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GENERALIZED VENEZIANO MODEL

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ON THE NATURE OF DYNAMICAL SUPPRESSIONS IN THE
GENERALIZED VENEZIANO MODEL^{*}

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ABSTRACT

It is shown by explicit numerical calculations that of a class of coupling suppressions existing in the Generalized Veneziano Model, which have been recently used to interpret the ψ data and other related phenomena, only a part can be attributed to the exponential growth with energy of the number of levels in the model. The remaining suppressions have a more direct dual origin.

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In a recent paper^{1/} a dual model origin has been proposed for the suppression effects affecting strong interactions and responsible, among other things, for the ψ narrow widths and for the observed copious production of "prompt" leptons. In a duality bootstrap, indeed, the constraints (as many as the amplitudes) systematically outnumber the available vertex couplings. Consistency can be achieved by having a relatively large fraction of couplings to vanish, which fact allows the evasion of a much larger number of duality constraints^{1/}.

This type of suppression mechanism for strong interactions receives explicit phenomenological backing from the analysis of the connection between linear zero regularities (related to duality) and observed dynamical suppressions affecting conventional resonances^{2/}. Its existence in the Generalized Veneziano Model (GVM) was remarked by Gliozzi^{3/}, who was able to identify a whole class of GVM decouplings, affecting essentially the smaller multiplicity decay modes and the lower angular momentum resonances. It was this GVM property which was actually used in ref.1 to interpret the ψ data and other related suppression phenomena.

In ref.3 the view was expressed that the GVM decouplings in question are intimately connected with the exponential growth with energy of the GVM number of levels. For large enough s , in fact, the latter systematically outnumber the GVM states of any finite system of decay particles, the number of which can increase no more than polynomially with s .

Purpose of this note is to show that, as a matter of fact, only a relatively small part of GVM decouplings can be explained in this way, and that most of them are to be regarded as representing an independent dynamical feature of the model and a direct consequence of the duality constraints. For this sake, the numbers of GVM levels and that of the possible GVM states with k (lightest scalar) particles are explicitly calculated, for each angular momentum J , as functions of s . The excess of one over the other (when it occurs) is then compared with the actual number of decouplings existing in the model, according to the rules of ref. 3.

First of all, some rectifications of the results of ref. 3 are in order. The rule for the decoupling of levels, as given in eq.6^{3/}, actually does combine resonance levels with different masses, and therefore it is not fully correct. One can construct resonance levels, with a well defined $\alpha(s)=N$, which decouple from k , or less, particle states by putting in eq.6^{3/}

$$(\beta_k)_{j\ell} = b_{\mu_\ell}^{(i_j + h_\ell)} \quad (1a)$$

with $j, \ell = 1, 2, \dots, k$ (not $k-1$), and

$$\sum_{j=1}^k (i_j + h_j) = N \quad (2a)$$

(when not otherwise specified, notations are as in ref.3). One can verify, in fact, that substituting $b_{\mu}^{(i)} \rightarrow p_{\mu}^{(i)}$,

one gets

$$\det(\beta_k) \rightarrow \sum_{\ell=1}^k p_{0\mu_\ell} M_\ell \quad (2)$$

where the M_ℓ 's are polynomial determinants of the same type as those constructed by Gliozzi^{3/}, and which do therefore vanish.

Working in the resonance rest frame, the time components of the $b_\mu^{(i)}$'s should be disregarded. Within GVM this corresponds to the holding of appropriate Ward-like identities. Therefore, the expression for $n_0(k)$, the minimal N at which there appear resonances decoupled from k particle states, becomes

$$\begin{aligned} n_0(k) &= 6p^2 + 4pq + \frac{1}{2}q(q+1) \approx 2/3 k^2 \\ k &= 3p + q, \quad q < 3 \end{aligned} \quad (3)$$

As to the number of k particle states, in order to avoid multiple counting one has to take into account that i) all configurations differing only by a permutation of the $p_{i\mu}$'s (together with the associated variables x_i 's), for $i = 1, \dots, k-2$, should be counted as one, because of the symmetry of the $p_\mu^{(i)}$'s with respect to these variables, ii) in the angular momentum analysis of the states, contractions of $p_{i\mu}$'s having the same index i should be disregarded, because leading to configurations identical to those already counted for lower m_i 's^{3/}. As a result of these restrictions, and because of the neglect of time components, the growth with s of the total number of k particle states (including the total magnetic quantum number dependence) is then $\sim s^{3k-4}$.

With the above criteria in mind, the countings of the GVM levels having given values of J and N and of the corresponding k particle states have been performed. GVM levels have been counted exactly only up to $N = 50^{4/}$. Beyond this value, the approximate formulas of Huang and Weinberg^{5/} for the total number of levels, and of Chiu, Heimann and Schwimmer^{6/} for the angular momentum distribution have been used. For $J = 1$ and $N = 50$ the resulting approximation is found to differ from the exact value by 25% only. For simplicity, numerical results are presented only for $J = 1$, this value having of course being chosen because of its relevance in e^+e^- annihilation. The results shown, however, are typical also of the other J 's. As it appears from fig.1, the values of N at which GVM levels begin to outnumber the available GVM k particle states happen to be considerably higher than those marking the appearance of levels decoupled from these states. That is, the number of decouplings implied by eq.1 is actually much higher than what is simply required by the "excess" argument advanced in ref.3.

Before ending, I would like to stress that there are no reasons to regard the decouplings described by the determinant rule of eq.1 as the only ones present in GVM. A comprehensive study of these effects could be in principle done by using the known form of the triple Reggeon vertex^{7/}. Such an analysis, though, is hindered by the ambiguities which exist in the choice

of a vector basis in a space of states having all the same quantum numbers, and which are distinguishable among themselves only because of their different couplings. Suppose, e.g., that two such states happen to have finite but equal couplings to a given coherent state. Their difference, which from all points of view can be equally interpreted as a resonance state, does of course decouple from the state in question. Thus, a simple change of basis in this family of GVM states can bring to rather drastic modifications in the physical interpretation.

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Going up to $N = 60$ would have required about ten times as much.
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FIGURE CAPTIONS

1. Numbers of GVM levels and of GVM k particle states with angular momentum $J = 1$, as functions of $\sqrt{N}$ ($=\sqrt{\alpha(s)} \approx \sqrt{\alpha' s}$). Curves interpolate integer N values. The black dot on each k curve marks the $\sqrt{N}$ threshold for the appearance of levels decoupled from k or less particle states, according to the determinant rule of eq.1.

GVM (J = 1)

K-BODY STATES

RESONANCES

————

K=6

K=5

K=4

K=3

K=2

10^{10}

10^5

10^0

1

2

3

4

5

6

7

8

9

10

$\sqrt{N} \ (\approx \sqrt{\alpha' s})$