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RESEARCH ON ELEMENTARY PARTICLE PHYSICS
Task P–Studies in Theory and Phenomenology of Elementary Particles

Annual Progress Report

for Period January 1, 1992–October 31, 1992

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Progress Report for 1992, DOE-FG02-91ER40677 Task P

Theory and Phenomenology

Abstract

Over the last year, work has focussed on two areas: the phenomenology of quark-gluon differentiation in jets, and theoretical studies involving Dirac-like equations for various systems. Substantive progress has been made in both areas. A paper comparing details of the Lund and Herwig simulations for quark and gluon jets has been written and accepted by Physical Review D. A paper describing a new type of Dirac equation for the relativistic harmonic oscillator, and finding solutions thereof, has been written and submitted for publication.

Progress in Phenomenology

We have continued our studies of jet labelling (i.e. the ability to discriminate between quark and gluon jets). Let me summarize the different efforts.

A)Comparison of Jet Fragmentation Schemes

In an attempt to estimate the "theoretical error" involved in use of available QCD Monte Carlo jet packages, we have used our 97 bin jet classification scheme (previously published - see Phys. Rev. D42,pp 811-814) to compare the Herwig and Lund packages. We used parameter sets for these two packages fit by the OPAL collaboration to their data for $e^+e^- \rightarrow Z_0 \rightarrow hadrons$; differences should reflect different hadronization treatments.

There are noticeable differences between the Herwig and Lund results; we have summarized these in a paper ("Comparison of Jet Fragmentation Schemes", by Graham, Jones and Daumerie, accepted by Phys. Rev. D). The major point of this paper is that our comparison method should be used with experimental data to see whether either simulation package can reproduce details.

The Herwig-Lund variation found suggests that detailed parameters obtained from fitting simulated data will probably not exactly reproduce real data. Hence, we must find methods of labelling quark and gluon jets which do not rely overly much on details from the theory. Nevertheless, both simulation packages have similar differences between quark and gluon jets; we believe that the "theoretical uncertainty" between quarks in Lund and quarks in Herwig (not to mention real quark jets in data) will not be so great as to make it impossible to distinguish quarks from gluons.

B)Pattern Recognition and Neural Net Studies

We have also devoted a fair amount of effort to learning methods of calculation from other fields which involve "cluster identification", "pattern recognition", etc. These include various neural net techniques, mapping methods, etc. which are designed to allow one to assign a label to a particular pattern of input data.

So far, our efforts have amounted to "brute force" applications of techniques in the literature; these do not do very much better in jet labelling than a careful analysis using our 97 classification bins and the jet mass. However, some of them lead to equally good results with a much smaller number of bins.

We have had some guidance in our study of the neural network, pattern recognition, etc. literature from people at the UIUC Beckman Institute; we must mention in particular Stephane Herbin and Klaus Schulten. This work is still very much in a "start-up" phase. This summer an undergraduate student and a graduate student from the physics department will join L.M. Jones and Mary Ann Graham in this effort; we hope that it will be possible to concentrate a lot of manpower on the problem during that period and settle on one or two "best" methods.

Recently, Mary Ann Graham passed the "prelim" exam; this means that she will be able to concentrate most of her time on research for the PhD thesis. Some aspect of this jet identification project will probably form the bulk of that thesis.

Progress in Theory

The major progress in theory this year has been the discovery by L.M. Jones of a new Dirac equation for the harmonic oscillator. This involves a)finding an (apparently previously unknown) linear equation for the "ordinary" harmonic oscillator, b)extending this to space-time, c)"mating" it with the Dirac gamma matrices to form a Dirac-type equation, and d)finding some classes of solutions. The work is described in a preprint, "Another Dirac Oscillator", which has been submitted for publication.

The Dirac oscillator is of interest to persons attempting wave-function modelling of confined systems (after all, we really can only solve the harmonic oscillator and the hydrogen atom in any great detail, without resorting to numerical methods); it is convenient to have a "toy model" with analytic solutions to play with.

Our interest in the model arose because of a continuing desire to examine systems in which anti-commuting (Grassmannian) coordinates are adjoined to space-time. Efforts are continuing to understand the algebraic structure of the Lorentz group extension to these coordinates . In working with these algebraic relations, it appeared that we would need operators in the ordinary space-time sector which had similar form to those in the Grassmannian sector. The linear operators used in our harmonic oscillator analysis are of this general form.

Papers Prepared During and Close to the Contract Year

"Fermi-Dirac Equations", R. Delbourgo and Lorella M. Jones, Submitted to the Australian Journal of Physics

"Another Dirac Oscillator",Lorella M. Jones, Submitted to Journal of Physics (part A)

"Comparison of Jet Fragmentation Schemes",M. A. Graham, L.M. Jones and P.R. Daumerie, Accepted by Phys. Rev. D.

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