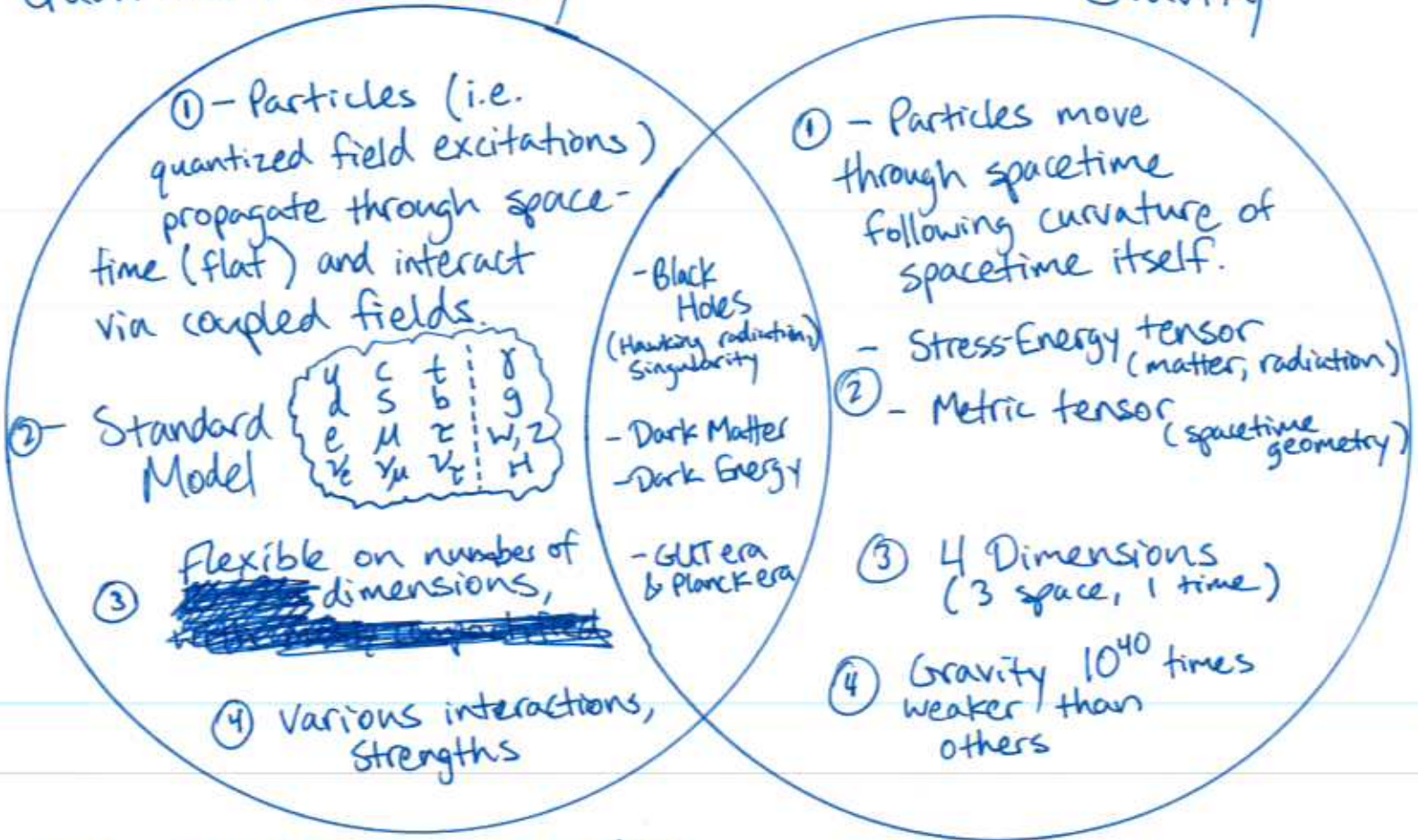


Toward a Quantum Theory of Gravity

Quantum Field Theory

Gravity



Math: Based on gauge symmetry, start with "Lagrangian" that describes energies/particles:

$$\mathcal{L} = (\text{quarks \& gluons}) + (\text{electro magnetism}) + (\text{weak interactions}) + (\text{Higgs mechanism}) + \dots$$

includes free fields, fermion fields, boson interactions, Higgs. Math can convert \mathcal{L} into relevant equations of motion

VERY DIFFICULT to add some gravity interaction, doesn't fit format

Math: Einstein field equations relate stress-energy tensor to metric:

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

includes spacetime curvature and mass/energy (cosmological constant optional)

VERY DIFFICULT to include more complex interactions or particles.

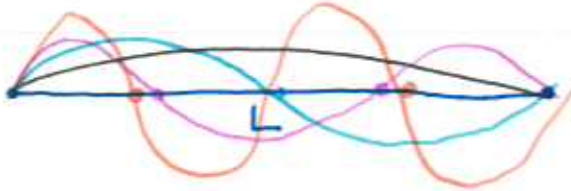
Hope remains: String Theory, AdS/CFT duality

String Theory

Attempt to reconcile QFT and gravity by replacing concept of a point particle with a tiny loop of string.

Just as a ^{real} string can vibrate in modes of half-integer wavelength, the loop of string can take on vibrational modes

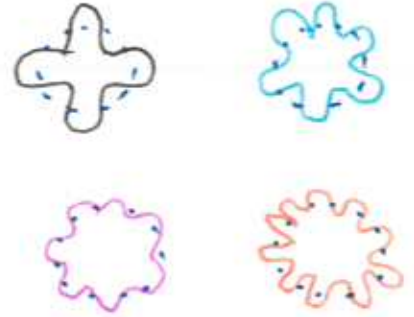
REAL STRING



- Ground state
- Level 1 (~~1~~ antinode)
- Level 2 (2 antinodes)
- Level 3 (3 antinodes)
- Level 4 (4 antinodes)

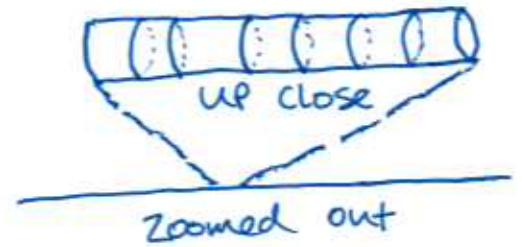
STRING THEORY


 diameter
 \sim Planck length
 1.6×10^{-35} m



The Different vibrational modes = different particles
 All particles "made of" vibrating strings

In order to describe all particles & their characteristics, the strings vibrate in extra dimensions. These "compactified dimensions" are like the surface of a long wire; up close they are traversable dimensions but from afar the wire is 1D.



Treating particles as strings simplifies the treatment of interactions, as in Feynman diagrams:

