Astronomy 353

(Spring 2007)

ASTROPHYSICS: From Black Holes to the First Stars

(Lecture 26: Epilogue: The Cosmic Frontier)

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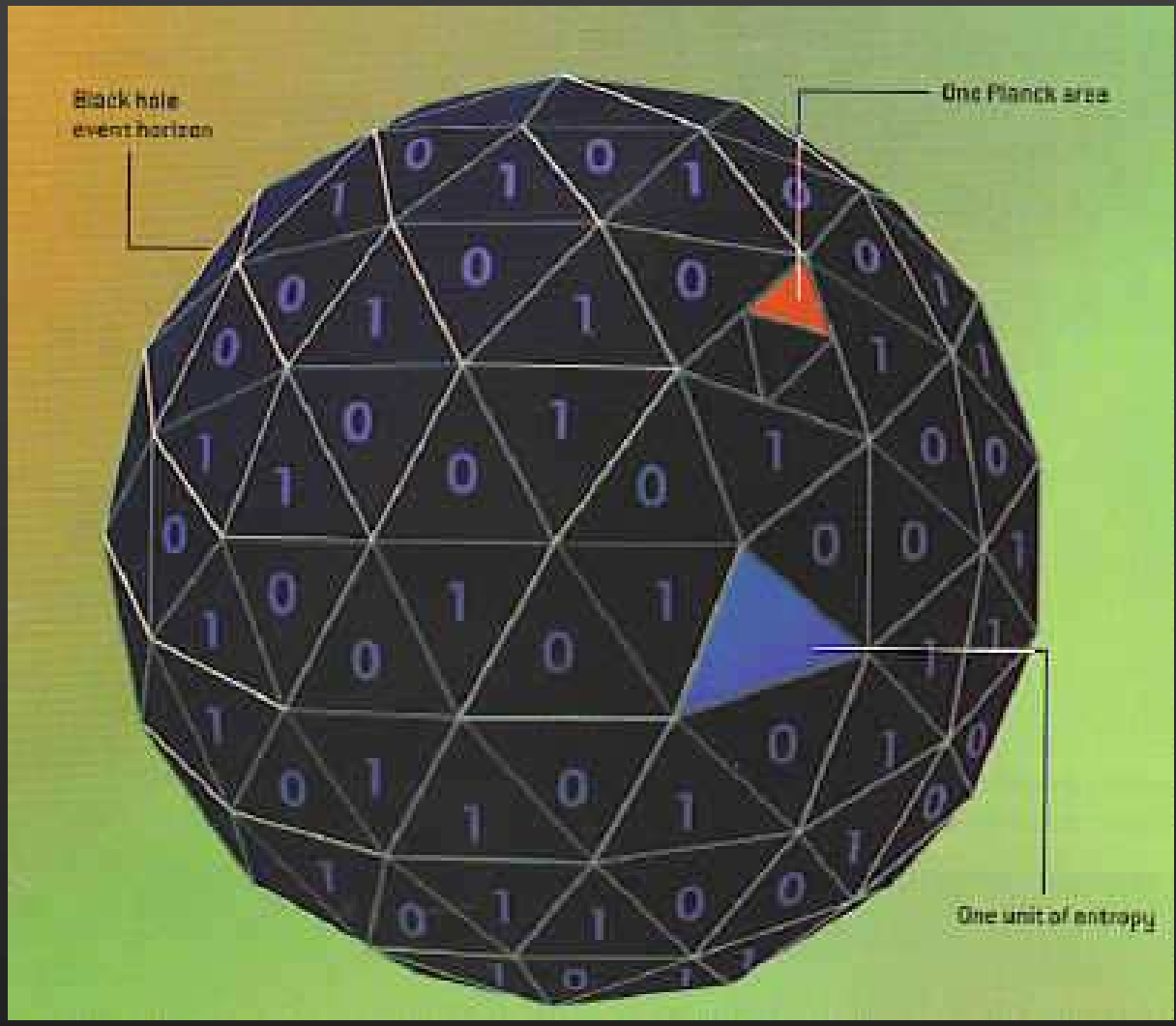
Information Content of Black Holes



$$S_{BH}=k_B 1/4\ A_{BH}/A_{PL}$$

Information Content of Black Holes

- Calculate BH entropy:

