The Holographic Principle

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Black hole information problem

- A classical (non-QM) black hole only has three properties: m, L, Q
- If matter drops in, all information about matter is lost => net decrease in entropy
- A non-QM black hole connected to QM-matter violates 2nd law of thermodynamics ("information loss problem")

Bekenstein

- Black holes have entropy themselves
- Assume that black holes have maximum entropy in their volume, how large would entropy be?
- Bekenstein: Take relativistic gas in fixed volume, heat it up (increase energy) until critical density is reached => calculate entropy

Bekenstein's finding

Entropy proportional to AREA of black hole!

Hawkins

- Area of black hole always increases with time (similar to 2nd law of thermodynamics)
- Consider light rays close to surface of black-holes, try to equilibrate black hole with hot photon gas
- => Compute entropy proportional to b.h. AREA (and fix prop. constant to 1/4)

Hawkins

- A
t
- C
h
p
- => Compute entropy proportional to b.h. AREA (and fix prop. constant to 1/4)

(It still doesn't solve unitarity problem, though)

Holographic principle

- Basically says that **all information contained in a volume is contained in its boundary, i.e. an area!**
- Somewhat puzzling, because it is very counter intuitive (Entropy increases proportional to R^2, not R^3)
- Does not rely on string theory or even supersymmetry

Only black holes?

- The following is very speculative:
- Extensions say that also information of ordinary mass is contained in the surface and not the volume
- Thus, Universe might only be 2-dim
- Hence, it is a "hologram" with information inscribed on the surface of the boundary

Maldacena conjecture

- Holographic principle with a gauge theory!
- It involves dynamics, not just static properties
- But uses supersymmetry and supergravity
- Information contained in a d-dim. volume (sugra) is described by a theory on the (d-1,2,...)-dim. surface (susy gauge theory)