A. M. Baldin, *Atomic nuclei as quark-gluon systems.* The picture of the nucleus as a system consisting of protons and neutrons has played a major role not only in science but also in the practical activities of man. However, since the advent of the quark theory of matter, it has become clear that this picture is approximate and of limited utility. There is now little doubt that quarks and gluons are "good" quasiparticles that must be used in any description of hadrons at short distances. More than that, since the theory of quarks and gluons (quantum chromodynamics—QCD) is the fundamental theory, we have to face the grand problem of using it to explain the existence of hadrons and nuclei, i.e., to construct a theory of quark-gluon matter—the theory of chromoplasma. The main source of information about the quark-gluon structure of the nucleus is relativistic nuclear physics[1-3], i.e., the region of many-baryon phenomena, defined by the condition

$$b_{ik} = -\left(\frac{p_i}{m_i} - \frac{p_k}{m_k}\right)^2 \gg 1, \qquad (1)$$

where p_i, p_k are the 4-momenta of particles and m_i, m_k are their masses. Let I and II denote colliding relativistic nuclei, and 1, 2, 3, etc., label the reaction products:

$$\mathrm{I} + \mathrm{II} \to 1 + 2 + 3 + \ldots .$$

Experimental methods developed at the High-Energy Laboratory of the Joint Institute of Nuclear Research yield the probability distributions for the quantities b_{ik} (i.e., for $b_1, b_{\mathrm{I}2},\ldots,b_{12}, b_{13},\ldots,b_{\mathrm{II}\,1}\ldots$).

One of the basic assertions confirmed experimentally is that the probability distributions for the b_{ik} decrease quite rapidly with increasing b_{ik}. This is a reflection of the basic property of quarks, known as asymptotic freedom. The physical meaning of this and of the criterion $b_{ik} \gg 1$ is that the interaction between quarks in a particle or nucleus i and quarks in a particle or nucleus k for $b_{ik} \gg 1$ is so weak that it can be treated by QCD perturbation theory or, in other words, at the level of elementary quark-gluon within hadrons i and k are, on average, small in comparison with the relative velocity of the hadrons i, k themselves. One of the most important results in relativistic nuclear physics is the determination of the limit above which quarks may be looked upon as quasi-free particles:[4]

$$b_{ik} \geqslant 5. \qquad (2)$$

When (2) is satisfied, the concept of the nucleon (proton or neutron)—which has been basic to nuclear physics—becomes inadequate and the proton-neutron model of the nucleus ceases to be valid. All phenomena then have to be treated at the quark level.

The principal objects of experimental study are the b_{ik} distributions and the relativistically invariant correlators in the same 4-velocity space. Model-independent results obtained in this way include the following: the correlation length (distance over which the correlator falls by a factor of e in this particular space) is only 1–2 and the asymptotic region of nuclear interactions in which quark phenomena (deconfinement of color) play a dominant role begins at relativistic energies of about $3.5A$ GeV where A is the mass number. For the last 15 years the Dubna proton synchrotron has been the only accelerator in the world capable of producing nuclei with energies above this limit.

Interpretations of measured distributions in terms of the parton model yield the distributions of quarks in nuclei (quark-parton structure functions of nuclei)[4] and predict relationships, some of which have been confirmed by deep-inelastic scattering of leptons by nuclei (the so-called EMC effect). One of the most significant conclusions of this interpretation is that the nucleus contains not only protons and neutrons but also fluctuations of quark-gluon plasma. Nuclei appear to be multiphase systems.

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