$$S_{BH}=k_B\ 10^{77}\ (M/M_o)^2$$

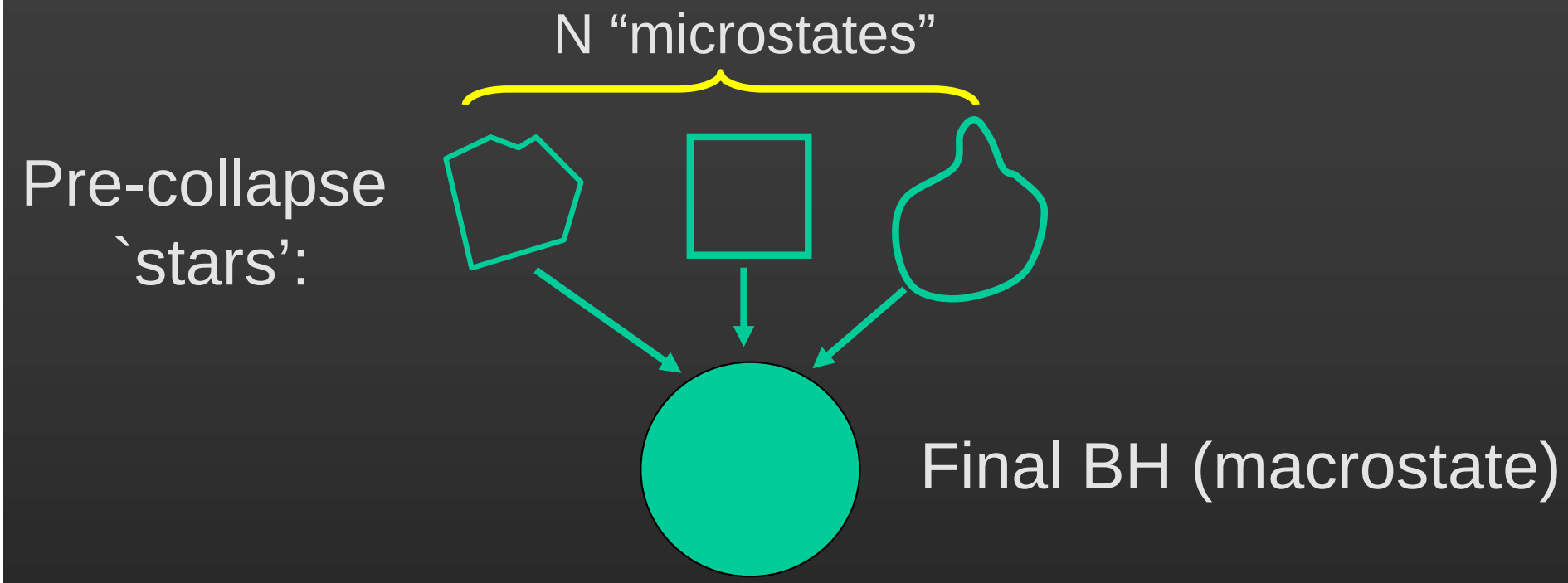
à This is HUGE! (Cf. Sun's entropy: $S_o \sim k_B\ 10^{58}$)

-Q: Why is BH entropy so large?

à A: connected to `no-hair theorem'!

Information Content of Black Holes

- Interpretation of BH entropy:



-No-hair theorem: Almost all pre-collapse stars (microstates) will end up as SAME BH (macrostate)!

