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SUM RULES FOR MESON AND BARYON PRODUCTION IN THE QUARK RECOMBINATION MODEL

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A quark-recombination model with quark distributions according to a generalized Kuti–Weisskopf model is used. Mesons are formed by v-s (valence-sea) and s–s recombination, baryons by vvv, vvs, vss and sss recombination. Sum rules for energy momentum conservation, baryon number, valence and sea quarks are shown to constrain the recombination parameters of the model significantly. The resulting model is consistent with experimental data. While the sss recombination into baryons is found to be quite normal we find a strong enhancement of ss recombination into mesons. This enhanced ss term represents in the model the central meson production via gluons.

1. *Introduction*

Phenomenological models for low $p_\perp$ particle production based in the quark parton model have recently been shown to predict many details. In contrast to hard collision processes, where the parton model can be understood from Quantum Chromodynamics, the gauge field theory of quarks and gluons, there are at present no QCD predictions for particle production in soft processes.

The longitudinal momentum distribution of protons in the fragmentation region of p–p collisions was first interpreted by Van Hove and Pokorski [1] as due to the recombination of three valence quarks of the original proton. The relevance of quark-partons for particle production in the fragmentation region was discussed repeatedly [2, 3]. Das and Hwa [4] explained the production of mesons in the fragmentation region of p-p collisions as due to the recombination of quarks. The model in this formulation was applied to baryon production by Ranft [5]. De Grand and Miettinen [6] did formulate the model using quark and multiquark distributions according to a Kuti–Weisskopf model [7]. Duke and Taylor [8] compared the model to meson production. They were able to understand particle production ratios like π^+/π^- and K^+/K^- also in the central region by using "enhanced" sea quark distributions.

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These enhanced sea quark distributions represent in the quark recombination model the gluon component of the incoming hadrons. During the long time scale characteristic for soft hadronic collisions, it is assumed that gluons will fluctuate into quark antiquark pairs with momentum distributions equivalent to the sea quark distributions and participate thus in the hadron production via the recombination mechanism.

The model as used here [9] has not been fully described. The details given in [10], [11] and [12] allow however to reproduce the calculation of single and multiple quark distributions needed in the present paper. The single and multiple quark distributions are used as given by a generalized Kuti–Weisskopf model which has been fitted to deep inelastic structure functions and which gives sea quark distributions much steeper than in the original Kuti–Weisskopf model. The strange sea distribution differs in normalization and shape from the nonstange sea.

In Section 2 the quark recombination model as used here will be defined. In Section 3 we formulate sum rules for energy momentum conservation, baryon number, valence quarks and sea quarks. In Section 4 the recombination parameters are determined. In Section 5 we compare the baryon production with experimental data. Section 6 gives a Summary.

2. *Formulation of the quark recombination model for meson and baryon production from incoming baryons*

Following [9] we use single and multiple quark distributions according to a generalized Kuti–Weisskopf model (see also [10] and [12]). For the quark distributions of a proton we use the notation:

Single quark and antiquark distributions

$$\frac{1}{x_i} q_i(x_i); \qquad \frac{1}{x_{\bar{j}}} q_{\bar{j}}(x_{\bar{j}}) \tag{1}$$

i might be a valence (u_{v1}, u_{v2}, d_v) or sea (u_s, d_s, s_s) quark and $\bar{j}$ is an antiquark ($\bar{u}_s$, $\bar{d}_s$, $\bar{s}_s$).

Quark-antiquark distribution

$$\frac{1}{x_i x_{\bar{j}}} q_{i\bar{j}}(x_i, x_{\bar{j}}). \tag{2}$$

Three quark distribution

$$\frac{1}{x_i x_j x_k} q_{ijk}(x_i, x_j, x_k). \tag{3}$$

These quark distributions fulfil the usual inclusive sum rules. We mention only the momentum sum rule:

$$\int q_i(x_i) dx_i = K_i(i), \qquad \sum_{l=i,\bar{j},g} K(l) = 1. \tag{4}$$

The valence quarks are normalized according to

$$\int \frac{1}{x_{iv}} q_{iv}(x_{iv}) dx_{iv} = 1. \tag{5}$$

With a suitable low x cut-off we introduce also sea quark multiplicities

$$\int_{m/\sqrt{s}}^{1} \frac{1}{x_{is}} q_{is}(x_{is}) dx_{is} = n(i_s). \tag{6}$$

