η Decay with a C-Violating $\eta\rho\pi$ Interaction

YASUNORI FUJII
Institute of Physics, College of General Education, University of Tokyo, Tokyo, Japan

AND

GORDON L. SHAW*
University of California, Irvine, California

(Received 13 February 1967)

One of the important tests for the presence of a C-violating semistrong interaction occurs in the decay $\eta \to \pi^+\pi^-\pi^0$. We examine a previously suggested model in which a π^+-π^- asymmetry is produced by the interference of the dominant mode $\eta \to \sigma\pi^0$ (where σ is an attractive $I=0$, S-wave $\pi^+\pi^-$ state) with the C-violating $\Delta I=0$ transition $\eta \to \rho\pi$. The $\eta \to \rho\pi$ amplitude involves three terms in which each $\pi\pi$ combination goes through a ρ state; enormous cancellation occurs and thus the resultant is sensitive to small perturbations. We find: (i) that consideration of the finite width of the ρ and the $\pi^\pm$-π^0 mass difference greatly alters the distribution of the π^+-π^- asymmetry in the Dalitz plot from that of previous calculations; (ii) that the $\pi^\pm$-π^0 mass difference increases the magnitude of the π^+-π^- asymmetry for a given C-violating coupling $g_{\eta\rho\pi}$.

It has been suggested that the CP-violating 2π decay mode of the K_L is due to a semistrong interaction which conserves parity and strangeness but violates C.[1] This interaction is thus expected to lead to a π^+-π^- asymmetry Δ in the decay $\eta \to \pi^+\pi^-\pi^0$ by interfering with the dominant C conserving $\Delta I=1$ mode shown in Fig. 1(a).[1,2] This asymmetry Δ has been searched for experimentally[3] and studied theoretically.[2,4,5] Although it appears that Δ is small ($\lesssim 1\%$)—if it exists—the experiments to determine it continue to be of great interest. One widely studied model for the C-violating amplitude is the mode $\eta \to \rho\pi$ with $\Delta I = 0$.[4–6] The $\eta \to \rho\pi$ amplitude involves the three diagrams in Figs. 1(b)–1(d). Enormous cancellation of these terms occurs and thus the resultant amplitude is sensitive to small perturbations. (This sensitivity was already noted in discussing the decay of a 0^{--} "η".)[7]

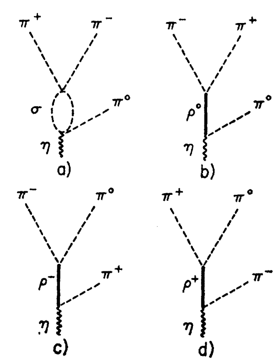

FIG. 1. (a) Dominant C conserving diagram for the decay (1); (b)–(d) C violating diagrams for the decay (1) in our model.

The purpose of this paper is to consider the effects of the finite width of the ρ and the π^+-π^0 mass difference. We find that the distribution of the π^+-π^- asymmetry in the Dalitz plot is greatly altered from that of previous calculations: (1) Dividing the Dalitz plot into the sextants shown in Fig. 2, it had been found that the π^+-π^- asymmetry of the middle sextants was opposite to that of the upper and lower pairs. We find that the finite width of the ρ changes this conclusion even for no $\pi^\pm$-π^0 mass difference. (2) Including the pion mass-splitting changes not only the distribution of the π^+-π^- asymmetry but also the magnitude of Δ for a given C-violating coupling $g_{\eta\rho\pi}$.[8]

The partial width for the decay

$$\eta \to \pi^+\pi^-\pi^0 \tag{1}$$

can be written as

$$\Gamma(\pi^+\pi^-\pi^0) = \frac{1}{(4\pi)^3}\frac{1}{2\eta}\int\int |M|^2 d(t_+ - t_-)dt_0, \tag{2}$$

where the t's are the kinetic energies of the pions in the rest system of the η and η is the mass of the η. Let the

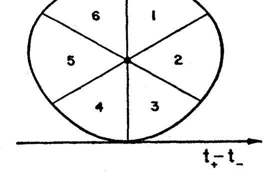

FIG. 2. Dalitz plot divided into sextants. The divisions correspond to the lines $t_+ = t_-$, $t_0 = t_-$, and $t_0 = t_+$.

* Supported in part by the U. S. National Science Foundation.
[1] J. Prentki and M. Veltman, Phys. Letters **15**, 88 (1965); T. D. Lee and L. Wolfenstein, Phys. Rev. **138**, B1490 (1965).
[2] T. D. Lee, Phys. Rev. **139**, B1415 (1965).
[3] C. Baltay, P. Franzini, J. Kim, L. Kirsch, D. Zanello, J. Lee-Franzini, R. Loveless, J. McFadyen, and H. Yarger, Phys. Rev. Letters **16**, 1228 (1966); A. M. Cnops, G. Finocchiaro, J. C. Lassalle, P. Mittner, P. Zanella, J. P. Dufey, B. Gobbi, M. A. Pouchon, and A. Muller, Phys. Letters **22**, 546 (1966); L. R. Fortney, J. W. Chapman, S. Dagan, and E. C. Fowler, in *International Conference on High Energy Physics, Berkeley, 1966* (University of California Press, Berkeley, California, 1967); A. Larribe *et al.*, Phys. Letters **23**, 600 (1966).
[4] M. Nauenberg, Phys. Letters **17**, 329 (1965).
[5] B. Barrett, M. Jacob, M. Nauenberg, and T. N. Troung, Phys. Rev. **141**, 1342 (1966).
[6] Y. Fujii and G. Marx, Phys. Letters **17**, 75 (1965); S. L. Glashow and C. M. Sommerfield, Phys. Rev. Letters **15**, 78 (1965).
[7] G. L. Shaw and D. Y. Wong, Phys. Rev. Letters **8**, 336 (1962).
[8] The coupling constant $g_{\eta\rho\pi}$ we use is twice as large as that used in Ref. 5.

TABLE I. The quantities $\Delta(t_0, t_+-t_-)$, $\Delta(t_0)$, $\Delta(t_+-t_-)$, Δ_i, and Δ are given with the dimensions of the square bin taken as 5.83 MeV for the case $\delta=0$, $\epsilon=0$, $\Gamma_\rho=0.7$, and $g_{\eta\rho\pi}=4.38$.[a]

$\Delta(t_0)$	$\Delta(t_0, t_+-t_-)$												
0.33	0.010	0.029	0.047	0.065	0.082	0.098	···	···	···	···	···	···	···
0.43	0.005	0.015	0.025	0.035	0.044	0.051	0.058	0.063	0.066	0.068	···	···	···
0.20	0.002	0.007	0.012	0.016	0.020	0.023	0.025	0.026	0.026	0.025	0.021	···	···
0.04	0.001	0.002	0.004	0.005	0.006	0.006	0.007	0.006	0.005	0.003	−0.000	−0.004	···
−0.00	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	−0.000	0.000	−0.000	−0.000	−0.001	−0.001
0.10	−0.000	−0.001	−0.001	−0.001	−0.000	0.001	0.003	0.005	0.009	0.013	0.018	0.024	0.031
0.30	−0.000	0.000	0.000	0.002	0.004	0.007	0.012	0.018	0.026	0.037	0.050	0.065	0.083
0.52	−0.000	−0.000	0.001	0.003	0.006	0.012	0.020	0.031	0.045	0.064	0.086	0.112	0.144
0.43	−0.001	−0.003	−0.004	−0.003	0.000	0.006	0.017	0.032	0.052	0.078	0.110	0.149	···
0.04	−0.005	−0.014	−0.021	−0.026	−0.027	−0.024	−0.015	0.000	0.023	0.054	0.095	···	···
−0.69	−0.013	−0.037	−0.060	−0.079	−0.093	−0.101	−0.101	−0.093	−0.074	−0.043	−0.000	···	···
−1.71	−0.027	−0.080	−0.131	−0.177	−0.217	−0.248	−0.270	−0.280	−0.277	···	···	···	···
−2.80	−0.050	−0.147	−0.242	−0.331	−0.413	−0.485	−0.544	−0.590	···	···	···	···	···
−2.74	−0.080	−0.238	−0.393	−0.541	−0.680	−0.809	···	···	···	···	···	···	···
−1.81	−0.115	−0.344	−0.569	−0.787	···	···	···	···	···	···	···	···	···
$\Delta(t_+-t_-)$	−0.27	−0.81	−1.33	−1.82	−1.27	−1.46	−0.79	−0.78	−0.10	0.30	0.38	0.35	0.26

