $\mathbf{f^F}$, $\mathbf{f^D}$, $\mathbf{f^S}$.

III.

By a solution of the algebraic eqs. **numerical values** of $\mathbf{f^F}$, $\mathbf{f^D}$, $\mathbf{f^S}$ are determined and their substitution into the rest expressions in (11) leads to an evaluation of all other coupling constants of ρ, ω, ϕ to hyperons.

IV.

Substitution of coupling constant ratios of ρ, ω, ϕ to hyperons **into the corresponding models (5)-(8)** renders possible a prediction of a behaviour of $\mathbf{G_E^Y(t)}$ and $\mathbf{G_M^Y(t)}$ (see Fig1s.1-6).

For $t > 4m_\pi^2$ the models (5)-(8) together with (3) are **complex functions** on the upper boundary of the cut.

The relative phase of $G_E^B(t)$ **and** $G_M^B(t)$ δ=δ_E-δ_M, can be obtained experimentally at the $e^+e^- \to B\bar{B}$ processes **by a measurement** (e.g. at the planned PEP-N Project at SLAC) of y-component of the polarization $\vec{\mathbf{P}}$

$$P_y = -\frac{\sin 2\Theta \cdot |G_E(s)||G_M^*(s)| \sin\delta(t)/\sqrt{t/4m_B^2}}{4m_B^2/t \cdot |G_E(s)|^2 \sin^2\Theta + |G_M(s)|^2(1+\cos^2\Theta)}$$

of one of the final particles, whereby the y-axis is orthogonal to the plane of the reaction $e^+e^- \to B\bar{B}$.

<u>Measurement:</u>

At the fixed value of t one has **to measure dσ/dΩ** of the process $e^+e^- \to B\bar{B}$ at

- **<u>two</u>** values of $\Theta \Longrightarrow |G_E|^2$, $|G_M|^2$ are determined
- **<u>one</u>** value of $\Theta \Longrightarrow P_y(\Theta)$ and as a result also δ=δ_E-δ_M are determined

<u>NOTE:</u>

If the relative phase δ=δ_E-δ_M is different from $\neq 0 \Longrightarrow$ also $P_y(\Theta) \neq 0$ even **in the annihilation of unpolarized e$^+$e$^-$** into $B\bar{B}$.

The **theoretical predictions** of δ=δ_E-δ_M for Λ, Σ, Ξ hyperons are shown in Figs. 7-9.

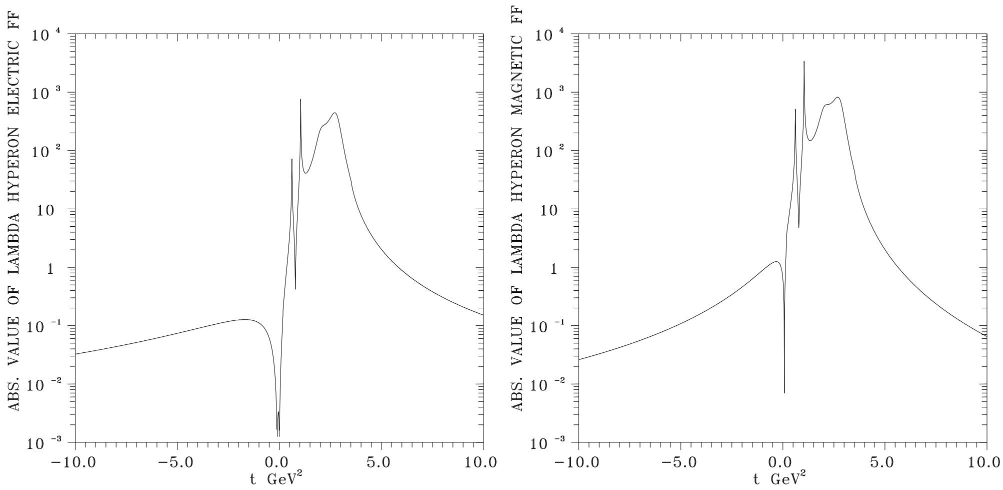

Figure 1:

