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HERA Events and Electro-Strong Interaction

P.C.M. Yock
Faculty of Science
University of Auckland
New Zealand

Abstract

The HERA events may support a model of electro-strong interactions. A clearer test can be carried out at CERN.

1. Introduction

Evidence for a previously unobserved interaction has been reported recently by the H1 and ZEUS collaborations [1,2]. Positrons were observed to be scattered inelastically by protons in the HERA collider more frequently than predicted by the standard model at momentum transfers greater than 120 GeV/c. The result, if it is not a statistical fluctuation, implies the existence of a new particle or a new interaction with unusual properties [3]. In the case of a new interaction, it is required to act between positrons and constituents of the proton over a range $\leq 10^{-18}$ m, and to have a strength intermediate between that of electromagnetic and strong interactions.

An interaction with the above properties was proposed previously in a model of electro-strong interactions [4-7]. The model is described here, and implications for experiments at DESY and CERN.

2. Electro-Strong Model

The electro-strong model is an alternative to the standard model, in which the quarks are replaced by a different set of hypothetical particles. These were termed 'subnucleons' and assumed to be heavy and highly charged [8]. The high charge was assumed to account for subnuclear binding, and also for conventional nuclear interactions as a residual effect. Four generations of subnucleons are required. They are not replications of one another. Conservation laws of baryon number and strangeness, etc., follow similarly to electric charge conservation. Electro-strong interactions may be able to account for weak interactions, although this has not been demonstrated quantitatively. The presence of strong interactions in the model has prevented the author from attempting detailed calculations.

The electro-strong model was formulated in an effort to construct a theory free of the renormalisation divergences and broken symmetries of conventional theory. It has not been demonstrated by direct calculation that either of these goals has been achieved. Nor is it known if they are achievable. Some proposals were made during the formulation of the model that were subsequently used in QCD [4,9]. These include the existence of hadron constituents with dual charges, confinement by a massless gauge field, charge neutrality of bound states, and the nuclear force being a residual effect of the confinement interaction.

3. Generalised Yukawa model

A generalised Yukawa model was proposed for hadrons [5,7]. The nucleon, for example, was envisaged as a bare, composite nucleon surrounded by a cloud of composite, virtual pions, as shown schematically in the Figure. A similar model was considered by Feynman [10]. The size of the bare nucleon was conjectured to be ~ 10^{-19} m, much smaller than the extent of the pion cloud ~ 10^{-15} m. The model requires that electrons are scattered coherently by the bare nucleon at SLAC energies, and that $\nu W_2 \approx (Q^2/2M\nu) \times f(Q^2/2M\nu)$, where f(x) is the probability that the bare nucleon has charge +e and fraction x of the total nucleon mass. The recent observation of events with an energetic forward neutron at HERA supports the concept of a pion cloud for the nucleon [11].

4. HERA events

The generalised Yukawa model requires new phenomena to occur at higher energies. At momentum transfers sufficient to reveal sub-structure in the bare nucleon, the electron-proton interaction will change qualitatively. The scattering will be caused by individual subnucleons, and the cross section will be determined by their high charges. This seems consistent with the frequency of events reported at DESY with $Q^2 > (120\ \text{GeV/c})^2$. If the DESY experiments are just entering the new regime, then the data may be expected to exhibit complicated threshold effects. With the scheme of weak interactions proposed in [7], the largest effects should occur in neutral current interactions.

5. Proposed LHC-LEP experiment

According to the above model, at $Q^2 >>$ (several TeV/c)^2, electron scattering should become entirely incoherent, and the experimental effects of the high subnucleonic charges should

become unmistakable. This could be expected to occur irrespective of considerations of whether or not confinement occurs. This regime might be approached at CERN, by combining the LHC and LEP machines to form a giant electron-proton collider. This is probably the clearest way to test the electro-strong model in the foreseeable future.

6. Conclusion

The experimental results from HERA may be able to be understood in terms of a previously proposed model of electro-strong interactions. Further data from HERA will clarify the situation. The major effects should occur in neutral current interactions according to the model. The effects should become larger and clearer at higher energies. This prediction could be tested using the LEP and LHC machines as a giant electron-proton collider.

The interpretation of the HERA data proposed here assumes that the quark model of hadrons is a model only, and that quarks are not real particles. This is not the first time the suggestion has been made [12]. Neither are the HERA data the first to be problematic for the quark model. The spin of the proton, and the decay rates of strange particles, for example, have long been unexplained [5,13]. Conceptual problems, such as fractional charge and broken symmetry, are also present in the quark model. The interpretation of the HERA data proposed here is conceptually similar to Rutherford's interpretation of α particle scattering. In both cases heavy, highly charged particles in the target are assumed to cause back scattering.

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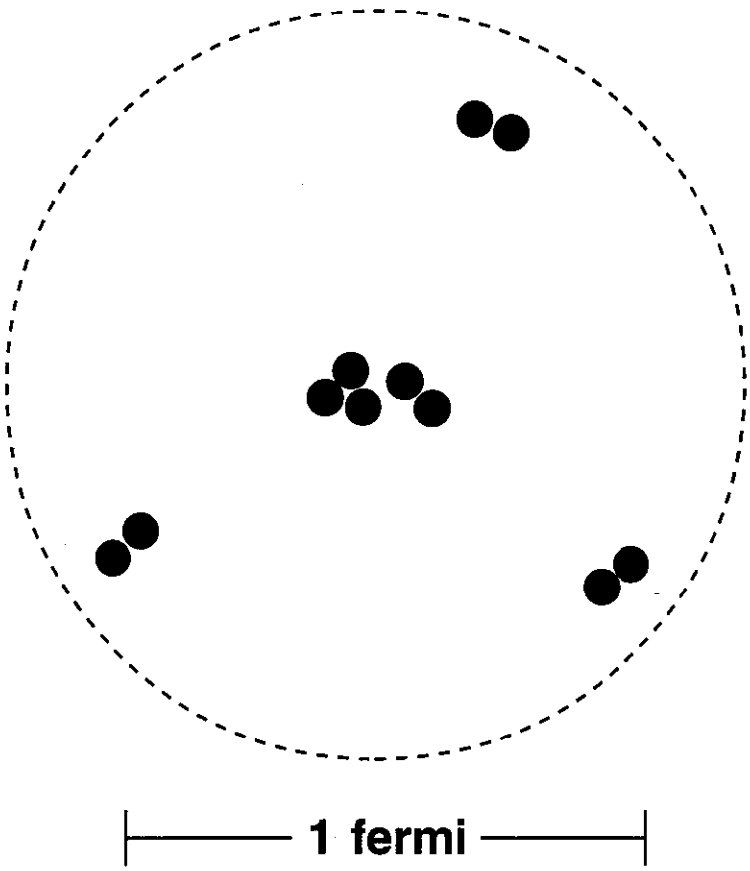

Figure. Generalised Yukawa model of the nucleon. The dots represent tightly bound subnucleons comprising the bare nucleon and virtual pions. The dashed line represents the extent of the pion cloud. In e-p interactions at SLAC energies, the electron is assumed to be scattered by the bare nucleon as a whole. At HERA energies, the internal structure of the bare nucleon may be beginning to be resolved.