RESULTS ON ■(1232) RESONANCE PARAMETERS: A NEW πN PARTIAL WAVE ANALYSIS

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The residue of the $\Delta(1232)$ pole derived from a speed plot for the VPI-GWU solution SP00 differs considerably from the value given by the Particle Data Group. An updated version of KH80 is in preparation.

1 Determination of Resonance Parameters from Speed Plots

The $\Delta(1232)$ can be treated as a resonance in the elastic region. Then the *speed* is defined by (W=total energy in the c.m. frame, $s = W^2$)

$$SP(W) = |dT(W)/dW|, \qquad T(W) = \frac{1}{2i}[exp(2i\delta(W) - 1]. \tag{1}$$

$T(W)$ is the dimensionless P33 partial wave amplitude and $\delta(W)$ its phase.

It is 'noncontroversial among theorists' (see Chew[1] and the references in my 'pole-emics', p.697 in Ref.[2] that in S-matrix theory the effects of resonances follow from first order poles in the 2nd sheet. Following many other authors, we consider the pole in the W-plane nearest to the physical real axis.

The resonant parts of $T(W)$ and of $\delta(W)$ are

$$T_R(W) = \frac{\Gamma/2}{M - W - i\Gamma/2}, \qquad \tan\delta_R(W) = \frac{\Gamma/2}{M - W}. \tag{2}$$

It follows for the speed of the resonant part of the P33 amplitude

$$SP(M) \equiv H = 2/\Gamma, \qquad SP(M \pm \Gamma/2) = H/2. \tag{3}$$

Fig.1 shows $SP(W)$ from the VPI-GWU solution SP00. The height H and the mass M are well defined, whereas the speed at half height shows a small asymmetry due to the background,

$$M = 1210.8\,MeV, \quad H = 20.2\,GeV^{-1}, \quad \Gamma = 99\,MeV. \tag{4}$$

A comparison with the table of the PDG (p.725 in Ref.[2]) shows an agreement with all earlier determinations of M and Γ. But we obtain $\Gamma/2 = 49.5\,MeV$ for the residue, whereas the value in Ref.[2] is $38\,MeV$. This is not due to a difference of the P33 phases but to the new method used in the determination from SM95. Our value for the residue is in reasonable agreement with the values derived from SM90, KH80 and CMB80.

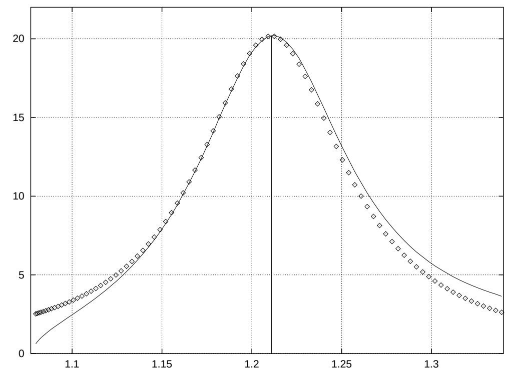

Figure 1. Speedplot for the Resonance $\Delta(1232)$. Solid line: from SP00, dots: from Eq.(2) using Eq.(4).

Fig.1 shows that $SP(W)$ calculated from the P33 phase (SP00) at $W = M \pm \Gamma/2$ almost agrees with the speed calculated from the resonant part of P33 alone. This confirms our result in Eq.(4). Next the background will be discussed [a].

2 The Background in the P33 Partial Wave

2.1 Contribution of the background to the phase

In the elastic region the background can be described by its phase

$$\delta_B(W) = \delta(W) - \delta_R(W). \tag{5}$$

At $W = M$ we have $\delta_R = 90°$ whereas the total P33 phase δ is much smaller: $\delta = 66°$, so $\delta_B = -24°$. Fig. 2 (left panel) shows that the W-dependence of δ_B is almost negligible in the range $W = M \pm \Gamma/2$.

