



# École doctorale de Physique en Île de France

ED564 : PSL – SU – UP – UPSaclay

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## Spin, topologie et géométrie

Alexei Chepelianskii (LPS Orsay)

### 1) SO(3) - some spin matrix properties and introduction to Lie algebras

Spin generators - transformation properties under rotation and time reversal.  
 Construting rotationally invariant Hamiltonians: example Luttinger Hamiltonian for semiconductors, graphene.  
 Examples of applications of the Wigner-Ekkart theorem (photo-emission for Si, HgTe band structure and BHZ model)

Introduction to Lie algebras : spin generators as an exemple of a Lie Algebra. Reconstruction of the group from the Lie algebra, example of calculations in quantum mechanics using the regular representation. Some elements of differential geometry.

### 2) Topology in condensed matter

Quantized Hall conductance and Chern numbers  
 Skyrmions and its topological invariant, the degree of a map  
 Z2 topological insulators (Volkov-Ponkratov, BHZ, Kane & Mele)

### 3) Introduction to Gauge theories - connections and topology

Group invariant measure (Haar measure)  $g^{-1}$  and sampling off random elements from SO(3)  
 From invariant form  $g^{-1} dg$  to principal bundles, general form of a connection and introduction of the curvature tensor  
 Example of connections and curvature tensors :  
 Affine connections from moving frames, examples of Levi-Civita connections  
 Berry connection, Berry curvature  
 Yang Mills action  
 Chern classes

-- 5 séances de 2h chacune --

**Location: Laboratoire de Physique des Solides, moyen amphi  
 bât.510, Université Paris-Sud, ORSAY**

**Dates: June, 10<sup>th</sup>, 17<sup>th</sup> and 24<sup>th</sup>, July 1<sup>st</sup> and 8<sup>th</sup>**

**Hours: 10:00-12:00 a.m.**

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