Deviation from the Exact $SU_3$ Symmetry in Hadronic Decays of $\psi$ and Contributions of Electromagnetic Interactions (*).

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Summary. — It is assumed that hadronic two-body decays of $\psi$ proceed via the $\psi$-$V$ ($V = \rho, \omega, \phi$) mixing and that the strong interactions which induce the $\psi$$\rightarrow$$V$ transition are mediated by gluons. The deviations from the exact $SU_3$ symmetry in the decays of $\psi$ and the contributions of the amplitudes via the $\psi$$\rightarrow$$V$ transition mediated by a photon are examined semi-phenomenologically by fitting the calculated branching ratios for these decays to the corresponding experimental data. Our results are the following. i) There are sizable deviations ($0.3 \lesssim \beta \lesssim 0.5$) from the exact $SU_3$ symmetry in the decays of $\psi$ into two-boson final states. They can be understood in terms of the symmetry-breaking effects in the residues of the vector meson poles. ii) The contributions of the amplitudes via the one-photon intermediate state are neither negligibly small nor dominant ($|G(u)/E(u)| \sim 2.8$). iii) The relative phase between the amplitudes via the gluon and the one-photon intermediate states is approximately equal to $\pi/2$. By using the values of the parameters estimated in this way, the branching ratios for the decays in which the amplitudes via the one-photon intermediate state dominate (in the $SU_3$ symmetry limit) can be predicted. $\Gamma(\psi$$\rightarrow$$2\gamma$) is also discussed by using the vector meson dominance hypothesis.

1. – Introduction.

Since the discovery (*1) of $\psi$, a lot of data on the decays of $\psi$ have been accumulated (*2). As a result of experimental and theoretical studies, $\psi$ has

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been considered as a bound state of the fourth quark (charmed quark c) and its antiparticle. Therefore, all the hadronic decays of $\psi$ are violating the OZI rule \(^{(3,4)}\), so that the investigation of the hadronic decays of $\psi$ will extract some information on the OZI-violating strong interactions, for example whether they satisfy the $SU_3$ symmetry or not. It may be an important factor in studying the structure of the OZI violation. For this purpose, it may be necessary to take account of the contributions of the electromagnetic interactions via one-photon intermediate states in the decays of $\psi$ into hadrons. This is intuitively inferred from the fact that the branching ratio for leptonic decays of $\psi$ amounts to about 15 per cent. On the other hand, there are many modes in the hadronic decays of $\psi$ to which electromagnetic interactions can contribute dominantly (in the exact $SU_3$ symmetry). In order to study these decays, in particular, we need to know the size of the deviation from the $SU_3$ symmetry limit in the decay amplitudes, the contributions of the electromagnetic interactions and the relative phase between the amplitudes via the gluon and the photon intermediate states.

Now it has been assumed \(^{(5-7)}\) that the decays of $\psi$ into two-boson final states proceed via $\psi \to V (= \rho, \omega, \phi)$ transitions which violate the OZI rule. TÖRNQVIST \(^{(1)}\) has concluded that the $\psi$-$V$ mixing due to unitarity effects via hadronic intermediate states is very small and three-gluon intermediate states may contribute dominantly. FritzsCh and Jackson \(^{(6)}\) have pointed out that the $\psi$-$V$ mixing has the symmetry-breaking effects of the $SU_3$ transforming like the hypercharge by introducing a quark mass dependence into the effective quark-gluon coupling constants. It seems, however, to be somewhat different from the standard picture \(^{(8)}\) of QCD. On the other hand, OKAZAKI et al. \(^{(5)}\) have calculated the branching ratios for two-body decays of $\psi$ by assuming tentatively that the effective $\psi$-$V$ vertex transforms like a $U$-spin

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