

Radial 1^{--} Excitations at DAPHNE

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The purpose of this note is to display a likely mass distribution of excited 1^{--} states that are accessible to a high luminosity e^+e^- collider like DAPHNE. Although several of these states were adumbrated some 15 years ago in experiments at ADONE and DCI, they have never been firmly established. The integrated luminosity was insufficient, the detectors were of limited capacity, and the mass systematics based on the Veneziano formula [1] were also regarded as tentative.

Although the 1^{--} states have not been so intensely pursued meanwhile, other data have accumulated on 2^{++} and 0^{++} states as well as strange mesons. These could all be summarized about 7 years ago [2] as supporting a linear dependence of m^2 on radial excitation with a coefficient of about $1.05 - 1.10 \text{ GeV}^2$, very much like the Regge trajectory value fundamental to Ref. [1].

The first comprehensive summary [3] of 1^{--} studies found evidence for φ' , φ'' and φ''' states at $\sim 1.47, 1.82,$ and 2.13 GeV and interpreted the ω -type state seen at 1.78 GeV as ω'' ; the ρ'' was located at $\sim 1.6 \text{ GeV}$, the necessary ρ', ω' were assigned to the $1.25 - 1.35 \text{ GeV}$ region. The chief missing element was any firm information on the location of the 3D_1 states - all the assignments above being excited 3S_1 states. The 3D_1 system was invoked speculatively to help explain the extreme narrowness of the state observed at 1.5 GeV in e^+e^- , which was taken as the ground state of φ_D , with the φ' being at a "lower, but a nearby energy" (arbitrarily called $\sim 1.47 \text{ GeV}$ just above).

Two new facts are now available: a ρ -type meson at $1465 \pm 25 \text{ MeV}$ has been identified [4] in analysis of e^+e^- and photoproduction data; and the $\rho'(1.3)$ seems to be definitely observed [5] in $\pi^+\pi^-$ from the reaction $K^-p \rightarrow \Lambda\pi^+\pi^-$. This makes $\rho(1465)$ an obvious choice as the ground state of the 3D_1 system. To make a complete projection of all 1^{--} states on the $q\bar{q}$ model now requires only 3 assumptions, all plausible by default - *i.e.*, counter arguments are not obvious:

- i) Radial excitations of 3D_1 follow the same spacing as 3S_1 , $\Delta m^2 = 1.05 - 1.10 \text{ GeV}^2$.
- ii) Corresponding ρ and ω states are nearly degenerate for 3D_1 as well as for 3S_1 .
- iii) The Δm^2 between φ and (ω, ρ) for any orbital is roughly constant, $\Delta m^2 \sim 0.5 \text{ GeV}^2$ being a compromise between $\varphi - (\omega, \rho)$ and $f'_2 - (f_2, a_2)$.

The resulting 1^{--} states group together in relatively narrow mass bands ($\pm \sim 20 \text{ MeV}$), as shown in Fig. 1, which is based on a more detailed numerical analysis [6]. The widths shown for the bands reflect mainly the uncertainty of the linear extrapolations in m^2 from the ground states. The chief point of Fig. 1 is to show for which total energies good luminosity beams from DAPHNE would be likely to encompass each succeeding triplet.

