

# GROUP THEORY IN QUANTUM MECHANICS

Ingredients:

Noether theorem: *Any differentiable symmetry of the action has a corresponding conservation law.*

Homogeneity in time – energy conservation

Homogeneity in space: – momentum conservation

Isotropy in space: – angular momentum conservation

Wigner theorem: The wave functions belonging to a given eigen energy  $E$  transform along a representation of the group  $G$  of the Schroedinger equation

$$H\psi(\{x\}) = E\psi(\{x\})$$

$$HR\psi(\{x\}) = ER\psi(\{x\}).$$

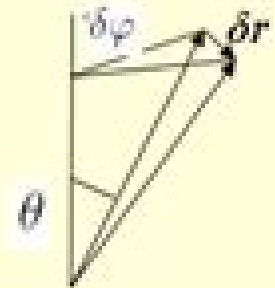
Infinitesimal operators as generators of Lie algebras

These operators perform infinitesimal translations and rotations in space time and form the basis of irreducible representations of continuous Lie groups. Example: rotations on a 3D sphere

$$J_z = -i \frac{\partial}{\partial \varphi}, \quad J^{\pm} = e^{\pm i \varphi} \left( \pm \frac{\partial}{\partial \theta} + i \cot \theta \frac{\partial}{\partial \varphi} \right)$$

$$J^2 = - \left[ \frac{1}{\sin^2 \theta} \frac{\partial^2}{\partial \varphi^2} + \frac{1}{\sin \theta} \frac{\partial}{\partial \theta} \left( \sin \theta \frac{\partial}{\partial \theta} \right) \right] \sim \Delta(\theta, \varphi)$$

Laplacian  $\Delta$  is invariant under transformations in Euclidean space. In case of rotation group  $SO(3)$  we deal with  $\Delta(\theta, \varphi)$  invariant under rotations on the sphere.



# Quantum Group Symetry And Qtensor Algebras

**Emilie Sanchez**



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