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QUANTUM THEORY OF FIELDS

Progress Report

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Description of Research Activities

1995-1996

During the period covered by this progress report, we have published the following three research papers:

1. " B_c Spectroscopy in a Quantum-chromodynamic Potential Model,"

S. N. Gupta and J. M. Johnson, Phys. Rev. D **53**, 312 (1996).

Abstract: We have investigated B_c spectroscopy with the use of a quantum-chromodynamic potential model which was recently used by us for the light-heavy quarkonia. We give our predictions for the energy levels and the $E1$ transition widths. We also find, rather surprisingly, that although B_c is not a light-heavy system, the heavy quark effective theory with the inclusion of the m_b^{-1} and $m_b^{-1} \ln m_b$ corrections is as successful for B_c as it is for B and B_s .

2. "Gauge-Boson Scattering Signals at the CERN LHC," S. N. Gupta,

J. M. Johnson, G. A. Ladinsky and W. W. Repko, Phys. Rev. D **53**, 4897 (1996).

Abstract: We have extended our earlier treatment of the gauge-boson scattering with radiative corrections in the standard model at supercollider energies, and computed the rates for gauge-boson scattering modes in pp collisions leading to the final states W^+W^- , $ZZ(4l)$, $ZZ(2l2\nu)$, $W^\pm Z$, and $W^\pm W^\pm$. Our results at the CERN LHC energy of $\sqrt{s} = 14$ TeV for $m_H = 1000$ GeV are compared with those recently obtained by Bagger *et al.* These results will be useful in the search for the Higgs bosons at supercollider en-

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ergies as well as for experimentally distinguishing the standard model from non-minimal Higgs models.

3. "Relativistic Two-photon and Two-gluon Decay Rates of Heavy Quarkonia," Suraj N. Gupta, James M. Johnson and Wayne W. Repko, Phys. Rev. D **54**, 2075 (1996).

Abstract: The decay rates of $c\bar{c}$ and $b\bar{b}$ through two-photon or two-gluon annihilations are obtained by using totally relativistic decay amplitudes and a sophisticated quantum-chromodynamic potential model for heavy quarkonia. Our results for the photonic and gluonic widths of the 1S_0 , 3P_0 , and the 3P_2 states are in excellent agreement with the available experimental data. The procedures and mathematical techniques used by us for the treatment of the fermion-antifermion bound states are also applicable to other decay processes.

The above record of our publications speaks for itself. Our third paper, in particular, on the relativistic two-photon and two-gluon decay rates of heavy quarkonia should be considered a classic. In this paper, we have developed a formalism for the treatment of bound-state decays which is far superior to anything in the earlier literature. We have also resolved the long-standing difficulty of the sharp disagreement between the earlier theoretical values and the experimental data for the decay rates of the paracharmonium S and P states. We have several other decay processes in mind which can also be treated by using our formalism.

An important application of our treatment, which is under active investigation by us, is the decays of the light-heavy quarkonia, especially the B decays. Our treatment is expected to lead to an improved determination of

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the CKM parameter V_{bc} .

We have also been making progress in exploring several other problems of current interest which were outlined in our last renewal proposal.

The principal investigator has fully complied with the contract requirements. He has devoted to the project 50% of his time during the academic year and 100% of his time during two summer months, and this pattern will be followed during the remainder of the current contract term.