RHEINISCHE FRIEDRICH - WILHELMS - UNIVERSITÄT BONN

PHYSIKALISCHES INSTITUT

James A. Crittenden

Physikalisches Institut der Universität, 53115 Bonn, Nußallee 12

Nußallee 12
53115 Bonn
Telefon: (0228) 73 - 3236
Telefax: (0228) 73 - 7869

Wlodek Guryn
Brookhaven National Laboratory
Upton, New York 11973

Open letter to Wlodek Guryn

concerning the role of experimental studies of diffractive processes in the context of present-day particle physics

September 18, 2000

Dear Wlodek,

During the recent International Workshop on Diffraction in High-Energy Physics in Cetraro, Italy, the issue of how best to present the study of diffractive processes to science policy experts and to the particle-physics community at large was addressed in some detail. Your question concerning funding proposals was among the more cogent depictions of the task facing us. With the present letter I wish to offer some ideas and the beginning of an answer. By publishing this answer as an open letter I intend to stimulate a discussion which will lead to a concise and persuasive description of the physics interest in the elucidation of diffractive processes.

I propose to formulate our argument in terms of the response to two questions:

1. **What is the basic motivation behind the interest in diffractive processes?**

   The interest in hadronic interaction rates at asymptotically high energies has a distinguished history of nearly fifty years and is more justified now than ever before. Even at the highest energies attained by modern accelerators we know that the total cross sections continue to increase with energy. Diffractive processes make up the dominant contribution to these highest-energy hadronic reactions. The quantum field theoretical approaches which have proven so useful in describing the electroweak interaction are not able to describe the fundamental physics underlying this phenomenon. The extrapolation *ad absurdum* to infinite reaction probability at at infinite energy remains at present uncontradicted by the present-day theoretical approaches. Thus this field of study is generally recognized as one in which experiment is leading theory.

   Startling results from the Tevatron and from HERA in the last five years have dramatically changed our perception of the nature of diffractive interactions. It has become obvious that diffractive processes make sizable contributions to interactions at very high momentum transfer. The observed power-law dependence on momentum transfer in both inclusive and exclusive channels in photon-proton interactions points to the possibility of a field theoretical approach involving the exchange of a field carrying the quantum numbers of the vacuum. No consensus has yet been reached on the precise nature of either the exchanged field or the hadronic constituent which serves as the scattering center. Despite the apparently fundamental properties of these objects, they remain unnamed and do not appear in the Lagrange density of the Standard Model.

2. **How do the new results relate to the present understanding of strong interactions?**

   Quantum Chromodynamics, a field theory with no intrinsic scale or indeed any other free parameters, has proven remarkably successful in describing hard hadronic reactions (excluding the recently discovered hard diffractive reactions.) However, this absence of intrinsic scale results in there being no motivated ansatz for the region of applicability of the perturbative calculational techniques which give such a field theory predictive power. Since there is intrinsically no reliable estimate for the minimum scale at which perturbative calculational techniques can be expected to succeed with a given accuracy, there is no way to estimate the fraction of the total cross section described by QCD. As a result, the only thing we know about the fraction of the total hadronic cross section which is described by QCD is that it is very small. We are therefore facing the urgent necessity of experimentally characterizing the dominant contributions to high-energy hadronic cross sections in order to complete our understanding of the strong force.

   QCD enjoyed spectacular success in predicting asymptotic freedom and, consequentially, in predicting the Bjorken scaling observed in deep inelastic electron-proton scattering at SLAC in 1967, and so engendered our present-day understanding of quarks as kinematical constituents of hadrons. In 1993, the HERA experiments H1 and ZEUS each independently discovered a class of reactions obeying a similar scaling law but showing no evidence for the color-string-breaking effects necessarily predicted by first-order QCD. The model-independent scaling consideration which motivated the postulate of small-sized scattering centers in the proton applies as well to the hard diffractive interactions observed at HERA in both exclusive and inclusive reactions. An active debate continues on the nature of the small-sized structures inside the proton which participate in this new class of reaction. It is for reasons such as these that we are convinced that the study of diffractive processes will prove essential in making the next step in the understanding of the internal structure of hadrons, i.e. the structure of matter at the limit of presently attainable spatial resolution.

Wlodek, I hope that you will find some of these remarks useful in your future science policy debates. And I trust that our fellow diffractive participants at Diffraction 2000 will have useful suggestions for sharpening these arguments.

Sincerely yours,

Jim