

## 1. Applications of Lattice QCD .....

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Quantum Chromodynamics (QCD) is one of the most interesting quantum field theories, exhibiting phenomena such as asymptotic freedom and confinement. Not only is it theoretically fascinating, it appears to be the correct physical model describing hadron structure and dynamics. In order to calculate properties of hadrons directly from QCD, numerical techniques must be used. Your essay should describe *briefly* the formulation of lattice QCD and how it is amenable to Monte Carlo computation.

The essay should then discuss the application of lattice QCD to *one* of the physically interesting problems listed below. Each application has some interesting theoretical questions which must be confronted by lattice methods. Explain how lattice QCD will further our understanding of the chosen application, and discuss the theoretical challenges and possible solutions which are discussed in the literature.

- Probing electroweak symmetry breaking and physics beyond the Standard Model through flavor-changing interactions
- QCD at high temperatures: the confinement-deconfinement transition
- Light hadron spectrum and structure (especially nucleon structure)
- Hadron-hadron bound states and scattering (especially 2 nucleons)

This is a broad field; do not go into depth into more than a couple issues. Use your own discretion regarding the focus of the essay, but seek my advice if you need more direction. Many useful papers, including pedagogical reviews, can be found on-line using hep-lat (<http://arXiv.org>) and SPIRES (<http://www-spires.dur.ac.uk>). Consult me regarding references for specific applications.

### Relevant Courses

*Essential:* Quantum Field Theory

*Useful:* The Standard Model

### References

M. Creutz, *Quarks, Gluons, and Lattices*, Cambridge Univ. Press, 1983.

I. Montvay and G. Münster, *Quantum Fields on a Lattice*, Cambridge Univ. Press, 1994.

J. Smit, *Introduction to Quantum Fields on a Lattice: A Robust Mate*, Cambridge Univ. Press, 2002.

A. Kronfeld, “Uses of Effective Field Theory in Lattice QCD,” hep-lat/0205021.