Following [4] and [5] we write the quark recombination into mesons and baryons as follows:

The distribution of a meson formed out of the valence quark i and the sea antiquark $\bar{j}$:

$$M_{i,\bar{j}}^{vs}(x) = \beta_{vs} \int \frac{dx_i}{x_i} \frac{dx_{\bar{j}}}{x_j} q_{i,\bar{j}}(x_i, x_{\bar{j}}) R_2(x_i, x_{\bar{j}}, x). \tag{7}$$

The distribution of a meson formed out of the sea quark i and the sea antiquark $\bar{j}$:

$$M_{i,\bar{j}}^{ss}(x) = \beta_{ss} \int \frac{dx_i}{x_i} \frac{dx_{\bar{j}}}{x_{\bar{j}}} q_{i,\bar{j}}(x_i, x_{\bar{j}}) R_2(x_i, x_{\bar{j}}, x). \tag{8}$$

The distribution of a baryon formed out of the three valence quarks i, j, k:

$$B_{ijk}^{vvv}(x) = \beta_{vvv} \int \frac{dx_i}{x_i} \frac{dx_j}{x_j} \frac{dx_k}{x_k} q_{ijk}(x_i, x_j, x_k) R_3(x_i, x_j, x_k, x) \tag{9}$$

and similar terms for B^{vvs}, B^{vss} and B^{sss} the recombination of baryons out of 2 valence, one sea, or one valence, two sea or three sea quarks. The recombination parameters β_{vs}, β_{ss}, β_{vvv}, β_{vvs}, β_{vss} and β_{sss} are at this stage free parameters, they are to be determined later from experiment and the sum rules. Following [4] we use the 2 quark recombination function R_2 in the following form:

$$R_2(\xi_i, \xi_{\bar{j}}) = \alpha_2 \xi_i \xi_{\bar{j}} \delta(\xi_i + \xi_{\bar{j}} - 1), \tag{10}$$

where $\xi_i = x_i/x$ and α_2 follows from the normalization

$$\int_0^1 d\xi_i \int_0^{1-\xi_i} d\xi_{\bar{j}} R(\xi_i, \xi_{\bar{j}}) = 1. \tag{11}$$

Following [5] we use the three quark recombination function R_3 in the form:

$$R_3^{(n)}(\xi_i, \xi_j, \xi_k) = \alpha_3^{(n)} \xi_i^n \xi_j^n \xi_k^n \delta(\xi_i + \xi_j + \xi_k - 1), \tag{12}$$

where again the parameters $\alpha_3^{(n)}$ follow from the normalization: $\alpha_3^{(1)} = 120$, $\alpha_3^{(2)} = 5040$. As found in [5] the actual power n used in the three quark recombination function is rather unimportant for the shape of the obtained baryon distribution.

Introducing the recombination functions (10) and (12) into the expressions (7) to (9) we obtain the meson distributions in the form

$$M^{\mathrm{vs}}_{i\bar{j}}(x) = \beta_{\mathrm{vs}}\alpha_2 \frac{1}{x}\int_0^x dx_i q_{i\bar{j}}(x_i, x-x_i) \tag{13}$$

and the baryon distributions in the form

$$B^{\mathrm{vvv}}_{ijk}(x) = \beta_{\mathrm{vvv}}\alpha_3^{(n)} \frac{1}{x^{(3n-1)}}\int_0^x dx_i \int_0^{x-x_i} dx_j x_i^{n-1} x_j^{n-1}(x-x_i-x_j)^{n-1} q_{ijk}(x_i, x_j, x-x_i-x_j). \tag{14}$$

From the hadron distributions like (13) and (14) we determine hadron multiplicities like

$$n^{\mathrm{vs}}(i, \bar{j}) = \int_{m/\sqrt{s}}^{1} \frac{dx}{x} M^{\mathrm{vs}}_{i\bar{j}}(x), \tag{15}$$

$$n^{\mathrm{vvv}}(i, j, k) = \int_{m/\sqrt{s}}^{1} \frac{dx}{x} B^{\mathrm{vvv}}_{ijk}(x), \tag{16}$$

where m in the low x cut off is a suitable hadron mass.

We define furthermore hadron inelasticities (momentum fractions carried away by one kind of hadrons)

$$K^{\mathrm{vs}}(i, \bar{j}) = \int_0^1 dx M^{\mathrm{vs}}_{i\bar{j}}(x) \tag{17}$$

$$K^{\mathrm{vvv}}(i, j, k) = \int_0^1 dx B^{\mathrm{vvv}}_{ijk}(x) \tag{18}$$

and similar for the ss, vvs and sss terms.

