SOME REMARKS ABOUT TWO-MAXIMA ANGULAR DISTRIBUTIONS IN JETS

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People are often putting the question: What is the ratio of jets which show the double maximum angular distribution to those without two maxima? However, I wonder if they actually wish to know the answer to this, or to a rather similar question. I think they would rather know the number of jets for which the anisotropic angular distribution of secondaries in the c.m. system can be described as a consequence of a very simple kinematic assumption that the particles are emitted isotropically from two centres moving in opposite directions in the c.m. system of colliding nucleons. Whether the angular distribution in this case shows the double maximum shape or not depends on two conditions. The first and rather trivial one is: what kind of coordinates you use for plotting the angular distribution. The second condition, a more physical one, is: what is the velocity of the hypothetical emitting centres in the c.m. system of colliding nucleons. If you plot the angular distribution in an often used coordinate log tan Θ, then you obtain two maximy for velocities of the centres which are high enough; for lower velocities only one maximum appears in the angular distribution. I think that it is not very interesting to know what is the percentage of jets showing two maxima or one maximum in this particular coordinate. What people perhaps would like to know is: How many jets can be described in this way, and then what is the frequency distribution of velocities of the two emitting centres for nucleon-nucleon collisions at given energy?

Now, what are the experimental facts? The first fact connected with this question is that the mean angular anisotropy of produced particles in the c.m. system increases slowly with increasing energy of colliding nucleons. But the anisotropy is not a precisely defined term. You can imagine infinitely many kinds or shapes of anisotropic angular distributions. Figure 1 shows some examples in polar coordinates and indicates possible developments of these anisotropies.

Now the question arises: Which kind of anisotropy is realized in high-energy collisions? This is just the second experimental fact that the shape of the anisotropy observed in jets is of the kind which can be phenomenologically described by the assumption that the emission of secondary particles takes place from two moving centres emitting isotropically in their own rest systems.

We can now answer the following questions, which may be of interest to theoreticians:

1. What is the percentage of nucleon-nucleon collisions for which the angular distribution can be described in this way?

The answer is: Within the limits of statistical fluctuations all jets with multiplicity not higher than, say, 20 ($n_s \lesssim 20$) can be described in this way.

2. What is the frequency distribution of $\bar{\gamma}$'s (Lorentz factors of centres moving in the c.m. system)?

It may be that this distribution for a given primary energy is subject to experimental bias. This question needs more experimental work. However, we can surely say that the mean value of $\bar{\gamma}$ increases with increasing energy [$\langle\gamma\rangle \approx 1.2, 1.5, 2, 4$ for E_p(eV) $\approx 10^{11}, 10^{12}, 10^{13}, 10^{14}$ respectively]. Of course, this is another more specific expression for the increase of anisotropy with increasing primary energy.

Now some people prefer to describe the observed anisotropy in terms of powers of cos Θ ($\cos^m\Theta$). In reality this distribution is very similar to the two-centre model distribution just discussed, and it would be rather difficult to decide which one gives a better fit to the experiment. I would like to say only that the "cos Θ power" description is a quite formal one. On the other hand, the two-centre model not only gives the description of the angular distribution, but also predicts some correlations between other jet characteristics. From energy conservation we expect the following correlations:

$$\frac{3}{2} n_s E_\pi \bar{\gamma} = 2 K \gamma_c M .$$

n_s - multiplicity;

E_π - mean energy of created particle in the centre's rest system;

K - inelasticity;

γ_c - Lorentz factor of colliding nucleons;

M - nucleon mass.

Such correlations are really observed[1].

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REFERENCES

1) Ciok et al., Nuovo Cimento 8, 166 (1958);
Nuovo Cimento 10,741 (1958).

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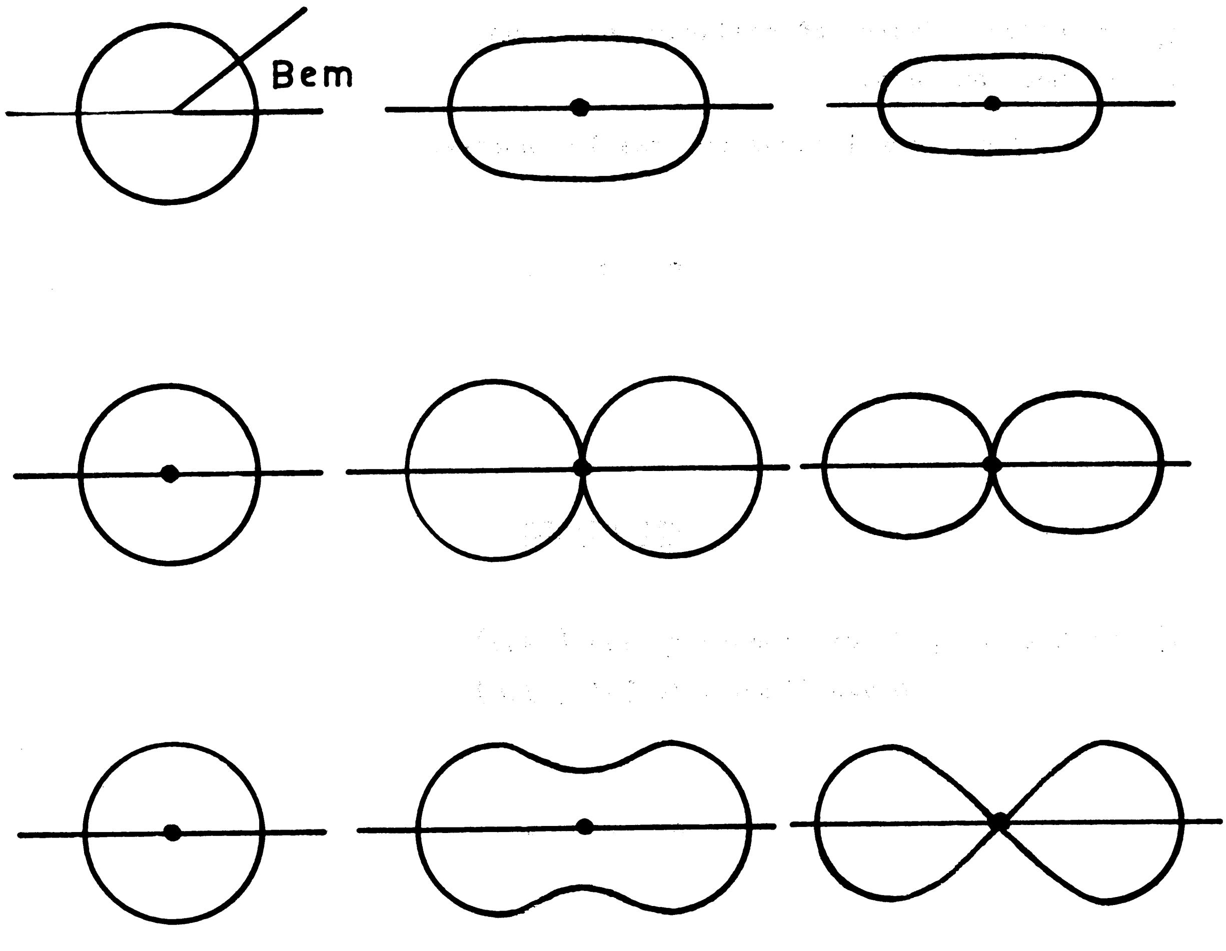

Fig. 1: Different possible developments of anisotropy.