



# Automatic Leptonic Tensor Generation for BSM Models

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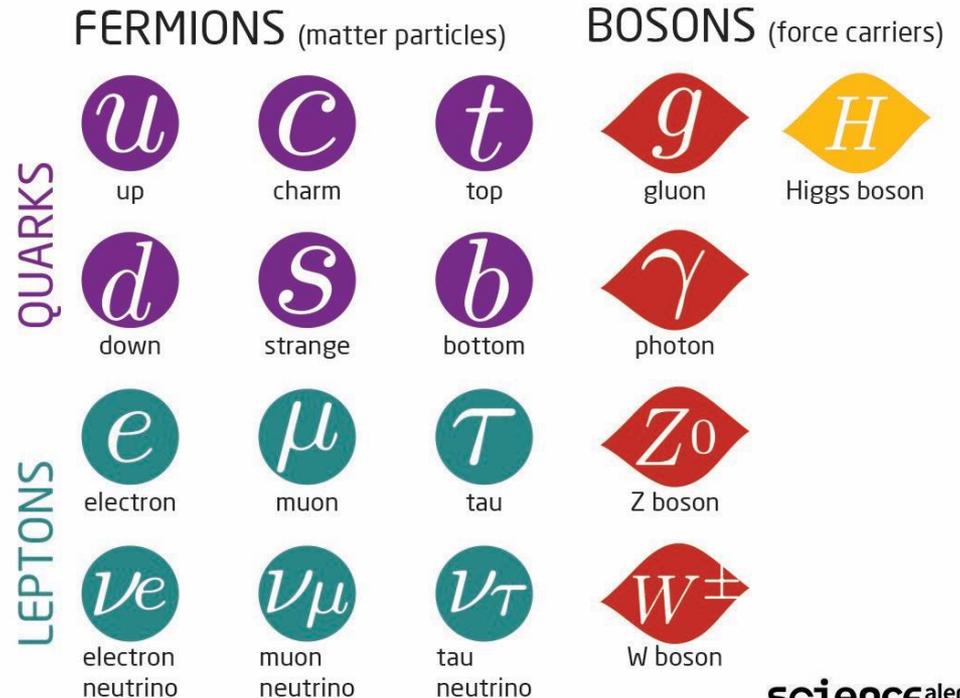
Five Minutes Five Slides - SIST

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# The Standard Model of Particle Physics

- Theory of the EM, weak and strong interactions.
- Describes most phenomena in nature to high accuracy.
- Is *not* complete.
  - Gravity.
  - Dark matter or dark energy.
  - Matter-antimatter asymmetry in the universe.
  - Neutrino oscillations.
  - And many more.

## The Standard Model of Particle Physics



# Beyond the Standard Model (BSM) Theories

- Attempts at explaining phenomena beyond the SM.
  - Examples: Supersymmetry, heavy neutrino models, sterile neutrino models, etc.
- Processes too complex to be evaluated by hand.
- Event generators → Simulate particle physics events.
  - Predictions compared to experiment.
  - Discrepancies could show hints of new physics.
  - Was the BSM theory accurate?
- Problem:
  - Time to implement 1 BSM theory by hand in an event generator: ~1 year.
  - Many BSM theories to be tested. Unfeasible.
  - Solution: automation.

# UFOs, ALOHA and MadGraph 5

- Universal FeynRules Output (UFO):
  - Load BSM model on Mathematica. Output UFO file.
  - Python format compatible with most LHC event generators.
  - Contains all information about the theory (e.g. particles, parameters, vertices, etc.)
- Automatic Language-independent Output of Helicity Amplitudes (ALOHA):
  - Input: UFO files.
  - Output: library with complete set of objects (e.g. wavefunctions) to compute Feynman diagrams.
- MadGraph 5:
  - Monte-Carlo event generator.
  - Input library from ALOHA. Output desired simulations (e.g. cross sections.)

# Our Project

- UFO + ALOHA + MadGraph 5:
  - Problem solved only for LHC physics.
- My project:
  - Develop a similar automatization process for *neutrino* BSM models.
  - Use of UFO files as starting point to compute Feynman rules of BSM theories.
  - More specifically:
    - Automatic calculation of leptonic tensor for neutrino calculations.
    - Lepton tensor + Hadronic tensor  $\rightarrow$  Measurable quantities.