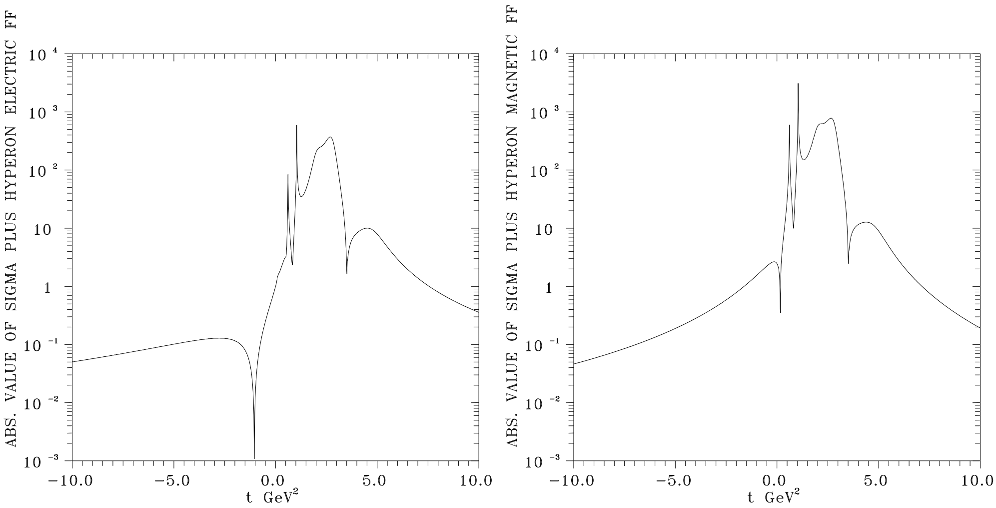

Figure 2:

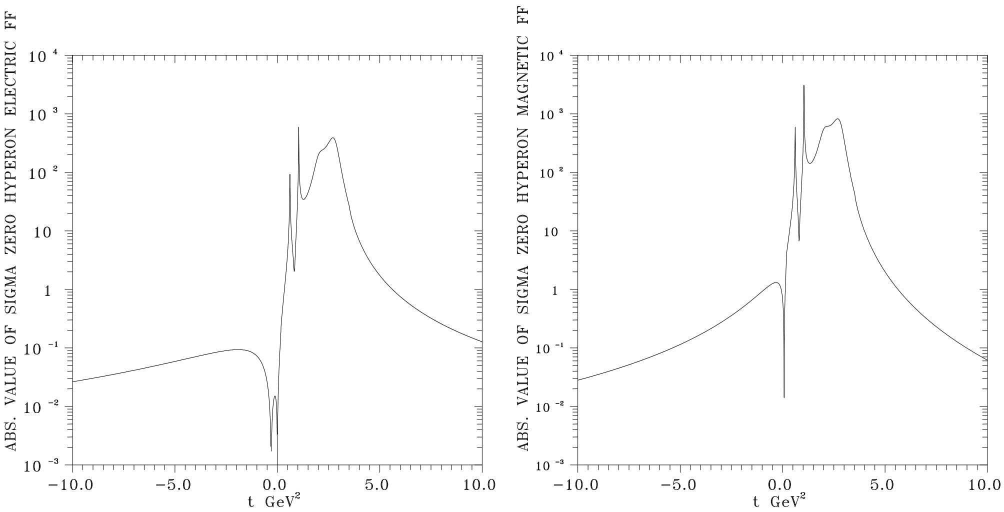

Figure 3:

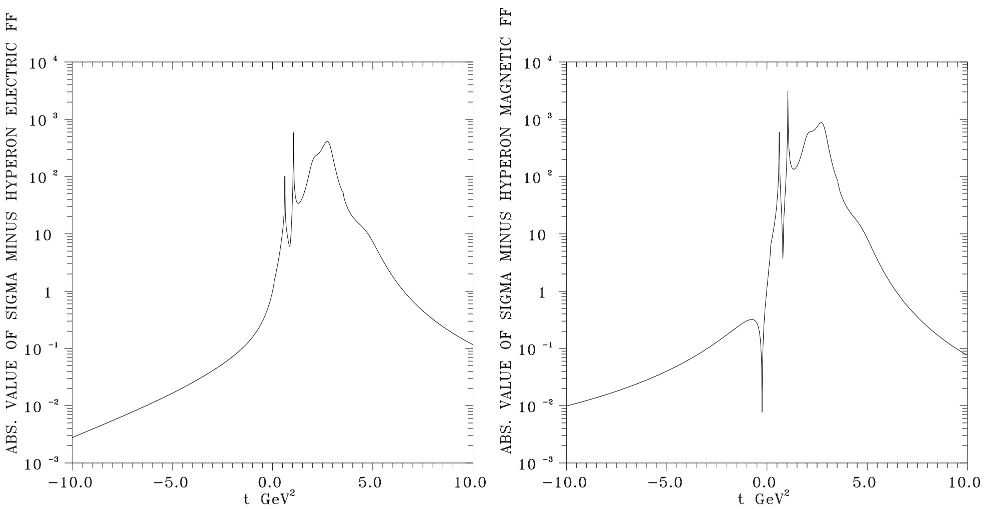

Figure 4:

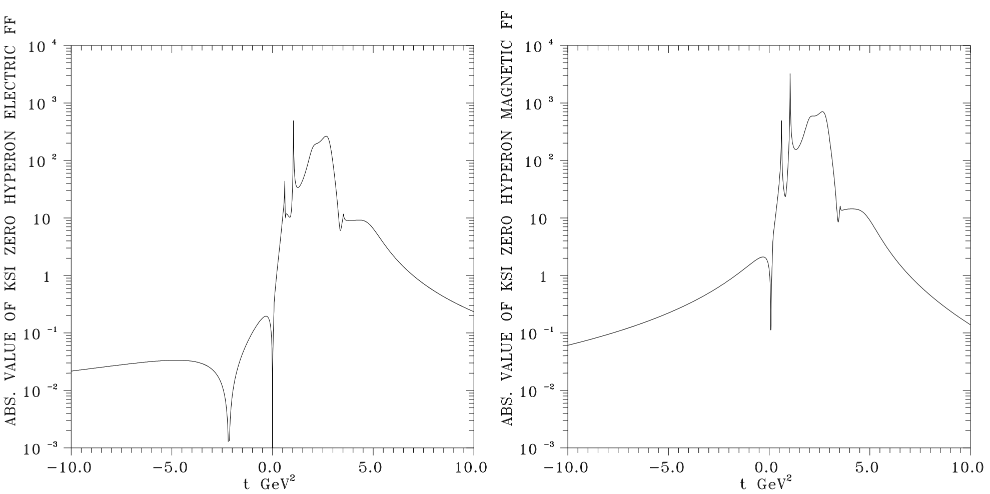

Figure 5:

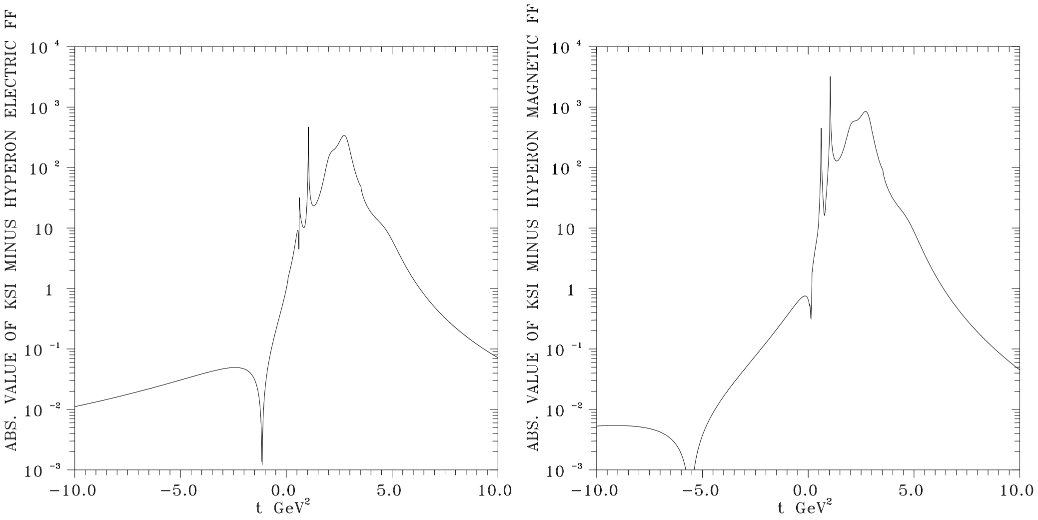

Figure 6:

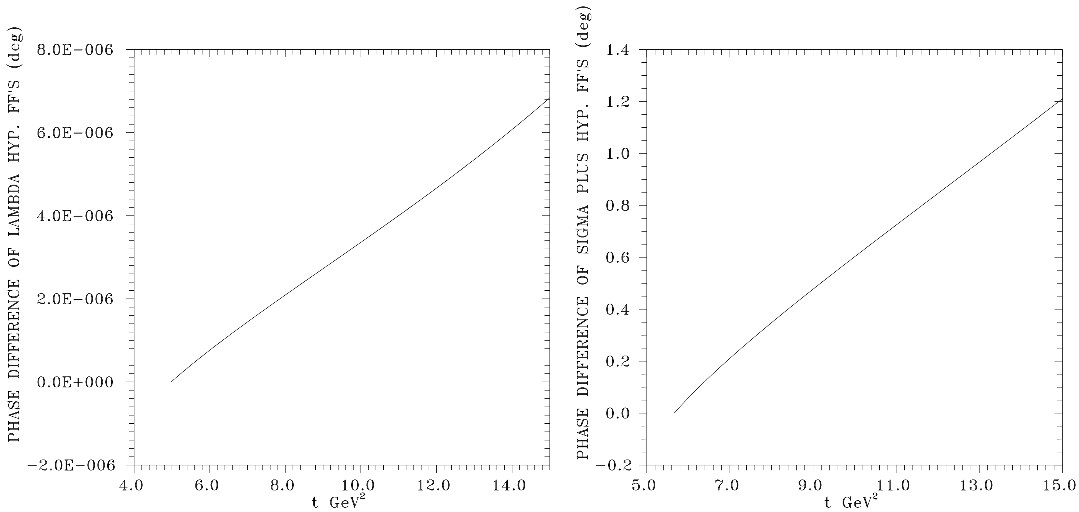

Figure 7:

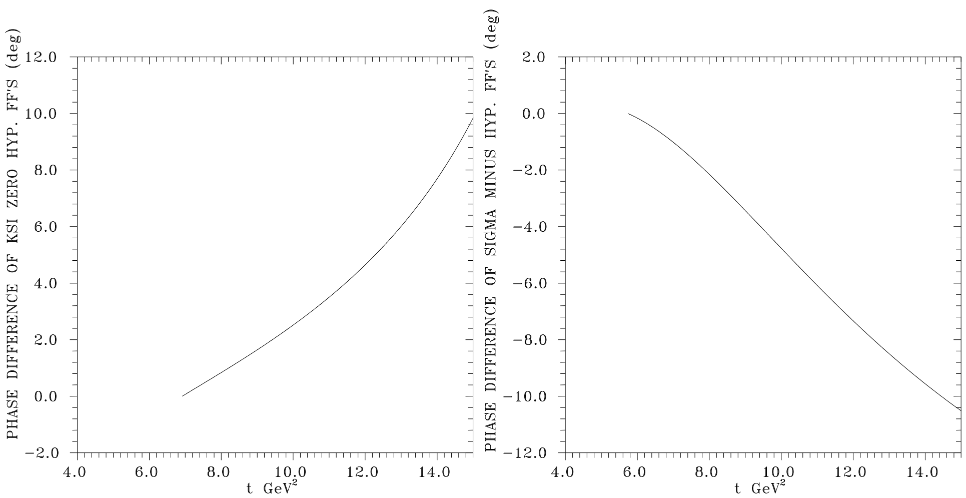

Figure 8:

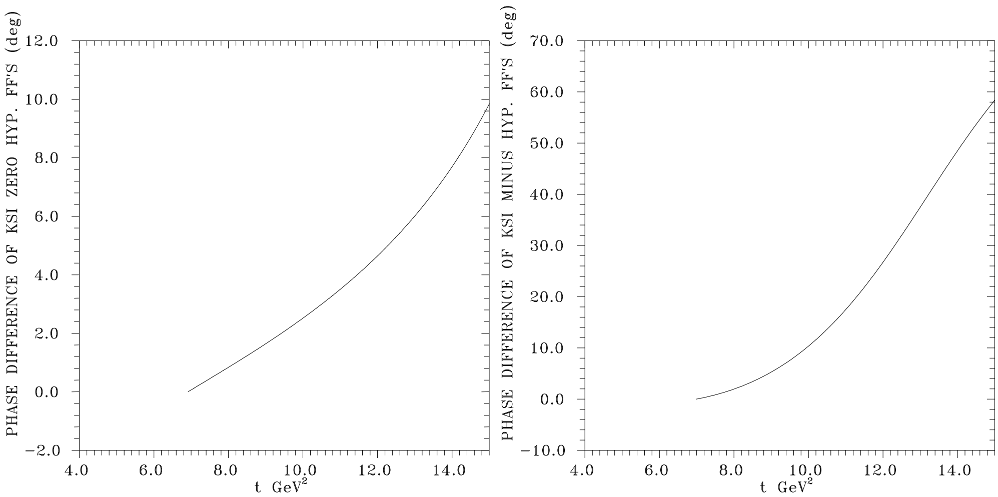
PHASE DIFFERENCE OF KSI ZERO HYP. FF'S (deg)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
−2.0
4.0
6.0
8.0
10.0
12.0
14.0
t GeV^2
PHASE DIFFERENCE OF KSI MINUS HYP. FF'S (deg)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
−10.0
4.0
6.0
8.0
10.0
12.0
14.0
t GeV^2

Figure 9: