THE DECAY $\varphi \rightarrow \pi\pi\gamma$ AS A MEANS FOR DETECTING
S WAVE RESONANCES AND C VIOLATION

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In this note we would like to point out that a careful study of the decay $\varphi \rightarrow \pi^+\pi^-\gamma$ can give interesting information on both even spin $\pi\pi$ resonances with isospin 0 and the possible existence of C violating effects in strong interactions [1,2].

Suppose that C is conserved to a high degree in strong and electromagnetic interactions. Remembering that spin, parity, G parity, isotopic spin and intrinsic C of the φ are 1, -, -, 0 and -

respectively, we note that the decay $\varphi \rightarrow \pi^+\pi^-\gamma$ must proceed with the two pions in a state of even angular momentum, i.e., $l = 2n$. Thus this reaction furnishes us a sample of events with pions in an even wave (and I-spin 0), which is extremely well adapted for study in the region where otherwise P waves (p-resonance) would be important.

Recently, some evidence was presented [3] in favour of a large $\pi^+\pi^- S$ wave resonance called

ϵ^0, around 720 MeV. Especially for this mass, separation of ρ^0 and ϵ^0 is usually quite difficult, but in the $\varphi \to \pi^+\pi^-\gamma$ the ϵ^0 would show up as a clear bump in the $\pi^+\pi^-$ invariant mass spectrum *. The angular distribution of π^+ (or π^-) with respect to the γ-line of flight can give Information on the spin of such a resonance. Of course ABC and a resonances could be studied here also.

The recently proposed [1] possibility of C violation in strong interactions could be tested here. If C is violated $\varphi \to \pi^+\pi^-\gamma$ may proceed with the pions in a state of odd angular momentum. One expects then a bump (due to the p) around 760 MeV of a P wave nature. It may be noted that in any case this p is depressed by a factor $10^{-1} - 10^{-2}$ associated with the C violating interaction. Again study of the angular distributions of π^+ or π^- could reveal the characteristic features of aP wave. This C violating effect could be seen rather easily through the interference with the C conserving S wave mode $\varphi \to \pi^+\pi^-\gamma$: the π^+ and π^- angular distributions and energy spectra would be different from each other, and for instance the number of π^+ with energy larger than that of the π^- would be different from the number of π^+ with energy smaller than the π^- energy.

Concerning the branching ratio of $\varphi \to \pi^+\pi^-\gamma$ we may remark that it should be quite appreci-

able - at least 10-20%. The reason for this is that other modes are quite suppressed: the decay $\varphi \to \overline{K}K$ has a very small phase space $(Q = 23$ MeV$)$, and $\varphi \to \rho\pi$ is suppressed by SU(6). Also $\varphi \to \pi^0\gamma$ is forbidden by SU(6) symmetry.

Similar remarks can be made for the process $\omega \to \pi^+\pi^-\gamma$ (branching ratio known to be about 3%), although the situation is more difficult due to the smaller phase space. The ρ or ϵ^0 bumps would be on the end of the mass spectrum, corresponding to the low energy part of the γ spectrum. But any reasonable production mechanism will also favour low energy γ's, which makes the ρ or ϵ^0 identification less easier. Any C violation may still show up as differences in π^+ and π^- distributions. A factor in favour of the ω is of course the larger production cross section.

We wish to thank Professor G. Puppi for a helpful discussion.

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* Of course, ϵ^0 can be established also by looking for a resonance in the $\pi^0\pi^0$ system.

References

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