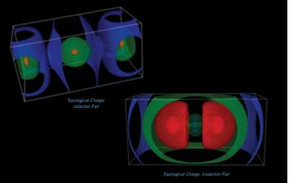
19

LATTICE QUANTUM CHROMODYNAMICS

THE SCIENCE

Quantum chromodynamics (QCD) is the study of how the quarks and gluons that make up hadrons (such as neutrons, protons, and pions) interact through the strong force. This requires the study of interactions at distances smaller than the diameter of a proton, about 10^{-15} meters across. The type of numerical simulation that physicists use to solve these problems is called lattice quantum chromodynamics (LQCD).

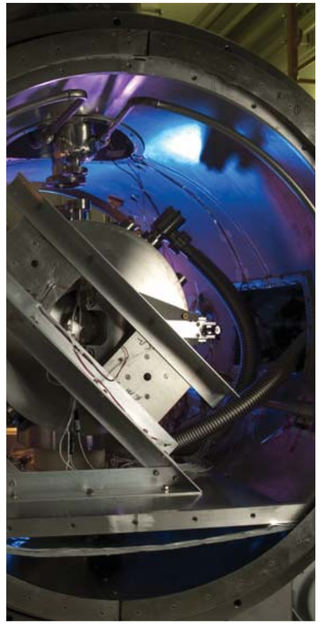


Topological Charge: Instanton Pair

THE STUDY OF HOW QUARKS AND GLUONS INTERACT THROUGH THE STRONG FORCE

18

17

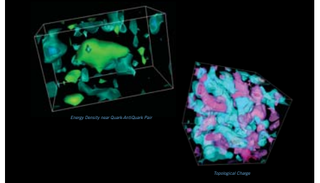


16

LATTICE QUANTUM CHROMODYNAMICS

THE COMPUTATIONAL PROBLEM

LQCD numerical simulations are critical to our fundamental understanding of processes described by the Standard Model of Physics, as well as descriptions beyond the Standard Model. LQCD simulations require the largest available high performance, parallel, computing resources, with state-of-the-art simulations consuming 10s to 1000s of TFlop/s-years. USQCD, a large group of collaborating US lattice theorists, is successfully exploiting GPUs running parallel codes, achieving up to a 10-fold increase in performance per dollar compared to conventional clusters.



Energy Density near Quark-AntiQuark Pair

Topological Charge

A NUMERICAL PROBLEM REQUIRING THE LARGEST PARALLEL COMPUTATIONAL RESOURCES

15

14

OUTSIDE