Summary. — It is assumed that the collision of two nucleons of high energy sometimes forms a "compound system" in thermal equilibrium. The secondary processes following the collision are then the decay products of this compound system. It is conjectured that the elastic scattering at large angles is primarily due to this mechanism. Its cross-section can then be calculated by simple thermodynamical methods. The pion cloud in the compound system is approximated by a massless boson gas. The Stefan-Boltzmann equation leads to an exponential energy dependence exp[−E/T] of the cross-section with \( T \sim E \) where \( E \) is the kinetic energy of the nucleons. The order of magnitude of the cross-section can also be estimated. These results agree with the experimental observations and with previously published computer calculations of the relevant phase space by Fast and Hagedorn and by Jones.

1. – Introduction.

Recently, there has been done very extensive measurements of the elastic pp cross-section at high energies — from 10 to 31 GeV/c in the laboratory system — and high momentum transfers, \( i.e., \) large scattering angles \( (1) \). The
results of these experiments seem to indicate the statistical character of the scattering at large angles as pointed out by several authors (26).

The elastic scattering at large angles is definitely greater than the diffraction scattering. The cross-section around $90^\circ$ in the centre of mass system shows a characteristic exponential decrease with energy, which is an indication of a statistical effect (Boltzmann factor).

A statistical theory makes the following assumption: during the collision, the total energy available is concentrated in a certain volume in which a state of thermal equilibrium is produced. The volume expands and, when it reaches a maximum value $V$, the thermal equilibrium ceases to be maintained; then the products of the collision leave the centre of collision roughly with the energies and the properties which they had at thermal equilibrium in the volume $V$.

To draw quantitative conclusions in regard to the elastic scattering from such a statistical model, one should compute the number of all possible states within a given volume $V$ (with the same total charge, strangeness and baryon number as those of the initial two protons) at a given energy and compare it with the number of states of two protons only at the same energy. The probability of an elastic scattering at large angles (outside the diffraction scattering) should then be proportional to the ratio of the number of two-proton states and the total number of states. This amounts to the calculation of many phase-space integrals. It is known that such numerical calculations are extremely difficult and need many hours of computer time. This work was performed at CERN (7). On this basis, Hagedorn and Jones (4) were able to find the energy-dependence of the statistical part of the elastic $pp$ cross-section at high energies. Their predictions fit the existing data on the $pp$ elastic scattering at large angles (1) with good accuracy.

In the present paper, we would like to consider the same problem using a thermodynamical approach. We consider the mixture of boson and fermion gases in the volume $V$ and calculate the number of possible states by the usual methods used in thermodynamics. In our opinion this approach has two main advantages:

i) it offers a simple picture of the high-energy «statistical» collisions,

(ii) it is based on established thermodynamical principles.


(30) R. Hagedorn: Large angle cross-sections $p+p \rightarrow A+B$ and $\pi+p \rightarrow A+B$ at high energies predicted by the statistical model, preprint (CERN, 1964).