Symmetries, Fields and Particles (M24)

Ben Allanach

Lie groups and Lie algebras are important in the construction of quantum field theories which describe interactions between known particles. Gauge theories, which describe many of the interactions in the Standard Model, rely on them. After some other preliminaries, we introduce representations in terms of square matrices. The group of rotations in three-dimensional space $SO(3)$ is covered, along with $SU(2)$ and the connection to angular momentum. Relativistic symmetries are discussed: in particular, the Lorentz and Poincaré groups and quantum fields. Lie groups and Lie algebras are covered in more generality, focusing on $SU(3)$ as a useful example. An overview of the results of the Cartan classification of simple Lie algebras is included. Finally, gauge theory is introduced.

Pre-requisites

Linear algebra including direct sums and tensor products of vector spaces. Special relativity and quantum theory, including orbital angular momentum theory and Pauli spin matrices.

Literature

1. *Lie Algebras in Particle Physics*, H. Georgi, Westview Press, 1999.

2. *Representations and Physics* 2nd edition, Taylor and Francis, 1998.

Additional support

Four examples sheets will be provided and associated examples classes will be given. There will be a revision class in the Easter Term.