In order to calculate the actual hadron or hadron resonance distributions we assume for instance that a $(i, \bar{j})$ meson belongs with probability α to the pseudoscalar nonet and with the probability $(1-\alpha)$ to the vector nonet. For baryon production we take the octet and decuplet baryons into account. If the interest is in distributions of stable mesons or baryons the decay of all relevant resonances has to be considered. We do not describe these problems in more detail here.

All hadron distributions defined above refer to one (target or projectile) fragmentation region only. To calculate the inclusive hadron distributions in hadron-hadron collisions the contributions from the two fragmentation regions have to be added. We neglect here the recombination of valence quarks belonging to different incoming hadrons. This term is not important at high energy where we are mostly interested. Furthermore we set the s–s–s recombination into baryons equal to the $\bar{s}$–$\bar{s}$–$\bar{s}$ recombination into antibaryons neglecting terms like vss+vvs+$\overline{\text{sss}}$ which are even less important than the small sss+$\overline{\text{sss}}$ term.

3. Sum rules

The following sum rules are used as constraints in determining the recombination parameters β_{vs}, β_{ss}, β_{vvv}, β_{vvs}, β_{vss} and β_{sss}.

3.1. Baryon number conservation

All explicit expressions given in this paper refer to the proton fragmentation region. We assume the production of baryons by sea-sea-sea recombination to be equal to the production of antibaryons by sea-sea-sea recombination of three antiquarks. Therefore only the vvv, vvs and vss terms appear in the baryon number sum rule.

TABLE I

Definition of hadron multiplicity sums, calculated with $\beta_{i\bar{j}} = 1$ and $\beta_{ijk} = 1$

$$n^{vs}(i_v) = \sum_{j_s'} n^{vs}(i_v, \bar{j}_s; \beta_{vs} = 1)$$

$$n^{vs}(\bar{j}_s) = \sum_{i_v} n^{vs}(i_v, \bar{j}_s; \beta_{vs} = 1)$$

$$n^{ss}(i_s) = \sum_{\bar{j}^s} n^{ss}(i_s, \bar{j}_s, \beta_{ss} = 1)$$

$$n^{ss}(\bar{j}_s) = \sum_{i_s} n^{ss}(i_s, \bar{j}_s; \beta_{ss} = 1)$$

$$n^{vvv} = n(u_{v_1}, u_{v_2}, d_v; \beta_{vvv} = 1)$$

$$n^{vvs}(i_v) = \sum_{j_v \neq i_v} \sum_{k_s} n^{vvs}(i_v, j_v, k_s; \beta_{vvs} = 1)$$

$$n^{vvs}(k_s) = \tfrac{1}{2} \sum_{i_v} \sum_{j_v \neq i_v} n^{vvs}(i_v, j_v, k_s; \beta_{vvs} = 1)$$

$$n^{vss'}(i_v) = \sum_{k_s} \sum_{j_s \neq k_s} n^{vss}(i_v, j_s, k_s; \beta_{vss} = 1)$$

$$n^{vss'}(j_s) = \tfrac{1}{2} \sum_{i_v} \sum_{k_s \neq j_s} n^{vss}(i_v, j_s, k_s; \beta_{vss} = 1)$$

$$n^{vss}(i_v) = \sum_{j_s} n^{vss}(i_v, j_s, j_s; \beta_{vss} = 1)$$

$$n^{vss}(j_s) = 2 \sum_{i_v} n^{vss}(i_v, j_s, j_s; \beta_{vss} = 1)$$

$$n^{ss's''}(i_s) = \tfrac{1}{2} \sum_{j_s \neq i_s} \sum_{\substack{k_s \neq i_s \\ k_s \neq j_s}} n^{sss}(i_s, j_s, k_s; \beta_{sss} = 1)$$

$$n^{ss's'}(i_s) = \sum_{j_s \neq i_s} n^{sss}(i_s, j_s, j_s; \beta_{sss} = 1)$$

$$n'^{ss's'}(j_s) = 2 \sum_{i_s \neq j_s} n(i_s, j_s, j_s; \beta_{sss} = 1)$$

$$n^{sss}(i_s) = 3n(i_s, i_s, i_s; \beta_{sss} = 1)$$

We use in the following expressions hadron multiplicity sums as defined in Table I. In calculating these multiplicity sums all the recombination parameters β are set equal to $\beta = 1$. Therefore the β parameters appear explicitely as factors in the sum rules. The baryon number sum rule is

$$\beta_{vvv} n^{vvv} + \beta_{vvs} \sum_{j_s} n^{vvs}(j_s) + \beta_{vss}[\sum_{i_v} n^{vss'}(i_v) + \sum_{i_v} n^{vss}(i_v)] = 1. \tag{19}$$

