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*Major Research Interests:* **Lattice gauge theory; discretizations of (i) Atiyah–Singer index theory, (ii) topological quantum field theories, and (iii) the Hodge star operator in computational electromagnetism**

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### **Interplay of mathematics and physics: Atiyah—Singer index theory and gauge theories of particle physics:**

Atiyah—Singer Index Theory, which relates the solution space of certain types of partial differential equations (PDEs) to topological data of the PDE, is a highlight of modern mathematics. It also has major physical consequences in gauge theories of particle physics where it implies a connection between fermionic zero-modes and gauge field topology. This explains, e.g., the large mass of the eta' meson in the theory of the strong nuclear interactions. Furthermore, a families version of index theory elucidates the anomalies whose presence spoils the consistency of certain types of quantum field theories known as chiral gauge theories (which includes the unified Standard Model of particle physics). This leads to anomaly cancellation conditions which restrict the allowable particle contents of such theories.

### **Lattice gauge theory and the challenge of developing a discrete version of index theory:**

Currently the only first principles approach to gauge theories (beyond perturbative expansions) is to formulate them on a space—time lattice. However, it is a major challenge to determine if and how the physical implications of index theory are captured in the lattice formulation. This amounts to developing a discrete version of index theory, a topic of major mathematical interest in its own right. It is a subtle problem, because straightforward discretization leads to vanishing index due to the appearance of spurious rough solutions of the discrete PDE. However, ways to deal with these have been developed, and progress towards a discrete version of index theory is promising. This is the main focus of my current research.

### **Other topics:**

I also work on other mathematical and theoretical issues in lattice gauge theories. Besides that, another of my topics is discretization of topological quantum field theories. There the goal is to derive new combinatorial descriptions of various topological invariants arising in these theories by capturing them exactly in the discrete model. Finally, I am also interested in the problem of discretizing the Hodge star operator, which is important in computational electromagnetism. A lesson from my earlier work on topological QFT is that the Hodge operator should be discretized in a lattice—dual lattice framework in order for topological quantities such as linking numbers to be correctly captured.

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### **Selected Publications**

D. H. Adams, *Pairs of massless quarks on the lattice.*  
Phys. Rev. Lett., submit 2010

D. H. Adams, *Theoretical foundation for the Index Theorem on the lattice with staggered fermions.*  
Phys. Rev. Lett., accepted, to appear in 2010

D. H. Adams, *Simplified test of universality in Lattice QCD.*  
Phys. Rev. Lett. 92:162002 (2004)

D. H. Adams, *Index of a family of lattice Dirac operators and its relation to the non-abelian anomaly on the lattice.*  
Phys. Rev. Lett. 86, 200 (2001)

D. H. Adams, *Doubled discretization of abelian Chern—Simons theory.*  
Phys. Rev. Lett. 78, 4158 (1997)