Experimental test of the hadron structure in the polarized $hadron - hadron$ elastic scattering

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RINGRAZIO TUTTI GLI ORGANIZZATORI DI QUESTA CONFERENZA,
IN PARTICICULARE STEFANO BIANCO E PASQUALE DI NEZZA
PER L'OPPORTUNITA' DATAMI
DI PRENDERE PARTE ALLA
CONFERENZA E DI VISITARE
DUE CITTA' BELLE E AFFASCINANTI:

FRASCATI & ROMA.

Present models reproduces binary reactions NN, πN, γN,... as interaction of the two point-like objects, where every hadron is constructed as point-like object with definite mass, momenta and quantum numbers.

What observables indicate the structure of the nucleon in the NN elastic scattering in the 0.5-2GeV energy region?

STRUCTURELESS (POINT-LIKE) PROTON is described via the definite mass, spin, isospin and four-momentum $q_p = (\sqrt{m_N^2 + \mathbf{q}_p{}^2}, \mathbf{q}_p)$.

$$f(E,\theta,\phi) \equiv F(s,t,\phi) = a(E,\theta) + b(E,\theta)(\mathbf{s_1}\cdot\mathbf{n})(\mathbf{s_2}\cdot\mathbf{n})$$

$$+c(E,\theta)(\mathbf{s_1}\cdot\mathbf{m})(\mathbf{s_2}\cdot\mathbf{m})$$

$$+d(E,\theta)(\mathbf{s_1}\cdot\mathbf{l})(\mathbf{s_2}\cdot\mathbf{l}) + e(E,\theta)((\mathbf{s_1}+\mathbf{s_2})\cdot\mathbf{n})$$

DEPENDENCE ON THE AZIMUTHAL ANGLE ϕ IS SEPARATED:

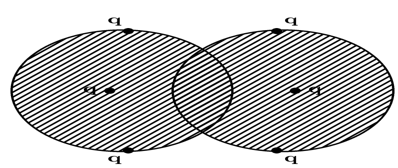
the mutually orthogonal unit vectors
$\mathbf{n} = \frac{(\mathbf{p'}\times\mathbf{p})}{|(\mathbf{p'}\times\mathbf{p})|}$;
$\mathbf{m} = \frac{(\mathbf{p'}-\mathbf{p})}{|(\mathbf{p'}-\mathbf{p})|}$;
$\mathbf{l} = \frac{(\mathbf{p'}+\mathbf{p})}{|(\mathbf{p'}+\mathbf{p})|}$
and $\mathbf{p} = \mathbf{q}_1 = -\mathbf{q}_2$.

Polarization observables of the NN elastic scattering are determined by the a, b, c, d, e amplitudes.

CRITERION: What object is point-like?

POINT-LIKE PARTICLE: $|V(1,2)| << M_1(M_2)$

PARTICLE EXCHANGE: $|V(1,2)| \leq M_1(M_2)$



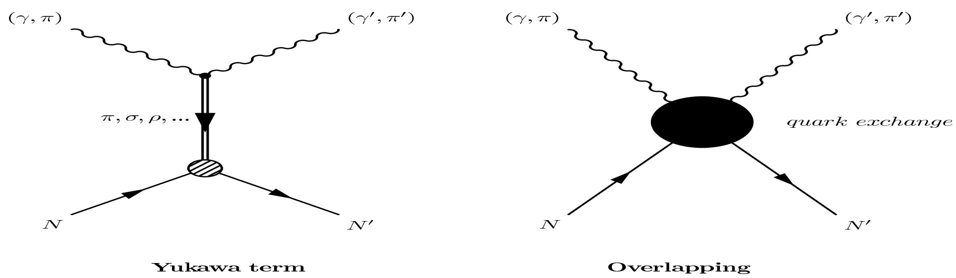
OVERLAPPING, CONTACT, QUARK EXCHANGE:

instead of $|V(1,2)| \Longrightarrow$

interaction of fractals

HADRONS AS A COMPOSITE PARTICLES:

OVERLAPPING,
CONTACT,
QUARK EXCHANGE TERMS



General dependence on ϕ of the NN scattering amplitude, i.e. nontrivial dependence on the vectors $\mathbf{n}, \mathbf{m}, \mathbf{l}$ and spin variables s_1, s_2 of two nucleons.

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$$f_{composed}(E,\theta,\phi) = a(E,\theta,\phi) + b(E,\theta,\phi)(\mathbf{s_1}\cdot\mathbf{n})(\mathbf{s_2}\cdot\mathbf{n})$$

$$+c(E,\theta,\phi)(\mathbf{s_1}\cdot\mathbf{m})(\mathbf{s_2}\cdot\mathbf{m}) + d(E,\theta,\phi)(\mathbf{s_1}\cdot\mathbf{l})(\mathbf{s_2}\cdot\mathbf{l})$$

$$+e(E,\theta,\phi)((\mathbf{s_1}+\mathbf{s_2})\cdot\mathbf{n})$$

This expression predicts an essential dependence on ϕ of the NN polarization observables.

Asymptotic particles in quantum mechanic and in quantum field theory are point-like objects.

But quark exchange and overlapping terms can change the spin-orientation of the interacted particles, This generates the azimuthal angle-dependence of the binary hadron-hadron scattering amplitude.

ϕ**-dependence lead to the size parameter of interaction, which indicates the nontrivial distribution of the final particles in the different scattering-planes.**

TWO-BODY INTERACTION $\Longleftrightarrow$ MANY-BODY INTERACTION

ϕ**-dependence and FORM-FACTORS:**

Form-factors are depending on the $t = (p' - p)^2$ **and not on** ϕ**.**

$$< \mathbf{p}'|j_\mu(0)|\mathbf{p} >= \frac{(p' + p)_\mu}{2m_\pi} F(t)$$

The experimental evidence of the proton structure effects can be done by a measurement of the following quantity by the fixed E *and* θ:

$$\Big[\lambda_{\pm}(\phi)\Big]_{fixed\ E\ and\ \theta} = \Big[A_{nooo}\frac{d\sigma_{pp\to p'p'}}{d\Omega} \pm (A_{nooo}\frac{d\sigma_{pp\to p'p'}}{d\Omega})_{\phi=0}\Big]_{fixed\ E\ and\ \theta}$$

$$= Re\Big(a^*(E,\theta,\phi)e(E,\theta,\phi)\Big) \pm Re\Big(a^*(E,\theta,\phi=0)e(E,\theta,\phi=0)\Big)$$

The most promising energy region for determination of the $\lambda(\phi)$ parameter is $E \sim 1-2GeV$, where the quark structure effects are nowadays indisputable.

CONCLUSION

The experimental evidence of the hadron structure effects can be done by a measurement of the azimuthal ϕ-angle distribution of the scattering planes by the fixed total energy E and scattering angle θ.

The essential dependence on the azimuthal ϕ-angle of the binary scattering observables is necessity condition of the structure effects of the interacted hadrons.

This means that the ϕ independence of the polarized observables of the $1+2 \Longrightarrow 1'+2'$ reaction indicates the structureless nature of the scattered particles.