$\Delta_3=-9.90$; $\Delta_2=1.54$; $\Delta_1=1.01$; $\Delta=-7.36$.

[a] The kinetic energy t_0 of the bins increases upward, and t_+-t_- increases from left to right.

mass of the charged pion $\equiv 1.0$ and that of the $\pi^0=1.0-\delta$. Neglecting terms of order δ, the boundary of the Dalitz plot for the integrations in (2) is given by

$$(t_+-t_-)^2=(t_0^2+2t_0)[1-4/((\eta-1)^2-2\eta t_0)]. \quad (3)$$

We divide M into two parts:

$$M=M_++M_-, \quad (4)$$

with the property that under charge conjugation,

$$CM_\pm C^{-1}=\pm M_\pm. \quad (5)$$

We choose M_+ to be dominated by the process in Fig. 1(a) so that the phase is determined by the $I=0$ S-wave $\pi^+\pi^-$ interaction. Using the Brown-Singer σ meson,[9] we have

$$M_+=\beta\bigg/\left[t_0+\frac{\sigma^2-(\eta-1)^2}{2\eta}-i\frac{\Gamma_\sigma\sigma k(t_0)}{2\eta k_\sigma}\right], \quad (6)$$

where

$$k(t_0)=[\tfrac{1}{4}(\eta-1)^2-1-\tfrac{1}{2}\eta t_0]^{1/2} \quad (7)$$

and

$$k_\sigma=(\tfrac{1}{4}\sigma^2-1)^{1/2}. \quad (8)$$

For the C-violating M_-, the diagrams in Figs. 1(b)–1(d) give for the $\Delta I=0$ transition

$$M_-=\tfrac{1}{2}ig_{\eta\rho\pi}g_{\rho\pi\pi}\Bigg[\frac{t_+-t_0-a\delta}{t_-+b-(i\rho\Gamma_\rho/2\eta)[k(t_-)/k_\rho]^3}+\frac{t_0-t_-+a\delta}{t_++b-(i\rho\Gamma_\rho/2\eta)[k(t_+)/k_\rho]^3}+(1+\epsilon)\frac{t_--t_+}{t_0+b-\delta(1-1/\eta)-(i\rho\Gamma_\rho/2\eta)[k(t_0)/k_\rho]^3}\Bigg], \quad (9)$$

[9] L. M. Brown and P. Singer, Phys. Rev. 133, B812 (1964).

where

$$a=(1+(\eta^2-1)/\rho^2)1/\eta-1, \quad (10)$$

$$b=(\rho^2-(\eta-1)^2)/2\eta, \quad (11)$$

$$k_\rho=(\tfrac{1}{4}\rho^2-1)^{1/2}. \quad (12)$$

The quantity ϵ represents possible electromagnetic corrections which could split the $g_{\eta\rho^\pm\pi^\mp}$ and $g_{\eta\rho^0\pi^0}$ couplings. Note that we do not consider any splittings in the ρ mass or width Γ_ρ. The experimental value $\Gamma_\rho=0.7$ corresponds to a $g_{\rho\pi\pi}\approx 5$. In the limit that the pion mass splitting $\delta=0$ (and $\epsilon=0$), and neglecting the width in the denominator, we obtain the familiar form

$$M_-=\tfrac{1}{2}ig_{\eta\rho\pi}g_{\rho\pi\pi}\frac{(t_+-t_0)(t_0-t_-)(t_--t_+)}{(t_++b)(t_-+b)(t_0+b)}, \quad (13)$$

which vanishes along the lines $t_0=t_-$ and $t_0=t_+$ (and $t_+=t_-$) that divide the Dalitz plot into the sextants shown in Fig. 2.

First we determine the parameters of M_+ from the decay (1) since the effects of any M_- are small. The detailed measured Dalitz distribution can be fit with the mass

$$\sigma=3 \quad (14)$$

and the width

$$\Gamma_\sigma=0.7. \quad (15)$$

We use the SU_3 relationship

$$\Gamma(\eta\to 2\gamma)=(\eta^3/3)\Gamma(\pi^0\to 2\gamma) \quad (16)$$

together with the experimental quantities[10]

$$\tau_{\pi^0}=0.89\times 10^{-16}\text{ sec}.$$

[10] A. Rosenfeld, A. Barbaro-Galtiero, J. Kirz, W. J. Podolsky, M. Roos, W. J. Willis, and C. G. Wohl, University of California Radiation Laboratory Report No. UCRL-8030, 1966 (unpublished).

TABLE II. The quantities $\Delta(t_0, t_+-t_-)$, $\Delta(t_0)$, $\Delta(t_+-t_-)$, Δ_i, and Δ are given with the dimensions of the square bin taken as 5.83 MeV for the case $\delta=0$, $\epsilon=0$, $\Gamma_\rho=0.1$, and $g_{\eta\rho\pi}=4.38$.

$\Delta(t_0)$	$\Delta(t_0, t_+-t_-)$												
−0.04	−0.001	−0.004	−0.006	−0.008	−0.011	−0.012	...	...	...	...	...	...	...
−0.24	−0.003	−0.009	−0.014	−0.020	−0.024	−0.029	−0.032	−0.035	−0.037	−0.037	...	...	...
−0.27	−0.003	−0.010	−0.016	−0.021	−0.026	−0.030	−0.033	−0.034	−0.034	−0.031	−0.027	...	...
−0.14	−0.003	−0.008	−0.014	−0.018	−0.021	−0.023	−0.023	−0.021	−0.017	−0.010	−0.000	0.013	...
0.17	−0.002	−0.006	−0.009	−0.011	−0.012	−0.010	−0.006	−0.000	0.010	0.023	0.040	0.062	0.089
0.51	−0.001	−0.003	−0.003	−0.003	−0.000	0.005	0.014	0.026	0.042	0.063	0.090	0.122	0.161
0.85	−0.000	0.000	0.001	0.004	0.010	0.019	0.032	0.050	0.073	0.103	0.140	0.185	0.238
1.10	−0.000	−0.000	0.002	0.006	0.013	0.024	0.041	0.064	0.094	0.133	0.180	0.237	0.306
0.75	−0.002	−0.005	−0.007	−0.006	0.000	0.011	0.029	0.054	0.089	0.134	0.191	0.260	...
0.06	−0.007	−0.020	−0.031	−0.039	−0.041	−0.036	−0.023	0.000	0.034	0.082	0.143	...	...
−0.94	−0.017	−0.050	−0.080	−0.106	−0.125	−0.136	−0.137	−0.125	−0.100	−0.059	−0.000	...	...
−2.12	−0.034	−0.099	−0.162	−0.219	−0.269	−0.308	−0.336	−0.349	−0.345	...	...	...	...
−3.25	−0.057	−0.171	−0.280	−0.384	−0.478	−0.561	−0.631	−0.684	...	...	...	...	...
−2.99	−0.087	−0.260	−0.429	−0.591	−0.743	−0.883	...	...	...	...	...	...	...
−1.88	−0.119	−0.357	−0.590	−0.816	...	...	...	...	...	...	...	...	...
$\Delta(t_+-t_-)$	−0.34	−1.00	−1.64	−2.23	−1.73	−1.97	−1.11	−1.05	−0.19	0.40	0.76	0.88	0.79

$\Delta_3=-11.40$; $\Delta_2=3.74$; $\Delta_1=-0.77$; $\Delta=-8.42$.

TABLE III. The quantities $\Delta(t_0, t_+-t_-)$, $\Delta(t_0)$, $\Delta(t_+-t_-)$, Δ_i, and Δ are given with the dimensions of the square bin taken as 5.83 MeV for the case $\delta=0.036$, $\epsilon=0$, $\Gamma_\rho=0.7$, and $g_{\eta\rho\pi}=1.75$.

$\Delta(t_0)$													
0.11	0.003	0.010	0.016	0.023	0.028	0.034	...	...	...	...	...	...	...
0.12	0.002	0.005	0.007	0.010	0.012	0.014	0.016	0.017	0.017	0.016	...	...	...
0.00	0.000	0.001	0.002	0.002	0.002	0.002	0.002	0.001	−0.001	−0.003	−0.005	...	...
−0.09	−0.000	−0.001	−0.002	−0.003	−0.004	−0.006	−0.007	−0.009	−0.011	−0.013	−0.016	−0.019	...
−0.15	−0.001	−0.003	−0.004	−0.006	−0.008	−0.010	−0.011	−0.013	−0.015	−0.017	−0.019	−0.020	−0.023
−0.14	−0.001	−0.003	−0.006	−0.008	−0.010	−0.011	−0.013	−0.014	−0.015	−0.015	−0.015	−0.015	−0.014
−0.10	−0.001	−0.004	−0.007	−0.009	−0.011	−0.012	−0.013	−0.013	−0.012	−0.011	−0.008	−0.004	0.000
−0.08	−0.002	−0.005	−0.009	−0.011	−0.014	−0.015	−0.015	−0.014	−0.011	−0.007	−0.002	0.006	0.016
−0.16	−0.003	−0.008	−0.014	−0.018	−0.021	−0.023	−0.024	−0.022	−0.019	−0.013	−0.004	0.008	...
−0.36	−0.005	−0.015	−0.025	−0.033	−0.040	−0.045	−0.047	−0.047	−0.044	−0.037	−0.026	...	...
−0.79	−0.009	−0.028	−0.046	−0.062	−0.076	−0.088	−0.096	−0.101	−0.101	−0.097	−0.087	...	...
−1.15	−0.017	−0.050	−0.081	−0.111	−0.139	−0.163	−0.183	−0.197	−0.207	...	...	...	...
−1.60	−0.027	−0.082	−0.134	−0.185	−0.232	−0.276	−0.314	−0.346	...	...	...	...	...
−1.43	−0.041	−0.123	−0.203	−0.281	−0.355	−0.424	...	...	...	...	...	...	...
−0.90	−0.057	−0.170	−0.282	−0.390	...	...	...	...	...	...	...	...	...
$\Delta(t_+-t_-)$	−0.16	−0.48	−0.79	−1.08	−0.87	−1.02	−0.71	−0.76	−0.42	−0.20	−0.18	−0.04	−0.02

$\Delta_3=-6.19$; $\Delta_2=-0.65$; $\Delta_1=0.11$; $\Delta=-6.73$.

TABLE IV. The quantities $\Delta(t_0, t_+-t_-)$, $\Delta(t_0)$, $\Delta(t_+-t_-)$, Δ_i, and Δ are given with the dimensions of the square bin taken as 5.83 MeV for the case $\delta=0.036$, $\epsilon=0.01$, $\Gamma_\rho=0.7$, and $g_{\eta\rho\pi}=0.875$.

