Before I give some recent results of a proportional- and spark-chamber experiment made at the CERN Proton Synchrotron (PS) \(^1\), I would like to make some remarks on what seems at the moment to be the general trends in large-angle two-body reactions. Figure 1a gives a schematic illustration of the situation and Fig. 1b gives some examples. In the forward and backward directions we have the dominant peripheral mechanisms with \(\frac{d\sigma}{dt} \sim s^n f(t \text{ or } u)\), where \(n = -2 \pm 2\). Outside the peripheral regions, or whenever peripheral processes are absent, we seem to have \(\frac{d\sigma}{dt} \sim s^N F(G_{cm})\), where \(N = -9 \pm 2\) \(^2\). In processes such as \(\bar{p}p + \bar{p}p\) and \(K^-p + K^-p\) there is no known peripheral mechanism to give rise to backward scattering; we see no evidence for two-particle exchange up to 6.2 GeV/c \(^1\). The variation of the cross-sections with energy is the same at 90° c.m. as it is at 180° \(^2\). The same non-peripheral mechanism seems therefore to govern these processes from outside the forward peripheral peaks all the way to 180°. I should warn you, however, that the data are still very limited and at rather low energies. At least two "finite-energy" effects may be present in the data.

i) We have earlier reported local variations, with energy near 5 GeV/c, of large-angle \(\bar{p}p + \bar{p}p\) cross-sections, which we tentatively ascribed to fluctuations in incoherent scattering through direct-channel resonances (Ericson fluctuations) \(^3\).

ii) In the energy region covered by the PS and AGS, the 90° c.m. points are not far from the tails of the forward and backward peripheral peaks. Superimposed on the general fast decrease in the large-angle cross-sections with energy, there are modulations on the curves probably due to the influence of peripheral coherent scattering processes \(^4\). It is of course important to extend the large-angle measurements to higher energies at NAL and SPS, in order to get rid of such effects.

Turning now to our recent experimental data \(^1\), we show in Fig. 2 how \(\bar{p}p + \bar{p}p\) compares with \(pp + pp\). We first notice that at 5 and 6.2 GeV/c we are probably still in an energy region where peripheral effects may influence 90° c.m. scattering. Our results on \(K^-p + K^-p\) and \(\pi^-p + \pi^-p\) \(^1\) show a decrease of nearly a factor of 10 in the 90° c.m. cross-section as energy increases from 5 to 6.2 GeV/c (\(\sim s^{-10}\)). Surprisingly enough there is no decrease in the case of \(\bar{p}p + \bar{p}p\), which we ascribe to fluctuations mentioned above, although we have no specific mechanism in mind. At 180°, on the other hand, the cross-section decreases by a factor of \(\sim 10\) (see Fig. 2), in agreement with \(\sim s^{-10}\).
The most striking feature in Fig. 2 is the large difference between \( pp + pp \) and \( \bar{p}p + \bar{p}p \) in the 90° c.m. region, where the ratio of the cross-sections is \( \sim 10^2 \). If there is a common mechanism which governs large-angle scattering, it has to account for this difference. A neutral current interaction (gluons)\(^5\) between constituents would in first approximation give equal cross-sections. The constituent interchange model\(^6\) gives a large difference, in qualitative agreement with the data. The quantitative agreement is not so good; the model gives a too low cross-section ratio (50), and does not reproduce the angular distribution beyond 90° c.m. However, we are certainly still not at sufficiently high enough energies to make detailed quantitative comparisons meaningful.

Our results on annihilations into \( \pi^+\pi^- \) and \( K^+K^- \) are shown in Figs. 3a and 3b. The peripheral peaks are due to baryon exchange processes. In an earlier publication\(^7\), we compared these cross-sections with the ones obtained by crossing the baryon exchange amplitudes which we deduced from our backward \( \pi^+p \) and \( K^+p \) elastic scattering data.

As to the large-angle data, they have been compared with the large-angle \( \pi p \) elastic scattering data by crossing the parton interchange amplitude\(^5\). The general shape of the angular distribution of \( \pi p \) elastic scattering around 90° c.m. is well fitted by the interchange amplitude\(^6,8\), and this fit provides us with the normalization factor. Crossing this amplitude to the annihilation channel, one gets the continuous line in Fig. 3a, which refers to the 5 GeV/c data. The data in Figs. 3 are the only ones at high enough energy that the large-angle region stands clearly out from the peripheral regions. It is apparent that much work is still required.

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\(^1\) L. W. Thomas and J. B. Marion, unpublished.
REFERENCES


Figure captions

Fig. 1a : Tentative trends in two-body (diffractive) processes.

Fig. 1b : Examples of large-angle elastic scattering (Ref. 8).

Fig. 2 : Comparison of pp and \( \bar{p}p \) elastic scattering (Ref. 1).

Fig. 3a : \( \bar{p}p \rightarrow n\bar{n}^+ \) at 5 and 6.2 GeV/c.

Fig. 3b : \( \bar{p}p \rightarrow K^-K^+ \) at 5 and 6.2 GeV/c.
Fig. 2
- Vandermeulen:
  Can you tell me what is the value of the interaction radius which would fit the elastic data in the optical model?

- Lundby:
  About 1.3 fm, but I do not know it exactly.

- Nilsson:
  What kind of exchange do you require in order to explain the backward peak?

- Lundby:
  There are contributions which go all the way to the backward region but they are not as large as experimentally observed. Then people, of course, say that there are cut contributions but this is against our data because they go too fast with energy.

- Kalogeropoulos:
  Has anybody done an optical calculation assuming not the black disk but rather an optical ray?

- Lundby:
  Do you mean only forward data? With large $p_T$ it would be rather difficult.

- Šimáč:
  What is the $s$-dependence of the central region ($\cos^2 \theta \approx 0$)?

- Lundby:
  It is about $s^{-10}$. 