If the background is taken into account, the T-matrix element for elastic scattering can be written

$$T(W) = T_B(W) + T_R(W)\exp(i\phi(W)), \quad T_B(W) = \sin(\delta_B)\exp(i\delta_B). \tag{6}$$

Elastic unitarity demands that $\phi(W) = 2\,\delta_B(W)$. The residue of the pole term is now complex-valued. Our calculation gives $\phi(M) = -48°$. A determination of ϕ from an *Argand plot of the speed vector dT/dW* gives the same result[4]. Again we find a

[a] see Ref.[6] for details and further references

large discrepancy with the value of the PDG[2] from SM95 $\phi = -22^\circ$ and also with the value from SM90, but agreement with KH80 and CMB80.

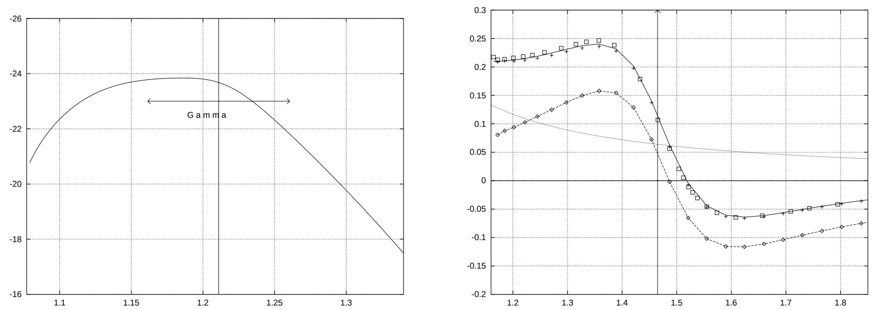

Figure 2. Left: Background phase in degrees vs. W in GeV. Right: Contributions to $ReT/q^3 * m_\pi^{-3}$ vs. s in (GeV^2).

Upper solid line: from SP00 (nearby squares from KA85), nearby circles from the r.h. side of Eq.(7). Background $L(s)$: decreasing line, solid line with circles: dispersion integral, evaluated with $ImT(SP00)$.

2.2 *The dispersion relation for the P33 partial wave*

The dispersion relation was studied in great detail by J. Hamilton et al. who showed that an approximation led to a *relativistic Chew-Low plot*[3]. An improved version was evaluated by R. Koch et al.[7,8], using KH80 and t-channel partial waves of our group[5] as input.

The relation is written for the *reduced amplitude* $F(s) = T(s)/q^3$ in order to suppress the contributions of distant sigularities in the s-plane which are neglected in our simplified calculation

$$ReF(s) = L(s) + \frac{1}{\pi}\int_{sth}^{\infty} \frac{ImF(s')}{s'-s} ds' \ . \qquad (7)$$

According to table 2 in Ref.[8], the dominant contributions to $L(s)$ come from the u-channel nucleon Born term (Chew-Low) and the t-channel S-wave. The sum can be approximated by an effective pole (m=nucleon mass)

$$L(s) = \frac{0.037}{s-m^2} \quad \text{units: } m_\pi^{-3}, s \text{ in } GeV^2 \qquad (8)$$

An accurate evaluation has recently been made by J. Stahov.

3 An Updated Version of the KH80 Partial Wave Analysis

Since fixed-t analyticity can be proven within the framework of QCD [9], *it is necessary to include this constraint in* πN *partial wave analysis*. Using the main part of a version of E. Pietarinen's program rewritten for a PC in 1992, H.M. Staudenmaier, C. Hansch and G. H. have produced a program which is running on our workstation alpha, including the graphics and a new data base. Since KH80 has a problem with new spin-rotation data [11], our earlier study of the zero trajectories has been taken up again, taking into account the important papers by I.S. Stefanescu. They include consequences of two-variable analyticity and questions of uniqueness and stability (see [10] for a review). - We hope that the test runs can be finished in 2001.

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