$\Delta(t_0)$													
0.05	0.001	0.004	0.007	0.009	0.012	0.014	...	...	...	...	...	...	...
0.00	0.000	0.001	0.001	0.001	0.001	0.001	−0.001	−0.000	−0.001	−0.003	...	...	...
−0.10	−0.001	−0.002	−0.003	−0.005	−0.006	−0.008	−0.010	−0.012	−0.015	−0.017	−0.020	...	...
−0.21	−0.001	−0.004	−0.007	−0.010	−0.013	−0.015	−0.018	−0.022	−0.025	−0.028	−0.032	−0.036	...
−0.33	−0.002	−0.006	−0.010	−0.014	−0.018	−0.022	−0.026	−0.030	−0.034	−0.037	−0.041	−0.045	−0.050
−0.41	−0.003	−0.008	−0.013	−0.018	−0.023	−0.028	−0.032	−0.037	−0.041	−0.046	−0.050	−0.053	−0.057
−0.49	−0.003	−0.010	−0.016	−0.023	−0.029	−0.035	−0.040	−0.045	−0.050	−0.054	−0.058	−0.062	−0.064
−0.60	−0.004	−0.013	−0.021	−0.029	−0.037	−0.044	−0.050	−0.057	−0.062	−0.067	−0.070	−0.073	−0.075
−0.69	−0.006	−0.017	−0.028	−0.038	−0.049	−0.058	−0.067	−0.074	−0.081	−0.086	−0.090	−0.093	...
−0.82	−0.008	−0.023	−0.039	−0.053	−0.067	−0.080	−0.092	−0.103	−0.112	−0.119	−0.124	...	...
−1.18	−0.011	−0.034	−0.055	−0.077	−0.097	−0.116	−0.133	−0.148	−0.161	−0.172	−0.180	...	...
−1.21	−0.016	−0.048	−0.080	−0.110	−0.140	−0.167	−0.193	−0.216	−0.236	...	...	...	...
−1.37	−0.023	−0.068	−0.112	−0.155	−0.197	−0.237	−0.274	−0.308	...	...	...	...	...
−1.07	−0.030	−0.091	−0.151	−0.209	−0.266	−0.320	...	...	...	...	...	...	...
−0.61	−0.039	−0.116	−0.192	−0.267	...	...	...	...	...	...	...	...	...
$\Delta(t_+-t_-)$	−0.15	−0.43	−0.72	−1.00	−0.93	−1.11	−0.93	−1.05	−0.82	−0.63	−0.67	−0.36	−0.25

$\Delta_3=-6.06$; $\Delta_2=-2.64$; $\Delta_1=-0.34$; $\Delta=-9.04$.

and

$$\Gamma(\eta \to 2\gamma)/\Gamma(\eta \to \pi^+\pi^-\pi^0) = 33.5/25.3 \quad (17)$$

to obtain

$$\Gamma(\eta \to \pi^+\pi^-\pi^0) = 8.5\times 10^{-7}. \quad (18)$$

Then we numerically integrate $|M_+|^2$ over the Dalitz plot to obtain from (2)

$$\Gamma(\pi^+\pi^-\pi^0) = 4.08\times 10^{-6}\beta^2.$$

Therefore

$$\beta^2 = 0.21. \quad (19)$$

Now we examine the $\pi^+-\pi^-$ asymmetry using our model C-violating M_- given by (9). Let $\Delta(t_0, t_+-t_-)$ be the number of events in a square bin centered at (t_0, t_+-t_-) minus the number for the bin centered (t_0, t_--t_+) with $t_+>t_-$. Further, let

$$\Delta(t_0) = \sum_{\substack{\text{bins in } t_+-t_- \\ \text{direction}}} \Delta(t_0, t_+-t_-),$$

$$\Delta(t_+-t_-) = \sum_{\substack{\text{bins in } t_0 \\ \text{direction}}} \Delta(t_0, t_+-t_-), \quad (20)$$

