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4 Novembre 1992

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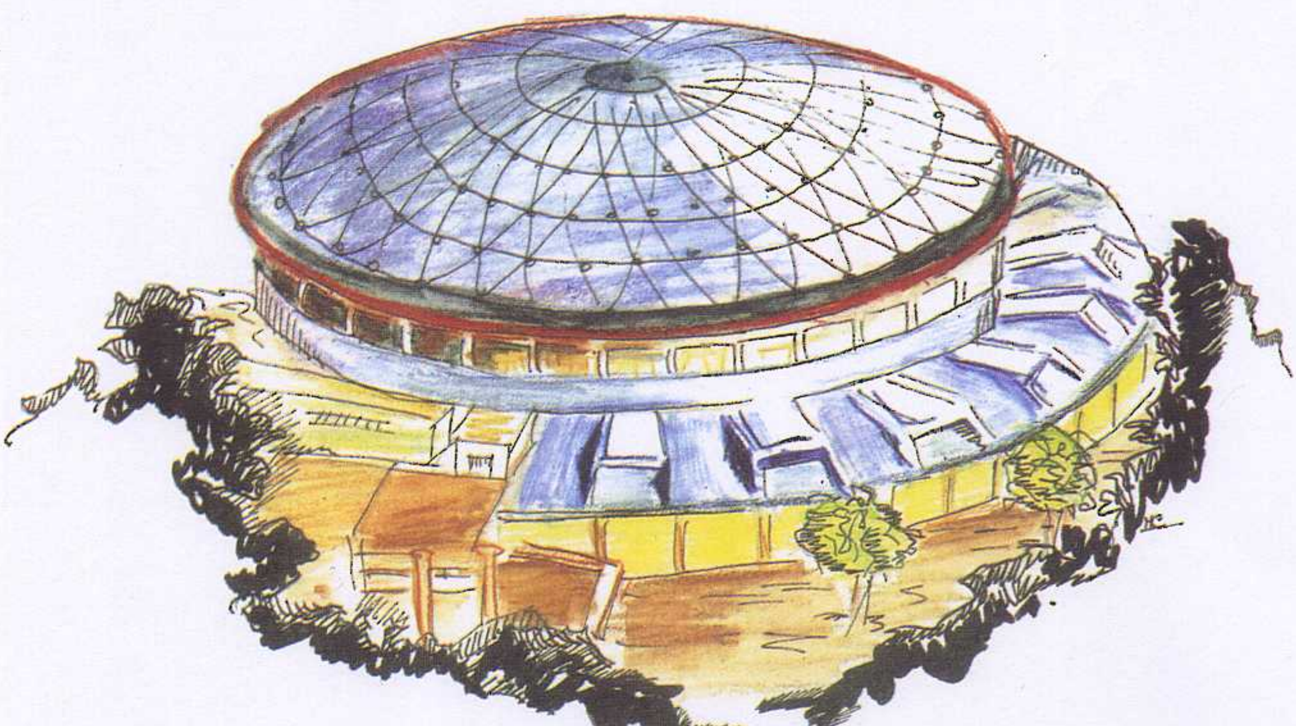
PSEUDOSCALAR MESONS AT DAΦNE

Contribution to the DAΦNE Physics Handbook



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Pseudoscalar Mesons at DAΦNE

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In the glueball hunters almanac, the $J^P = 0^-$ glueball is predicted to be rather low-lying, though this is less certain than in the case of $J^P = 0^+$. The $J^P = 0^-$ channel is interesting because there are clear candidates in the region immediately above 1 GeV ($\eta(1285)$, the iota $\eta(1440)$ which now appears to consist of two states) whose constitutions are uncertain.

If DAΦNE is run above 1 GeV energy in the c.m. it may be possible to produce the $\eta(1285)$ or $\eta(1440)$ in the final state hadrons and isolate radiative transitions to ϕ (hence probing their intrinsic $s\bar{s}$ content). However, this is for the future and needs more study than presently available. These states will not be directly accessed at DAΦNE run at $E = M_\phi$, but their masses are near enough to the $\eta'(960)$ that it raises the possibility that $\eta(960)$ is not a pure $1S(q\bar{q})$ state but involves mixtures of $2S(q\bar{q})$ and/or gluonic components. Thus it is important to understand the low mass $J^P = 0^-$ states in as much detail as possible. The ϕ can help in this respect.