3.2. Valence quark sum rule

These sum rules express the demand, that the produced hadrons contain the same number of valence quarks of each flavour as the original hadron. We write for the i_v quark (it is $i_v = u_{v1}, u_{v2}$ or d_v)

$$\beta_{vs} n^{vs}(i_v) + \beta_{vvv} n^{vvv} + \beta_{vvs} n^{vvs}(i_v) + \beta_{vss}[n^{vss'}(i_v) + n^{vss}(i_v)] = 1. \tag{20}$$

3.3. Sea quark sum rule

We demand the number of sea quarks used for recombination into hadrons to be equal to the number of sea antiquarks used for recombination into hadrons. In order to formulate this sum rule, we first write sum rules for the sea quarks and sea antiquarks used in the quark recombination into hadrons.

Sea quarks ($i_s = u_s, d_s$ or s_s):

$$\begin{aligned} &\beta_{ss} n^{ss}(i_s) + \beta_{vvs} n^{vvs}(i_s) + \beta_{vss}[n^{vss'}(i_s) + n^{vss}(i_s)] \\ &+ \beta_{sss}[n^{ss's''}(i_s) + n'^{ss's'}(i_s) + n^{ss's'}(i_s) + n^{sss}(i_s)] = n(i_s) \end{aligned} \tag{21}$$

Sea antiquarks ($\bar{i}_s = \bar{u}_s, \bar{d}_s, \bar{s}_s$)

$$\beta_{vs} n^{vs}(\bar{i}_s) + \beta_{ss} n^{ss}(\bar{i}_s) + \beta_{sss}[n^{ss's''}(\bar{i}_s) + n^{ss's'}(\bar{i}_s) + n'^{ss's'}(\bar{i}_s) + n^{sss}(\bar{i}_s)] = n(\bar{i}_s). \tag{22}$$

We require equal numbers of sea quarks and sea antiquarks used for the recombination into hadrons $n(i_s) = n(\bar{i}_s)$ and note furthermore that the number of hadrons and antihadrons formed by ss and sss recombination are equal. Therefore the coefficients of β_{ss} and β_{sss} in (21) and (22) are identical. We obtain the sea quark sum rule for sea quarks i_s or sea antiquarks $\bar{i}_s$

$$-\beta_{vs} n^{vs}(\bar{i}_s) + \beta_{vvs} n^{vvs}(i_s) + \beta_{vss}[n^{vss'}(i_s) + n^{vss}(i_s)] = 0. \tag{23}$$

This rule couples the recombination into mesons in the vs term and the vvs and vss recombination into baryons. The number of sea antiquarks used for the recombination with one valence quark into a meson has to be equal to the number of sea quarks recombined with one or two valence quarks into baryons.

3.4. Momentum sum rule

We require that the mesons and baryons produced by quark recombination carry the total momentum of the fragmenting hadron. About 50% of the momentum is originally carried by gluons which do not participate directly in the simple quark recombination model as used here. We take the same point of view as Duke and Taylor [8]. During the long time scale available for soft hadron production the gluons fluctuate into quark antiquark pairs with distributions of the same shape as the sea quark distribution and participate in this form in the recombination to hadrons. Demanding the energy momentum sum rule for recombination into mesons and baryons is therefore equivalent to the use of enhanced sea quark distributions in [8].