$$\Delta_i = \sum_{\substack{\text{bins in} \\ \text{sextant } i}} \Delta(t_0, t_+-t_-),$$

and

$$\Delta = \sum_{i=1}^{3} \Delta_i.$$

Our normalization is such that the total number of decays (1) is 100, so that Δ is given in percent. The above quantities are presented in Tables I–IV for the following cases (I) $\delta=0$, $\epsilon=0$, $\Gamma_\rho=0.7$; (II) $\delta=0$, $\epsilon=0$, $\Gamma_\rho=0.1$; (III) $\delta=0.036$, $\epsilon=0$, $\Gamma_\rho=0.7$; (IV) $\delta=0.036$, $\epsilon=0.01$, $\Gamma_\rho=0.7$. Comparing Tables I and II, we note that *even* for δ (and $\epsilon=0$) the Δ_i do *not* alternate in sign when the experimental value of the ρ width as used [in the denominators of (9)]. Even though M_- vanishes along the lines $t_0=t_+$ and $t_0=t_-$ dividing the sextants, M_- gets out of phase with M_+ along another line so that $\Delta(t_0, t_+t_-)$ again changes sign for case I, and thus Δ_1 has the opposite sign from Δ_3. Including a small splitting in the coupling, i.e., $\epsilon=0.01$, we see in Table IV that the Δ_i all have the same sign.[11]

The second important feature to note is the value of $g_{\eta\rho\pi}$ required to produce a given Δ for the above cases (denoted by a superscript):

$$\begin{aligned} |\Delta^{\mathrm{I}}| &= 1.7|g_{\eta\rho\pi}|, \\ |\Delta^{\mathrm{II}}| &= 1.9|g_{\eta\rho\pi}|, \\ |\Delta^{\mathrm{III}}| &= 3.8|g_{\eta\rho\pi}|, \\ |\Delta^{\mathrm{IV}}| &= 10.4|g_{\eta\rho\pi}|, \end{aligned} \quad (21)$$

where Δ is given in percent. Thus including δ and ϵ substantially increases the size of Δ for a given $g_{\eta\rho\pi}$.

As expected, a model in which M_- is a $\eta\to\rho\pi$ amplitude with a $\Delta I=2$ transition [$\epsilon=-3$ in (9)] is not sensitive to including δ, nor to making Γ_ρ narrow.

Now, following Barrett *et al.*,[5] we compare the decay

$$\eta \to \pi^0 e^+ e^- \quad (22)$$

calculated through the sequence $\eta\to\pi^0\rho\to\pi^0\gamma\to\pi^0e^+e^-$ to the asymmetry Δ in (1). From Eq. (15) of Ref. 5 together with (16) and (17), we have

$$R \equiv \frac{\Gamma(\eta\to\pi^0e^+e^-)}{\Gamma(\eta\to \text{all decays})} = 0.010\left(\frac{g_{\eta\rho\pi}^2}{4\pi}\right). \quad (23)$$

Now for a $\pi^+\pi^-$ asymmetry in (1) of $\leq 1\%$, our case III in (21) yields $|g_\eta|\leq 0.26$. Thus, we should expect $R\leq 0.54\times 10^{-4}$ which is much smaller than the presently available measured upper limit 2.3×10^{-3}.[12]

We wish to acknowledge helpful discussions with Professor M. Nauenberg. We would like to thank Professor L. I. Schiff for his hospitality at the Institute of Theoretical Physics, Department of Physics, Stanford University, where part of this work was done.

[11] This is characteristic of a model in which the $\eta\to\rho\pi$ amplitude is a $|\Delta I|=2$ transition. We see that a small mixture of a $|\Delta I|=2$ amplitude introduced by ϵ greatly influences the Dalitz plot. A somewhat larger admixture of $|\Delta I|=2$ amplitude would completely dominate the $\Delta I=0$ amplitude.

[12] C. Baglin *et al.*, Phys. Letters **22**, 219 (1966).