CERN-TH.5319/89

THE MASS OF THE $c\bar{s}$ P STATE

André Martin
CERN -- Geneva

ABSTRACT

A newly-discovered $c\bar{s}$ state is shown to be very well reproduced by an existing potential model.

CERN-TH.5319/89
March 1989

In 1981 I proposed a fit of the $b\bar{b}$, $c\bar{c}$, $s\bar{s}$ and $c\bar{s}$ bound states up to slightly above the dissociation threshold of these states into pairs of mesons with visible flavour, by a power potential [1]

$$V = - 8.064 + 6.870 r^{0.1},$$

where the units are powers of GeV, the separation between 0^- and 1^- states being taken into account by a term

$$V_{ss} = C \frac{\vec{\sigma}_1 \cdot \vec{\sigma}_2}{m_1 m_2} \delta^3(r_1 - r_2),$$

where C is adjusted to fit the $J\psi-\eta_c$ separation. The effective masses of the quarks are $m_s = 0.518$, $m_c = 1.8$ and $m_b = 5.174$ GeV.

The model predicts only the centre of gravity of the $\ell = 1$ and $\ell = 2$ states. The fit is extremely good. The worst case is that of the χ_b states for which the model predicts 9.86 GeV, while experiment gives 9.90 GeV. This is presumably due to the sensitivity of the $\chi_b-\gamma$ separation to the short-distance part of the potential which, in our model, disagrees with QCD. Otherwise, for ψ' , ψ'' , $\psi'''(4030)$, χ_c , η_c , η_c' , γ , γ' , γ'' , γ''' , χ_b' , D_s , D_s^* , ϕ , ϕ' , there is no deviation by more than 20 MeV. In fact, at the time this paper was written, the agreement for the D_s and D_s^* was not so good, since the prediction was 1.99 and 2.11 GeV, while experiments gave 2.02 and 2.14 GeV, but these experiments were wrong and D_s has a mass of about 1.97 GeV, while $D_s^*-D_s$ is slightly larger than 140 MeV [2].

Recently, the ARGUS group at DESY [3] has found a new $c\bar{s}$ state at

$$M = 2536 \text{ MeV},$$

decaying into D^*K^0 . This state is presumably a P state with $J^P = 1^+$ or 2^+ , since $J = 0^+$ is incompatible with parity and angular momentum conservation. We find, without changing any parameter, that the centre of gravity of the P state should be at

$$M = 2532 \text{ MeV}.$$

The agreement between "theory" and experiment looks too good, since the fine structure of the P states is disregarded. However, we do not expect the 1^+2^+ separation to be very large. For $c\bar{c}$ it is 44 MeV and for $c\bar{u}$, if the states recently discovered by ARGUS and CLEO at 2420 and 2459 MeV [4] are precisely 1^+ and 2^+ P states, the separation is of the same order of magnitude and should also be of the same order of magnitude for the $c\bar{s}$ systems. If we take the rather pessimistic view that $R = (1^+-0^+)/(2^+-1^+)$ lies between 0 and 2, we conclude that our prediction is at most 30 MeV away from experiment.

The only problem is why potential models work so well, and this problem has not been answered so far, but, in spite of the criticisms of some of my friends, it is a fact that the potential approach is the one which has the most predictive power in heavy and medium-heavy quark spectroscopy.

I am grateful to Giorgio Bellettini and Mario Greco for their hospitality and for the stimulating atmosphere of the Rencontres de Physique de la Vallée d'Aoste, where this work was initiated.

REFERENCES

- [1] A. Martin, Phys. Lett. 100B (1981) 119.
- [2] Review of Particle Properties, M. Aguilar-Benitez et al., Phys. Lett. 170B (1986) 1.
- [3] H. Schröder, Invited talk at the "Rencontres de Physique de la Vallée d'Aoste" 1989, to appear in the Proceedings.
- [4] R. Morrison, Invited talk at the "Rencontres de Physique de la Vallée d'Aoste" 1989, to appear in the Proceedings.