We formulate the momentum sum rule using the inelasticities (17), (18) which are calculated with all β_{ij} and β_{ijk} equal to one.

$$\beta_{\mathrm{vs}} \sum_{i_{\mathrm{v}}} \sum_{\bar{j}_{\mathrm{s}}} K^{\mathrm{vs}}(i_{\mathrm{v}}, \bar{j}_{\mathrm{s}}) + \beta_{\mathrm{ss}} \sum_{i_{\mathrm{s}} \bar{j}_{\mathrm{s}}} K^{\mathrm{ss}}(i_{\mathrm{s}}, \bar{j}_{\mathrm{s}})$$

$$+ \beta_{\mathrm{vvv}} K^{\mathrm{vvv}}(\mathrm{u}_{\mathrm{v}1}, \mathrm{u}_{\mathrm{v}2}, \mathrm{d}_{\mathrm{v}}) + \beta_{\mathrm{vvs}} \tfrac{1}{2} \sum_{k_{\mathrm{s}}} \sum_{i_{\mathrm{v}}} \sum_{j_{\mathrm{v}} \neq i_{\mathrm{v}}} K^{\mathrm{vvs}}(i_{\mathrm{v}}, j_{\mathrm{v}}, k_{\mathrm{s}})$$

$$+ \beta_{\mathrm{vss}} \Big[\tfrac{1}{2} \sum_{i_{\mathrm{v}}} \sum_{j_{\mathrm{v}}} \sum_{k_{\mathrm{s}} \neq j_{\mathrm{s}}} K^{\mathrm{vss}}(i_{\mathrm{v}}, j_{\mathrm{s}}, k_{\mathrm{s}}) + \sum_{i_{\mathrm{v}}} \sum_{j_{\mathrm{s}}} K^{\mathrm{vss}}(i_{\mathrm{v}}, j_{\mathrm{s}}, j_{\mathrm{s}}) \Big]$$

$$+ \beta_{\mathrm{sss}} \left[\frac{2}{3!} \sum_{i_{\mathrm{s}}} \sum_{j_{\mathrm{s}} \neq i_{\mathrm{s}}} \sum_{\substack{k_{\mathrm{s}} \neq i_{\mathrm{s}} \\ k_{\mathrm{s}} \neq j_{\mathrm{s}}}} K^{\mathrm{sss}}(i_{\mathrm{s}}, j_{\mathrm{s}}, k_{\mathrm{s}}) + \frac{2}{2!} \sum_{i_{\mathrm{s}}} \sum_{j_{\mathrm{s}} \neq i_{\mathrm{s}}} K^{\mathrm{sss}}(i_{\mathrm{s}}, j_{\mathrm{s}}, j_{\mathrm{s}}) \right.$$

$$\left. + 2 \sum_{i_{\mathrm{s}}} K^{\mathrm{sss}}(i_{\mathrm{s}}, i_{\mathrm{s}}, i_{\mathrm{s}}) \right] = 1. \tag{24}$$

4. *Values for the recombination parameters* β

The sum rules (19), (20), (23) and (24) are available to constrain the recombination parameters β_{vs}, β_{ss}, β_{vvv}, β_{vvs}, β_{vss}, and β_{sss}. There are two equations (20) but the parameters for valence u and valence d quarks are rather similar, therefore we will not use them as two linear independent equations. Similarly, there are three equations (23) but again because of the similarities of the parameters which are due to the similarities in shape of all sea quark distributions, we use only one of them as linearly independent.

Therefore, we have 4 sum rules for the 6 recombination parameters β. We need supplementary experimental information in order to assign numbers to the recombination parameters. We use two different methods:

(*i*) In order to reduce the number of independent parameters, we set two of the recombination parameters equal

$$\beta_{\mathrm{vss}} = \beta_{\mathrm{vvs}}. \tag{25}$$

Furthermore, we estimate the parameter β_{sss} from the multiplicity of produced antiprotons as measured experimentally [13]. This gives

$$\beta_{\mathrm{sss}} \approx 0.15. \tag{26}$$

Due to the strong energy dependence of $\bar{\mathrm{p}}$ production, this value is rather unsafe at this stage. However this parameter appears only in the momentum sum rule (24) where this term with the numerical value (26) plays only a minor role.

The remaining 4 parameters are β_{vs}, β_{ss}, β_{vvv} and β_{vvs}. They can be determined from the 4 sum rules. We use (20) for one of the valence u-quarks and (23) for the sea u quark. Calculating all coefficients in the sum rules using the generalized Kuti–Weisskopf quark distributions [9] in the hadron multiplicity sums of Table I and the inelasticity sums of Eq. (24) we obtain the following system of equations

$$\begin{aligned} 1.416\beta_{vvv}+5.133\beta_{vvs} &= 1 \\ 0.789\beta_{vs} \qquad\qquad +1.416\beta_{vvv}+2.673\beta_{vvs} &= 1 \\ -1.126\beta_{vs} \qquad\qquad +1.380\beta_{vvv}+1.449\beta_{vvs} &= 0 \\ 0.263\beta_{vs}+0.049\beta_{ss}+0.591\beta_{vvv}+1.074\beta_{vvs} &= 0.96. \end{aligned} \tag{27}$$

