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(SUMMARIES AND CONTRIBUTIONS)

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e^+e^- ANNIHILATION INTO HADRONS

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A number of questions raised by the recent experimental results are examined:

1) The problem of the self-damping of $\sigma_h = \sigma(e^+e^- \to \text{hadrons})$ through the strong vacuum polarization produced by itself [1]. Dominance of the one-photon channel (i.e. one photon including vacuum polarization corrections) is assumed and accepted as valid at least until the corrections from vacuum polarization become as big as ~30% or so. The imaginary part of vacuum polarization

$$\mathrm{Im}\,\Pi(s) = \frac{\alpha}{3} R(s) = \frac{\alpha}{3} \frac{\sigma_h(s)}{\sigma_{\mu\mu}(s)} , \qquad (1)$$

where σ_h is $\sigma(e^+e^- \to \text{hadrons})$ and $\sigma_{\mu\mu}$ is $\sigma(e^+e^- \to \mu^+\mu^-)$ is supposed to behave as cs^β where β is <1 to ensure convergence of the usual once-subtracted dispersion relation for $\Pi(s)$ (i.e. we assume that no new re-normalization constants are necessary to calculate, for instance, the vacuum polarization corrections to g-2). The ratio σ_h/σ_p where σ_p is the conventional point-like cross-section,

$$\sigma_p = \frac{4\pi\alpha^2}{3s}$$

shows a maximum whose value depends only on the exponent β

$$\left(\frac{\sigma_h}{\sigma_p}\right)_{max} = -\frac{3}{8\alpha} \mathrm{tg}\,(\pi\beta) . \qquad (2)$$

At the maximum

$$\left(\frac{\sigma_h}{\sigma_p}\right)_{max} = \frac{1}{2} R(s_{max}) .$$

For instance, for $\beta = 0.95$ the maximum in Eq.(2) is of 8.1 and is expected to occur at $\sqrt{s} \cong 8 \div 9$ GeV; for $\beta = 0.9$ it is of 16.7 at $\sqrt{s} \cong 12 \div 14$ GeV; for $\beta = 0.8$ it is of 37.3 and at $\sqrt{s} \cong 22 \div 24$ GeV . The strong vacuum polarization will bring deviations from scaling in deep inelastic scattering (for instance, for $\beta = 0.9$ one expects + 15% deviations in the ratio

)?

$$\frac{F_2(\omega, Q^2)}{F_2(\omega, Q'^2)}$$

for $Q'^2 = 5\ \mathrm{GeV}^2$, $Q^2 = 50\ \mathrm{GeV}^2$. (The deviations expected in asymptotic free theories are known to be ω-dependent and of opposite sign [2].)

2) The superconvergence relation

$$\int ds\ \mathrm{Im}\left[\Pi(s) - \Pi_R(s)\right] = 0 ,$$

where asymptotically $\mathrm{Im}\Pi(s) \to \mathrm{Im}\Pi_R(s)$ is considered and applied for $\mathrm{Im}\Pi_R(s) = \frac{\alpha}{3} cs^{\beta}$. From calculation of the low-energy resonance contributions and an assumed constant behaviour of $R(s)$ in the less known intermediate region after $(1\ \mathrm{GeV})^2$ and before the s^{β} rise one finds fits such as $R(s) = 2(\sqrt{s})^{0.65}$.

3) A phenomenological classification of sub-asymptotic contributions is given in terms of the singular behaviour for $\omega \to 0$ of such terms. Three extreme models leading to linear rise of $R(s)$, constant addition to R ,[3] and approach from below to constant R , are discussed and multiplicity bounds derived.

The massive quark model [4] is examined in the frame of such classification. The sub-asymptotics of the parton model is calculated under plausible assumptions and shown to disagree with data unless the average transverse momentum $\langle p_T \rangle$ in the parton disintegration is unreasonably high (at least $\langle p_T \rangle \sim 0.8$ GeV).

4) An argument is given showing directly through use of a sum rule related to the commutator

$$[[H, Q_i^{em}], j_i^{em}(0)]$$

that a strong long-range interaction among partons is needed to fit the data.

5) A brief review of existing models is given:

Calculations based on the work by Chanowitz, Ellis and Crewther (Terazawa, Etim, Greco, etc.)
Pati-Salam model with exotic current
Budini's theory of compound Yang-Mills fields
Renormalization group (Kogut's considerations)
Richter's idea (Greenberg-Yodh, Nanopoulos-Vlassopolous)
Infinite parton model (Raitio, Hangoh, Cabibbo-Karl)
Statistical and thermodynamical models (Engels, Schilling, Satz)
Virtual baryons (Di Giacomo)
Cragie-Rothe: cascade model
Amati-Fubini: ideas of scaling
Model of Moffat et al.
Renard's and Bramon, Etim, Greco models
The calculation of Ferro-Fontan and Rubinstein
Spin-1 charged partons (Cleymans-Komen, Fritzsch-Minkowski).

REFERENCES

1) R. Gatto (to appear in Phys. Letters).
2) D. Gross (to be published).
3) J. Polkinghorne (to appear in Phys. Letters).
4) R. Gatto and G. Preparata (CERN preprint, March 1972).