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HYBRID MESONS ($Q\overline{Q}g$) IN $N\overline{N}$ ANNIHILATION*

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ABSTRACT

We estimate the branching ratios of hybrid ($Q\overline{Q}g$) meson production in nucleon–antinucleon annihilation reactions $N\overline{N} \rightarrow (Q\overline{Q}g) + Q\overline{Q}$ at rest.

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ABSTRACT

We estimate the branching ratios of hybrid ($Q\overline{Q}g$) meson production in nucleon-antinucleon annihilation reactions $N\overline{N} \rightarrow (Q\overline{Q}g) + Q\overline{Q}$ at rest.

$N\overline{N}$ annihilation reactions provide exciting possibilities to study mesonic resonances beyond the usual $Q\overline{Q}$ spectrum. Particularly the search for $Q\overline{Q}g$ mesons containing an explicit dynamical excitation of the gluon field is most promising, since hybrids are predicted to display unique features: exotic quantum numbers ($J^{\pi C}$) and dynamical selection rules for their decay modes. We have investigated the possibility of producing hybrids from $p\bar{p}$ atomic states in reactions of the type $N\overline{N}(L = 0, 1) \rightarrow \pi + Q\overline{Q}g$. We consider the lowest-lying $Q\overline{Q}g$ states of the Bag Model obtained by coupling a color octet $Q\overline{Q}$ pair to a transverse electric (TE) mode of the gluon field g, i.e.

$$\left[(Q\overline{Q})_{^3S_1} \otimes \mathrm{TE}\right]_{J^{\pi C}(I^G)=0^{-+},1^{-+},2^{-+}(0^+,1^-)},$$
$$\left[(Q\overline{Q})_{^1S_0} \otimes \mathrm{TE}\right]_{1^{--}(0^-,1^+)} \qquad (1)$$

Production rates for hybrid mesons are found to display a strong dependence on the quantum numbers and kinematical factors associated with the transition. The dependence on the orbital angular momentum L of the $p\bar{p}$ atomic state, accessible in $p\bar{p}$ annihilation at rest, would provide a striking signature for the production of hybrids. The exotic TE hybrids $\hat{\rho}(1^{-+}(1^-))$ and $\hat{\omega}(1^{-+}(0^+))$ are predicted to be dominantly produced from S-wave $p\bar{p}$ atomic states with production branching ratios on the 10^{-4} level, whereas the nonexotic pseudoscalar $\hat{\rho}(0^{-+}(1^-))$ is accessible from P-states with a branching ratio of the order 10^{-2}.

In estimating branching ratios for the formation of $Q\overline{Q}g$ hybrid mesons in $N\overline{N}$ annihilation reactions at rest, we have employed a microscopic model[1–3] with constituent quarks and gluons in analogy to the annihilation model[4] for the production of $Q\overline{Q}$ mesons. In $N\overline{N}$ annihilation, gluons are provided through the destruction of $Q\overline{Q}$ pairs in the initial state. The effective gluon field produced can

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We predict that the dominant decay mode is $\hat{\omega}(1^{-+}) \rightarrow \pi a_1(1260) \rightarrow 4\pi$.

For $p\bar{p}$ P–wave annihilation, we find that the non–exotic hybrid $\hat{\rho}(0^{-+}(1^-))$ is most frequently produced, with

$$BR\left(p\bar{p}(L=0) \rightarrow \pi^0 \hat{\rho}^0\left(0^{-+}\right)\right) \approx (1.0 - 3.6) \times 10^{-2} \text{ for } m_{\hat{\rho}(0^{-+})} = 1.3 \text{ GeV}$$
$$\approx (0.5 - 3.6) \times 10^{-2} \text{ for } m_{\hat{\rho}(0^{-+})} = 1.6 \text{ GeV} \quad (5)$$

For $m_{\hat{\rho}}$ in the range 1.3 - 1.6 GeV, the dominant decay mode is expected to be $\hat{\rho}(0^{-+}) \rightarrow 3\pi$, with the three pions in relative s–waves.

In conclusion, we find that if $Q\overline{Q}g$ hybrids exist in the mass region below 1.6 - 1.7 GeV, it should be possible to produce them with rates measurable at LEAR in $N\overline{N}$ annihilation at rest. This has the key advantage that one can isolate $L = 0, 1$ processes, and test dynamical selection rules. For larger hybrid masses near 1.9 GeV, as predicted in the flux tube model[8], one must study $N\overline{N}$ annihilation in flight. In this case, we estimate that optimum kinematic matching for the reaction $N\overline{N} \rightarrow \pi + Q\overline{Q}g$ is achieved in the region 1.5 - 2.5 GeV/c of $\bar{p}$ lab momentum.

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