The 4 equations are (19), (20), (23) and (24). In the last equation, the momentum sum rule the parameter β_{sss} according to (26) was already inserted. The system (27) can easily be solved and we obtain

$$\begin{aligned} \beta_{vs} &= 0.432 \\ \beta_{ss} &= 11.76 \\ \beta_{vvv} &= 0.207 \\ \beta_{vvs} &= 0.138. \end{aligned} \tag{28}$$

In order to discuss and understand these numbers we consider the contributions to the momentum sum rule (24). The momentum fractions of the 5 terms following from (28) and (24) are

vs — mesons 0.114,

ss — mesons 0.576,

vvv — baryons 0.122,

vvs and vss — baryons 0.148,

sss — baryons and antibaryons 0.04. (29)

The momentum carried by secondary baryons is with only 29% lower than known from experiment. The reason for this low number is connected to the fact, that the quark recombination model is only able to describe the nondiffractive component of particle production. Therefore that part of the inclusive baryon distributions, which is peaked most strongly in forward direction is missing, as we will also see comparing baryon distributions to data in the next Section.

The large parameter β_{ss} and the correspondingly large momentum fraction carried by mesons produced from sea-sea recombination is connected with the enhanced sea quark distributions obtained in the fit of Duke and Taylor [8]. This feature agrees therefore with the meson distributions as measured experimentally. The first three equations (27) (baryon number, valence and sea quark sum rules) are sufficient to determine β_{vs}, β_{vvv}

and β_{vvs}. The parameter β_{ss} is determined from the fourth equation, the momentum sum rule. Originally before fixing β_{sss} (26), there was also the term for baryon and antibaryon production by sea-sea-sea recombination. Only about 40% of the momentum are accounted by the vs, vvv and vvs meson and baryon production. The sss term as expected from $\bar{p}$ production is rather insignificant.

Why is the production of sea-sea mesons about 15 times more efficient than the production of sea-sea-sea baryons or antibaryons? The rason for this seems to be in the actual production mechanism. We know that about 50% of the momentum in the hadrons is carried by gluons. What is called sea-sea recombination in the model is in reality the production of mesons from the gluon component of the colliding hadrons. What we learn from the exercise is that gluons transform mainly into mesons and meson resonances,

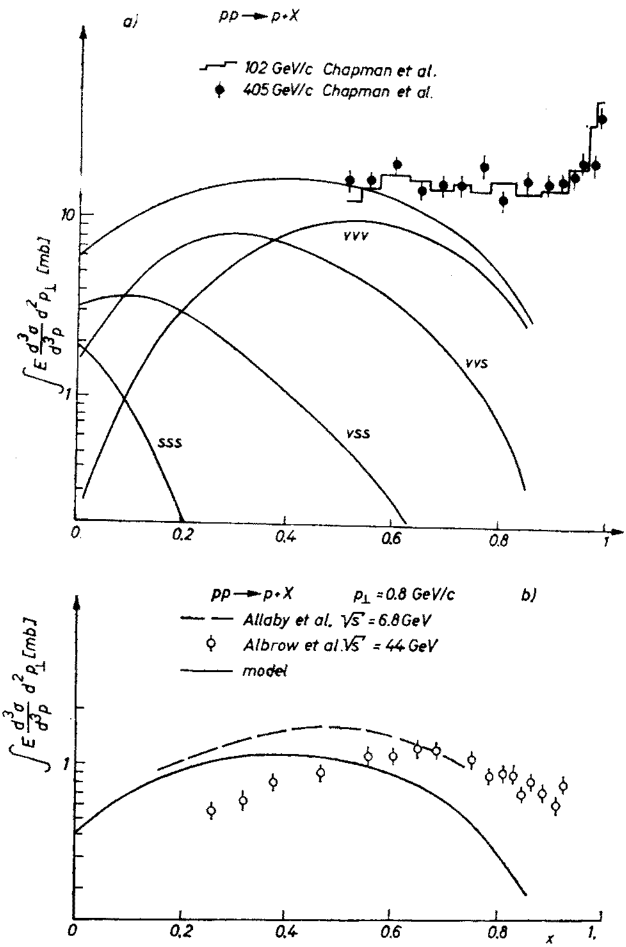

Fig. 1. Comparison of the quark recombination model for pp → p+X with data according to Ref. [16]; (a) We give the total inclusive p production as well as the vvv, vvs, vss and sss terms. Data for the total x distribution are only available at $x > 0.5$, (b) The shape of the total inclusive p production is compared to date measured at fixed $p = 0.8$ GeV/c at two different primary energies

not into baryon-antibaryon pairs. This situation makes the concept of "enhanced" sea quarks rather doubtful.

