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978-0-521-85609-6 - Strong Interactions of Hadrons at High Energies: Gribov Lectures on Theoretical Physics
V. N. Gribov
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STRONG INTERACTIONS OF HADRONS AT HIGH ENERGIES

V. N. Gribov was one of the creators of high energy elementary particle physics and the founder of the Leningrad school of theoretical physics. This book is based on his lecture course for graduate students. The lectures present a concise, step-by-step construction of the relativistic theory of strong interactions, aiming at a self-consistent description of the world in which total hadron interaction cross sections are nearly constant at very high collision energies. Originally delivered in the mid-1970s, when quarks were fighting for recognition and quantum chromodynamics had barely been invented, the content of the course has not been 'modernized'. Instead, it fully explores the general analyticity and cross-channel unitarity properties of relativistic theory, setting severe restrictions on the possible solution that quantum chromodynamics, as a microscopic theory of hadrons and their interactions, has yet to find. The book is unique in its coverage: it discusses in detail the basic properties of scattering amplitudes (analyticity, unitarity, crossing symmetry), resonances and electromagnetic interactions of hadrons, and it introduces and studies reggeons and, in particular, the key player – the 'vacuum regge pole' (pomeron). It builds up the field theory of interacting pomerons, and addresses the open problems and ways of attacking them.

Vladimir Naumovich Gribov received his Ph.D. in theoretical physics in 1957 from the Physico-Technical Institute in Leningrad, and became the head of the Theory Division of the Particle Physics Department in 1962. From 1971, when the Petersburg (Leningrad) Institute for Nuclear Physics was organized, Gribov led the Theory Division of the Institute. In 1980 he became Head of the particle physics section of the Landau Institute for Theoretical Physics, Moscow. From 1981 he regularly visited the Research Institute for Particle and Nuclear Physics in Budapest where he was a scientific adviser until his death in 1997. Vladimir Gribov was one of the leading theoretical physicists of his time, who made seminal contributions in quantum electrodynamics, neutrino physics, non-Abelian field theory, and, in particular, the physics of hadron interactions at high energies.

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V. N. GRIBOV

Prepared by

Y. L. DOKSHITZER AND J. NYIRI

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Foreword

Quantum Chromodynamics (QCD) was in its infancy when Gribov delivered his lectures on strong interactions. Since then QCD had been established as the true microscopic theory of hadrons.

The main (though not the only) focus of these lectures is to present the 'old theory' of hadron interactions (known as *reggistics*). This theory has realized the 'Pomeranchuk–Gribov programme' of describing strong interactions without appealing to the internal structure of hadrons. The old theory was launched in 1958 by the Pomeranchuk theorem and reached a climax in Gribov's prediction of an asymptotic equality of hadron cross sections 15 years later. With the advent of QCD, it was abandoned by the great majority of theorists in the mid-1970s and has been neither taught nor learnt since.

QCD – the 'new theory' – is now in its fourth decade. The QCD Lagrangian approach did marvels in describing *rare* processes. This is the realm of *hard interactions* that occur at *small distances* where quarks and gluons interact weakly due to the asymptotic freedom. The domain of expertise of the old theory is complementary: it is about normal size hadron–hadron cross sections, *soft interactions* that at high energies are dominated by peripheral collisions developing at *large distances*. QCD only starts to timidly approach this domain, with new generations of researchers borrowing (sometimes improperly) the notions and approaches developed by the 'old theory'.

A few non-scientific comments are due before you start reading (better still, working through) the book.

The lectures you are about to encounter were given in early 1970s, and so they are presented here: no attempt has been made to 'modernize' the text. (Editor's comments are few and relegated to the footnotes marked (ed.).)

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Let me mention two problems that emerged when preparing this text: one surmountable, another not. The first derived from the fact that the lectures were delivered twice (in 1972–1973 and then in 1974–1975). The only invariant in these two series was the format of lectures (four hours at the blackboard each Thursday; never a piece of paper with pre-prepared notes to guide the lecturer). The rest was subject to variability. So, a compromise often had to be found between two different presentations of the same topic.

The second problem is as follows. The equations of this book contain 3180 *equality signs*, while they seldom appeared on the blackboard. With Gribov-the-lecturer, the symbol = was clearly out of favour.

I think it was being done on purpose. Gribov was a generous teacher and always implied that his students were capable of deriving mathematically correct formulae, given the rules. He was trying to teach students, in the first place, how to think, how to approach a new problem, how to develop a 'picture' of a phenomenon in order to guess the answer prior to deriving it. And ignoring equality signs served as additional means for stressing 'what was important and what was not' in the discussion.

Unfortunately, this flavour of a live lecture is impossible to preserve in a printed text which has its specific, and opposite, magic of certainty. I am afraid that having debugged equations, the lectures may have lost in pedagogical impact.

I always looked upon these lectures as a treasure chest. I sincerely believe that when you open it, you will find it filled not with obsolete banknotes but with precious gold coins.

Yuri Dokshitzer

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