Inclusive baryon-exchange reactions

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The cross sections for the multiple production of mesons and a baryon pair with a small invariant mass in nucleon-nucleon collisions are quite large, have an elevated multiplicity, and fall off slowly with the energy (in proportion to $1/\sqrt{s}$).

Among all final states in high-energy nucleon-nucleon interactions, it is possible to single out some in which there is a pair of baryons with a small relative momentum (on the order of the average momentum of the secondary particles). As can be seen from Fig. 1a, at high energies of the colliding nucleons this process is caused in the multiperipheral kinematics by an exchange of baryon charge by the t channel. This process deserves special attention, because it is closely analogous to nucleon-antinucleon annihilation (Fig. 1 b), which is also accompanied by an exchange of baryon charge in the t channel. The cross section for the $\bar{p}p$ annihilation, $\sigma_{\rm ann}^{\bar{p}p}$, becomes equal to the difference between the total cross sections for the $\bar{p}p$ and pp interactions at an energy of a few GeV[1]:

$$\sigma_{\rm ann}^{\bar{p}p} = \sigma^{\bar{p}p} - \sigma^{pp}; \qquad (1)$$

i.e., this cross section is quite large, and it falls off slowly with the energy, in proportion to $1/\sqrt{s}$. Furthermore, the meson multiplicity in $\bar{p}p$ annihilation is slightly higher than the multiplicity in non-annihilation processes at the same energy. The ratio of multiplicities is about 3/2. There is the possibility that this behavior persists for inclusive reactions with baryon exchange.

The quark-gluon model of strong interactions[2] predicts that the cross section for $\bar{p}p$ annihiliation, $\sigma_{\rm ann}^{\bar{p}p}$, will be equal to the cross section for the inclusive process with baryon exchange in the t channel:

$$\sigma(pp \to 2B + X) = \sigma_{\rm ann}^{\bar{p}p}. \qquad (2)$$

The model also predicts that the ratio of the charged-particle multiplicity in inclusive processes with baryon exchange in nucleon-nucleon collisions to the average multiplicity of charged particles at the same energy will be 3/2.

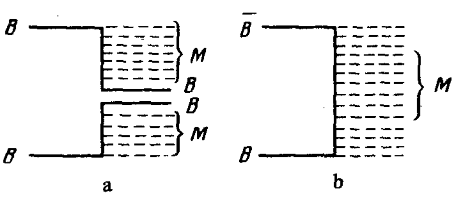

FIG. 1.

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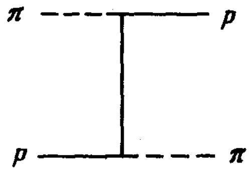

FIG. 2.

Exclusive reactions with baryon exchange, e.g., πN backscattering (Fig. 2), have now been studied in some detail. In this case the baryon exchange in the t channel leads to a more rapid decay of the cross section with increasing s (in proportion to $1/s$ or $1/s^{3/2}$). An iteration of baryon exchange in the t channel in the multiperipheral comb leads to a slowing of the decrease in the cross sections along the s scale, as an iteration of the f pole in the behavior $1/\sqrt{s}$ leads to a pomeron exchange which does not fall off with the energy. A study of inclusive reactions with baryon exchange is interesting not only for testing the relation of (2) but also for identifying the mechanisms for annihilation processes and for constructing realistic models for annihilation at high energies.

It would be particularly interesting to study inclusive reactions with baryon exchange at nuclei, e.g., the reactions $pd \rightarrow (3B)_{\rm slow} + X$, where there are three slow baryons and an unspecified number of mesons in the final state. The cross section for this reaction, $\sigma[pd \rightarrow (3B)_{\rm slow} + X]$, should also fall off as $1/\sqrt{s}$, and the magnitude of this cross section can provide information about the color structure of the deuteron, as was pointed out in Ref. 3.

[1] J. C. Rushbrooke and B. R. Webber, Phys. Rep. **44**, 1 (1978).
[2] A. B. Kaĭdalov, in: Élementarnye chastitsy Desyataya shkola fiziki ITEF (Elementary Particles: Tenth School of Physics of the Institute of Theoretical and Experimental Physics), No. 2, Énergoatomizdat, Moscow, 1983.
[3] P. É. Volkovitskiĭ, Preprint ITEF-57, Institute of Theoretical and Experimental Physics.

Translated by Dave Parsons