(*ii*) In a second method to determine the recombination parameters β we use more experimental data. A least squares fit is used to determine the recombination parameters from

— the sum rules
— the $\bar{p}$ multiplicity
— experimental data in inclusive proton and Λ production [14]
— data in the π^+/π^- production ratio as function of x as measured at FNAL [15] and the CERN–ISR [16].

The parameters obtained in this fit agree rather well with the values given above. Therefore we do not give this second set of parameters here.

5. *Baryon distribution in the quark recombination model*

We found already in Section 4 that the momentum carried by secondary baryons in our formulation of the quark recombination model is smaller than found experimentally. The reason is mainly that the quark recombination model describes only the nondiffractive component of particle production. Therefore we cannot expect to obtain good agreement to baryon distributions at large values of the Feynman x. In Fig. 1 and 2 we compare the baryon distributions as obtained with the model with experimental data. In Fig. 1 we present the comparison for the process pp $\rightarrow$ p+X and in Fig. 2. for pp $\rightarrow$ Λ+X. The data

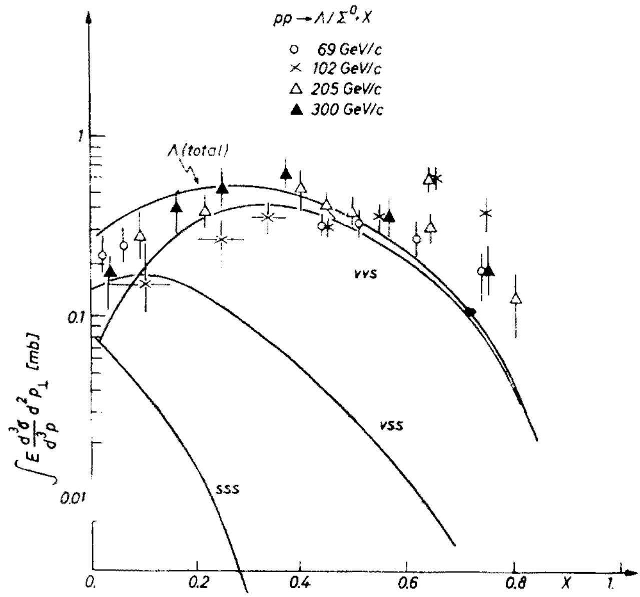

Fig. 2. Comparison of the quark recombination model for pp $\rightarrow$ Λ+X with data according to Ref. [16]. The data at 69 GeV/c is due to Ammosov et al., the data at 102 GeV/c is due to Chapman et al., the data at 205 GeV/c is due to Jaeger et al. and the data at 300 GeV/c is due to Sheng et al. Besides the total Λ distribution we give also the vvs, vss and sss contributions separately

are due to [14]. The agreement in the region of small and moderate x values, where the contribution from diffractive production is not dominant, is good, but in order to describe the production in the total x range the diffractive component has to be added.

6. *Discussion*

We have demonstrated that the sum rules for baryon number, valence quarks and sea quarks as well as the momentum sum rule lead to significant constraints on the recombination parameters β of a quark recombination model. Together with a rather small amount of experimental data, essentially the total multiplicity of antiproton production, the recombination parameters can be determined. No fit to experimental distributions as in [9] is needed to determine the recombination parameters. We find again a strong enhancement for sea-sea recombination into mesons similarly to the enhanced sea quark distribution found by Duke and Taylor in their comparison to experimental data. This sea enhancement occurs however only for the production of mesons and meson resonances not for baryon or antibaryon production. It is an artifact in a model where gluons are represented by the enhanced sea quark distributions. The fact that the enhancement does not occur for baryon production makes the concept of the enhanced sea quark distribution rather doubtful. A model where the gluons transform directly into mesons and meson resonances seems to be preferable.

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