BNL 33016
Conf-830368--1

LATTICE GAUGE THEORIES

BNL--33016

DE83 013114

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April 1983

Talk presented at the Non-Perturbative Quantum Chromodynamics Conference, Oklahoma State University, March 7 - 9, 1983

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LATTICE GAUGE THEORIES

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In the last few years lattice gauge theory has become the primary tool for the study of nonperturbative phenomena in gauge theories. The lattice serves as an ultraviolet cutoff, rendering the theory well defined and amenable to numerical and analytical work. Of course, as with any cutoff, at the end of a calculation one must consider the limit of vanishing lattice spacing in order to draw conclusions on the physical continuum limit theory. The lattice has the advantage over other regulators that it is not tied to the Feynman expansion. This opens the possibility of other approximation schemes than conventional perturbation theory. Thus Wilson used a high temperature expansion to demonstrate confinement in the strong coupling limit. Monte Carlo simulations have dominated the research in lattice gauge theory for the last four years, giving first principle calculations of nonperturbative parameters characterizing the continuum limit.

Before reviewing some of the recent results with lattice calculations, I wish to spend a few minutes reviewing the parameters of the theory of the strong interactions. First of all there are the quark masses. These presumably arise from some grand unification of the forces of nature, and are generally regarded as uncalculable in the gauge theory of the strong interactions alone. Their values are related to the pseudoscalar meson masses, which would vanish in a chirally symmetric world of vanishing quark masses. The remarkable feature of the strong interactions is that these are the only parameters. In principle all dimensionless quantities, such as the ratio of the ρ meson mass to the nucleon mass, are determined once the quark masses are given. This applies not only to mass ratios, but also to quantities such as the pion-nucleon coupling constant which once was considered a possible expansion parameter for a fundamental theory of baryons and mesons.

But what about the strong coupling constant; isn't that a parameter? Indeed, it is not; the coupling drops out of physical quantities via the phenomenon of dimensional transmutation [1], which I will now discuss in the context of the lattice regulator. On a lattice