EVIDENCE FOR N^* REGGE TRAJECTORY CLANS WITH APPROXIMATE PARITY DEGENERACY*

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Resonances recently discovered in πN phase-shift analyses are assigned to linear Regge trajectories. The proposed classification is interpreted as evidence for (i) secondary trajectories displaced down from the leading trajectories by $\alpha_S \simeq \alpha_L - n$ (n an integer) and (ii) approximate degeneracy of trajectories with opposite parity, the same signature, and equal isospin (i.e., MacDowell symmetric).

The discovery of nine (or possibly more) new inelastic πN resonances[1,2] in the most recent round of phase-shift analyses is a significant step towards unraveling the recurrence pattern of the $Y=+1$ fermion Regge trajectories. Previously, the πN resonance states which dominated in total cross-section data were classified[3] as recurrences on N_α, Δ_δ, N_γ, and Δ_β Regge trajectories that rise roughly linearly with (mass)^2. The additional states which had cropped up in earlier phase-shift studies and in production experiments were not convincingly assigned to trajectories. In this brief note we point out that now essentially all of the presently known πN resonance states can be assigned to simple recurrence patterns. This classification involves secondary Regge trajectories which are displaced from the leading trajectories by approximately integral multiples of angular momentum. Furthermore, all trajectories in the scheme are approximately MacDowell symmetric; that is, trajectories with equal I (isospin), the same τ (signature), and opposite P (parity) are roughly degenerate.[4]

The proposed classification of the resonances[2] is presented in Fig. 1. 14 of the discovered resonances are paired as MacDowell symmetric states with degenerate masses. As shown,

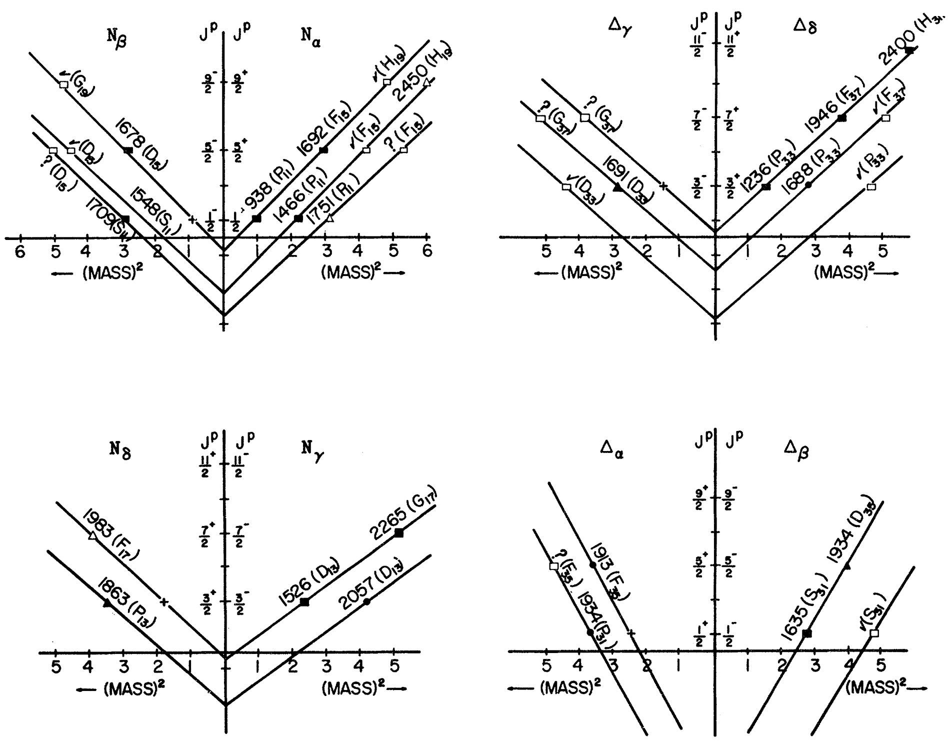

FIG 1. Proposed classification of πN resonances on MacDowell-symmetric Regge trajectories. The notation is an adaptation of the nomenclature of Ref. 1: solid squares, well established resonance; solid circles, probable resonance; solid triangles, resonance interpretation in doubt; open triangles, unconfirmed resonance; checks, indication of increasing absorption in partial wave; open squares, predicted state; plus signs, extinguished state; question marks, no information available.

the MacDowell trajectory pairs are rigorously required to join at the point $M^2=0$. The approximate linearity of the leading N_γ and Δ_δ trajectories is required by assignments of higher mass states,[2] not shown in the figure. The remaining trajectories are drawn in a linear manner only for present convenience in representation. If the low-lying trajectories also rise linearly with $(\text{mass})^2$, then there will be a great multiplicity of resonances in the 2- to 4-BeV mass region. If these lower lying trajectories are in fact associated with the leading trajectories as we have inferred, then all the classified N recurrences in Fig. 1 should have octet SU(3) character and the Δ recurrences, decuplet character.

Thus far, phase-shift studies have given no indication for the states $N_\beta(\sim938, \frac{1}{2}^-)$, $\Delta_\gamma(\sim1236, \frac{3}{2}^-)$, $N_\delta(\sim1520, \frac{3}{2}^+)$, and $\Delta_\alpha(\sim1635, \frac{1}{2}^+)$. These states are the lowest members of the leading trajectories with quantum numbers $J-L=I+1$. The absence of these states would require the corresponding Regge residues to vanish at these spin-mass values.[4] Such constraints on the residues may in turn serve as a useful criteria for the suitability of theoretical models of the underlying dynamics.[5]

The following observations are relevant to the classification scheme of Fig. 1:

(i) The trajectory intercepts at $M^2=0$ are displaced by approximately integral multiples of angular momentum.

(ii) The bulk of the new resonances that were found[1] have low spins and are highly inelastic. Therefore, even if recurrences on secondary trajectories occur at high-mass values, they may still have a negligible influence on phenomenological calculations based on the interference model.[3]

(iii) It is conceivable that some of the missing states in Fig. 1 are so highly inelastic that they can only be observed in production experiments.

(iv) The existence of secondary trajectories for the N^* resonance spectrum leads us also to expect secondary trajectories for the $\gamma\neq1$ baryon resonances and for the meson resonances. In this connection, the $E(1420)$ meson, with a $I=0$, $J^P=0^-$ assignment, may be the first member of a trajectory about one unit of angular momentum down from the $X^0(959,0^-)$ meson trajectory. Similarly, the $\delta(965)$ may be on the first secondary trajectory of the pion. There is already a striking similarity of meson and baryon trajectories in that they seem to have approximately the same slopes.

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[1]C. Lovelace, Rapporteur's talk in Proceedings of the Heidelberg International Conference on High Energy Physics, 1967 (to be published).

[2]The masses of the new resonances, as well as the degree of certainty of existence, are taken from Ref. 1. Evidence for increasing absorption at other masses (suggestive of possible resonance behavior and denoted by check marks in Fig. 1) has been inferred from the phase-shift plots of Ref. 1.

[3]V. Barger and D. Cline, Phys. Rev. Letters 16, 913 (1966), and Phys. Rev. 155, 1792 (1967).

[4]See, for example, V. Barger and D. Cline, "Degenerate Regge Trajectories and Parity Doublets of Baryon Resonances," (to be published). If the suggested interpretation of the N^* resonance spectrum is correct, only an approximate symmetry is to be expected (i.e., the masses of opposite-parity states will not be exactly degenerate).

[5]It should be noted that the proposed theoretical interpretation is not without difficulties. A questionable extrapolation or analytic continuation through zero energy is required. It may also be difficult to explain the vanishing of the residues as required by this model.