

Fundamental Constituents of Nature ?

*“ can be characterized by
examining how they transform
under the symmetries as*

translations, rotations, ... ”

Mass

Spin



E. Wigner

Spin



0 Higgs Boson (origin of mass)

1 Photon, W&Z Bosons, Gluon
(EM, Weak, Strong interactions)



gravity



strong force

2 Graviton (gravitational interaction)



weak force



electromagnetism

Massless particles → **Gauge Symmetry**

3

Massive higher spin particles : **composites**

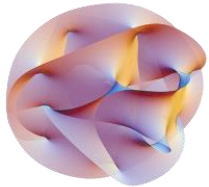
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⋮

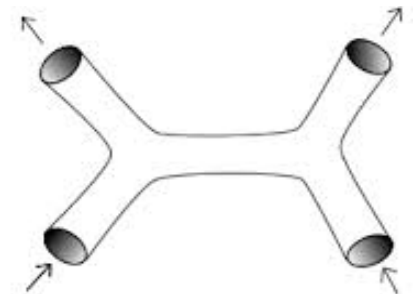
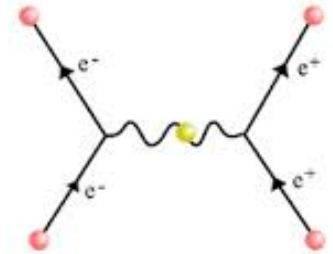
Quantization of Gravity

Quantum Theory of Gravity with infinitely many higher spin particles



String Theory

- Fundamental constituent : **string**
 - ✓ Different vibration \rightarrow Different particle (m, s)
 - ✓ Candidate for Unification
- Higher spin particles are all **massive**



Quantum Theory of Gravity with infinitely many higher spin particles



Higher Spin Gravity

- Higher spin particles are all **massless**
- Symmetry Breaking → **String Theory**
- Infinite **Gauge** Symmetries
 - severe restriction on interactions
 - (almost) uniquely fixes the theory