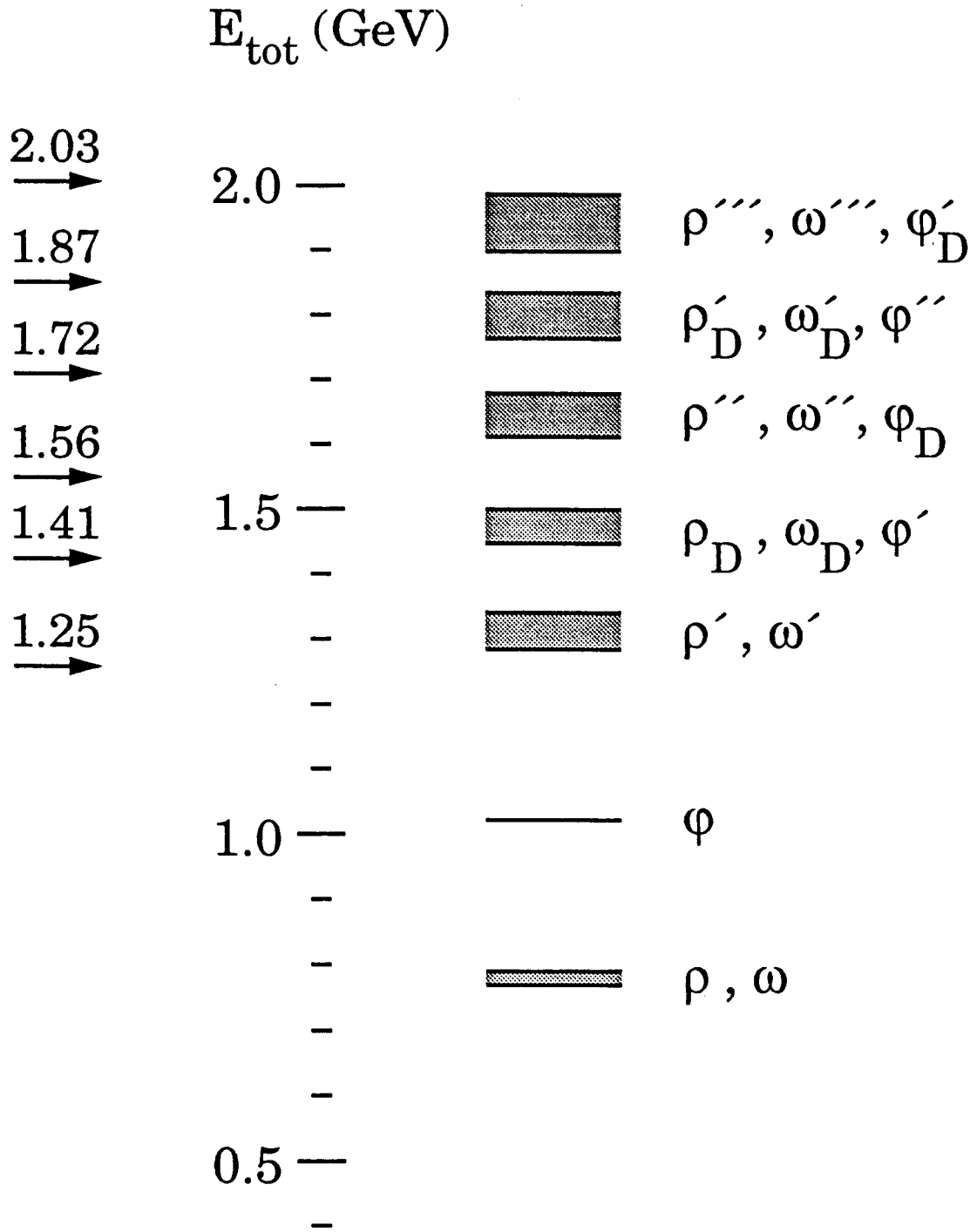


FIG. 1

Starting with the band at ~ 1.5 GeV [7], all the higher excited bands have the same structure: 3 closely spaced levels, one each of φ , ω and ρ type. The ω , ρ have the same orbital in L and n (radial quantum number); the φ has $L' = 2-L$ and $(2n' + L') = (2n + L) - 2\delta_{0L}$. The (ω, ρ) degeneracy is just SU(3) ideal mixing, the additional φ degeneracy is on present understanding accidental. That degeneracy is so close, however, as to hint at an underlying but unrecognized symmetry.

However intriguing the pattern of Fig. 1 may be, it is not really secured by experiment; and the higher the mass range that can be encompassed, the firmer the foundations for further exploration.

References

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