The Relationship between Hadron-Hadron Multiparticle Production and $e^+e^-/\bar{p}p$ Annihilation.

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Summary. Two models of multiparticle production are discussed: that with two-quark jets and that with three components one of which is the three-fireball term. Multiplicity sum rules for the latter are derived.

The data of Basile et al. (1) on multiparticle production in pp inelastic interaction have shown that, after removal of the leading protons, the remnants exhibit close similarities to the data from $e^+e^-$ annihilation at the corresponding (reduced) $s$-value. This somewhat surprising result has recently been explained in a simple manner by Bardadin-Otwinowska, Szekowski and Wroblewski (2). These authors assume that in nondiffractive interactions all the particles produced in $h'h$, $v'h$, $e^+e^-$ annihilation originate from two-quark (diquark) jets. In $e^+e^-$ annihilation one has a quark jet together with an antiquark jet. In $h'h$ interactions, such as $\pi^+p$, one has an interaction triggered by the (two) wee quarks (antiquarks) with the release of a quark (antiquark) jet from the incoming meson and a diquark jet from the incoming baryon. In $\nu\bar{\nu}$ interactions the incoming $\nu$ knocks out a quark—producing a quark jet—and releases a diquark jet.

An immediate consequence of this picture is that the average multiplicities in all these interactions can be expressed in terms of average quark (antiquark) and/or diquark jets, as follows:

\[
\begin{align*}
\langle n \rangle_{e^+e^-} &= 2\langle n_q \rangle, \\
\langle n \rangle_{ND} &= 2\langle n_{qq} \rangle, \\
\langle n \rangle_{\pi p}^{\text{ND}} &= \langle n_{qq} \rangle + \langle n_q \rangle, \\
\langle n \rangle_{\nu p} &= \langle n_{qq} \rangle + \langle n_q \rangle.
\end{align*}
\]

(1)


By eliminating the quark and diquark jet multiplicities Bardadin-Otwinowska et al. obtain

\begin{equation}
\langle n \rangle_{e^+e^-} = \langle n \rangle_{\pi p}^{\text{ND}} + \langle n \rangle_{\pi p}^{\text{ND}} - \langle n \rangle_{\pi p}^{\text{ND}}
\end{equation}

and

\begin{equation}
\langle n \rangle_{\nu p} = \langle n \rangle_{\pi p}^{\text{ND}}, \quad \langle n \rangle_{\nu p} = \langle n \rangle_{\pi p}^{\text{ND}}.
\end{equation}

Equations (2) and (3) when compared with experimental data are well satisfied (2). In this jet model the results of Basile et al. is simply attributed to the two-jet structure common both to the e+e− annihilation and to the other processes considered.

There exists, however, another interpretation of the results of Basile et al. based upon the three-component model of h′h′ interactions (3). The three components of this model are (in the simplest identification) i) an annihilation term (when it exists), ii) the total-diffraction interactions (TD) including the elastic interaction, and iii) the nondiffractive (ND) interactions. We restrict ourselves to this last component—the three-fireball term (see fig. 1)—in this 3 FB term the main particle production occurs

![Fig. 1. – The three-fire-ball diagram (ND interactions).](image)

in the central fireball which is nothing other than a (generalized) annihilation process. The leading fireballs (often simple outgoing leading particles) are the same as those of the diffractive events and can hence be independently studied. In such a model it becomes obvious that, if one can identify and eliminate the leading fireballs (which carry away the major part of the incoming energy, but contribute in general a minor part to the outgoing multiplicity), then what remains should show the characteristic properties of annihilation data. This central fireball = annihilation hypothesis has the notable virtue of having been proposed and published before the advent of the data of Basile et al. However, in applications (4) the annihilation data used was that of pp annihilation and not e+e− annihilation. Such a choice is justified by the fact that the central fireball is a strong-interaction process, possibly gluon annihilation or Regge-pole annihilation, while e+e− annihilation requires precise s-channel quantum numbers which is not the case for strong annihilation. Nevertheless, there are striking similarities between the data on e+e− annihilation and pp annihilation foremost of which is the characteristic (narrow) annihilation KNO plot of \( \langle n \rangle P_n \) vs. \( n/\langle n \rangle \), which we reproduce (4) in fig. 2.