The gift of nature is that ϕ is, to an excellent approximation, pure $s\bar{s}$. Its radiative decay to quarkonium states will filter out their $s\bar{s}$ component. The $J^P = 0^-$ states (η, η') do not couple to the $K\bar{K}$ channel and so there is no ambiguity from $K\bar{K}$ hadronic loops in the $\phi \to \gamma(0^-)$ study, in contrast to the foregoing $\phi \to \gamma(0^+)$. Hence, with confidence, we may study $\phi \to \gamma\eta, \phi \to \gamma\eta'$ and probe the $s\bar{s}$ content of the η-states. When combined with good data on $\eta' \to \rho\gamma$, $\eta' \to \omega\gamma$ (which probe the $u\bar{u}, d\bar{d}$ content) one can determine whether the $\eta - \eta'$ system is orthonormal in the $1S$ sector or requires further components. To illustrate this, write

$$
\begin{aligned}
|\, \eta > &= X_\eta \,|\, N > + Y_\eta \,|\, S > + Z_\eta \,|\, G > \\
|\, \eta' > &= X_{\eta'} \,|\, N > + Y_{\eta'} \,|\, S > + Z_{\eta'} \,|\, G >
\end{aligned}
$$

where the basis states are

$$| N >= \frac{1}{\sqrt{2}} | u\bar{u} + d\bar{d} >, \quad | s >=| s\bar{s} >, \quad | G >=| \text{gluonium} >$$

with normalisation $X^2 + Y^2 + Z^2 = 1$ for the η and η'. If $Z_\eta = Z_{\eta'} = 0$ the X and Y are directly related to the traditional pseudoscalar mixing angle.

Baltrusaitis et al (Phys Rev **D32**, 2883, 1985) have computed the X, Y from studies of $\psi \to VP$; the idea being that the V are ideal flavour filters against which the flavour content of the P can be weighed, (i.e. $\psi \to \omega\eta$ selects the $| N >$ component of the η, thus

$$\frac{\Gamma(\psi \to \omega\eta)}{\Gamma(\psi \to \rho\pi)} \equiv N_\eta^2 \equiv \frac{\Gamma(\psi \to \rho\eta)}{\Gamma(\psi \to \omega\pi)}$$

The results of their original fit to $\psi \to VP$ and $V \to P\gamma$ yielded

$$| X_\eta |= 0.63 \pm 0.06 \quad | Y_\eta |= 0.83 \pm 0.13 \quad X_\eta^2 + Y_\eta^2 = 1.1 \pm 0.2$$
$$| X_{\eta'} |= 0.36 \pm 0.05 \quad | Y_{\eta'} |= 0.72 \pm 0.12 \quad X_{\eta'}^2 + Y_{\eta'}^2 = 0.65 \pm 0.18$$

The results are consistent with 10^0 mixing angle and with "equal weighting" of the N and S content. Furthermore there need be no extra component, $Z \neq 0$. The η' is more provocative, there being a 2σ effect where $Z \neq 0$. The $Y_{\eta'}$ is consistent (within large errors) with the 10^0 angle but $X_{\eta'}$ seems quenched. Moreover the $X_{\eta'}$ from $\psi \to VP$ seems to disagree with that deduced from $V \to P\gamma$ and $P \to \gamma\gamma$. However these latter conditions all depend on a single number, $\Gamma(\eta' \to \gamma\gamma)$ and if this changed by 30% the results would agree. Hence copious data on $\phi \to \eta'\gamma$ will provide a direct measure of $Y_{\eta'}$ with which one can supplement the above analysis. With good statistics $\eta' \to \omega\gamma$ and $\eta' \to \gamma\gamma$ can be measured and reduce the errors on the η' mixing angles.

A detailed study of $\phi \to \eta'\gamma$ and η' decays at DAΦNE may therefore teach us much about the dynamical structure of the pseudoscalar mesons.