FYS5190/FYS9190 - Supersymmetry

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Scheduling

• **Monday 10.15 & Friday 12.15:** lectures ~ every week in FØ467 until end of November (~ 14 weeks).

• **Detailed lecture plan** on home-page.

• **Home-exam/project (20%)**: Need to agree on time for exam (which week).

• **Exam (80%)**: Oral exam some time in December. Need to agree on day.
Curriculum

- **Lecture notes** are provided (to be updated).
Curriculum

- Weeks 1-4: The algebraic origin of SUSY.
- Weeks 5-6: Construction of a low-energy SUSY Lagrangian.
- Weeks 7-9: The Minimal Supersymmetric Standard Model (MSSM).
- Week 10: Practical calculations in the MSSM.
- Week 14: SUSY Dark Matter
- Week 15: Variations on the MSSM (if time).
First week

- **Today:** some practical information, group theory basics.
- **Friday:** more group theory. Hopefully we manage Chapter 1 of the lecture notes during the first week.
- **Monday next week:** Poincaré group/algebra (the fundamental symmetry of Special Relativity).
- So, in fact no SUSY in sight...
Symmetries in physics

• We know Einstein's (Lorentz’) symmetry well. Lengths of external four-vectors are invariant:

\[ x^\mu \rightarrow x'^\mu = \Lambda^\mu_\nu x^\nu, \quad x'^2 \equiv x'^\mu x'_\mu = x^\mu x_\mu \equiv x^2 \]

• This can be extended to the Poincaré symmetry:

\[ x^\mu \rightarrow x'^\mu = \Lambda^\mu_\nu x^\nu + a^\mu, \quad (x' - y')^2 = (x - y)^2 \]

• Noether’s theorem: continuous symmetry ⇔ conserved quantity

• The basis of energy–momentum conservation.
(Super)symmetries in physics

• We also have **internal** gauge symmetries:

\[ SU(3)_c \times SU(2)_L \times U(1)_Y \]

• These symbols represent transformations of the fields in the SM that leave the Lagrangian (action) invariant.

• Supersymmetry asks:
  
  − Can the Poincaré symmetry be extended? Yes.
  
  − Can we unify internal and external symmetries? Yes, but not the way we would have liked...