$k_B\ 10^{77} \sim S = k_B \ln N$

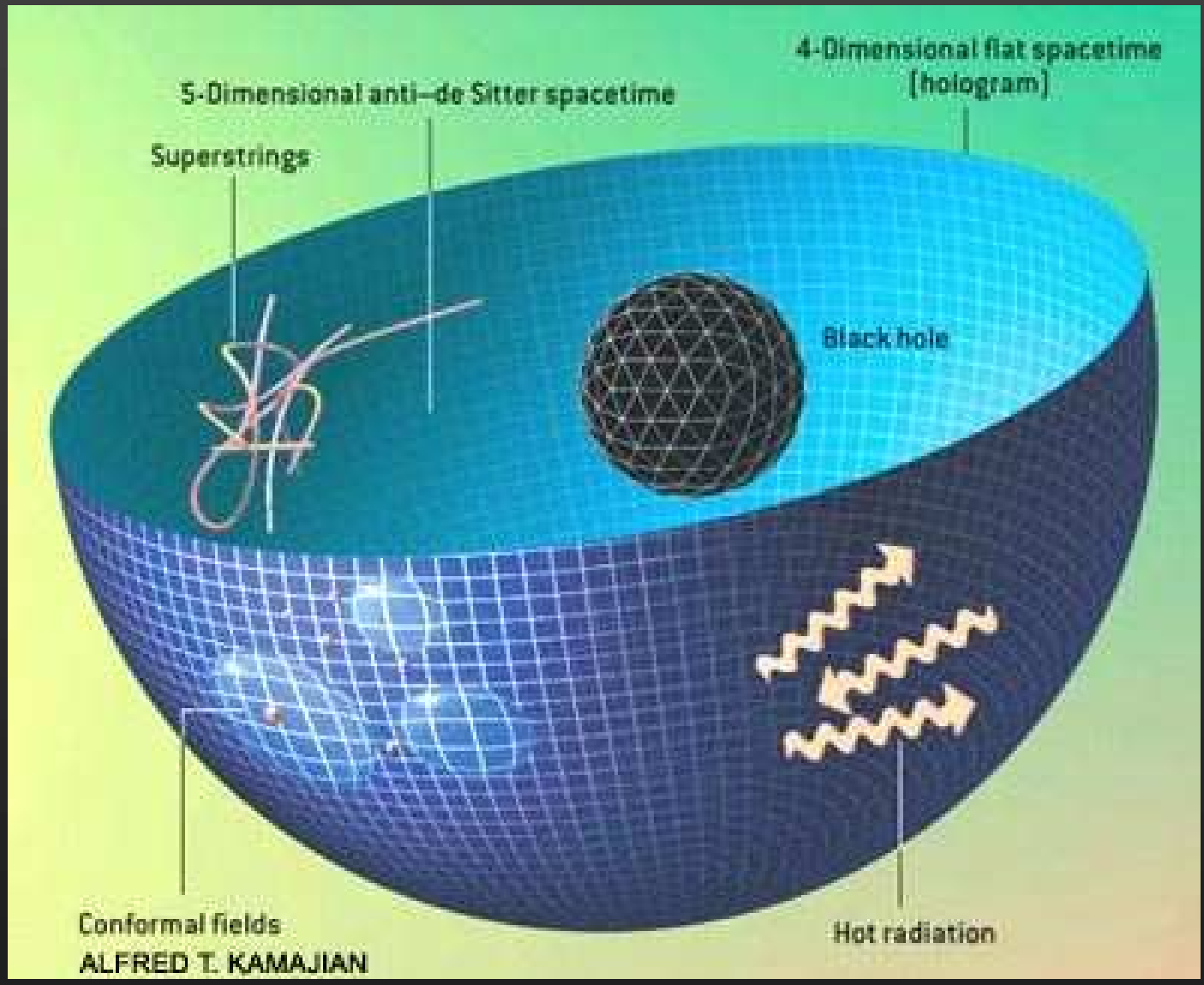
à $N \sim \exp(10^{77}) \sim 10^{10^{77}}$

Black Holes and the Holographic Principle

-Holographic principle: physics in interior nD spacetime

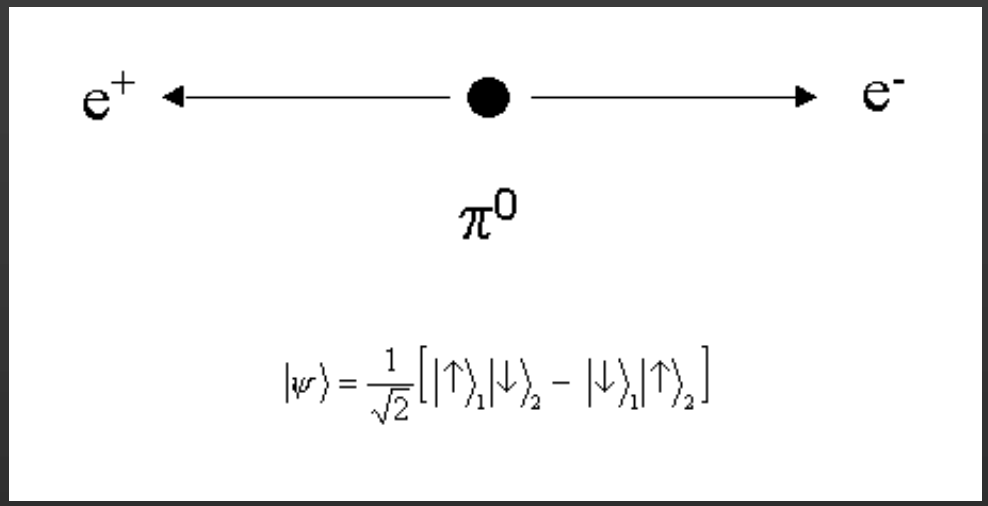
equivalent to physics on (n-1)D surface spacetime!

Black Holes and the Holographic Principle



Black Hole Computers

EPR (Einstein-Podolski-Rosen) pair

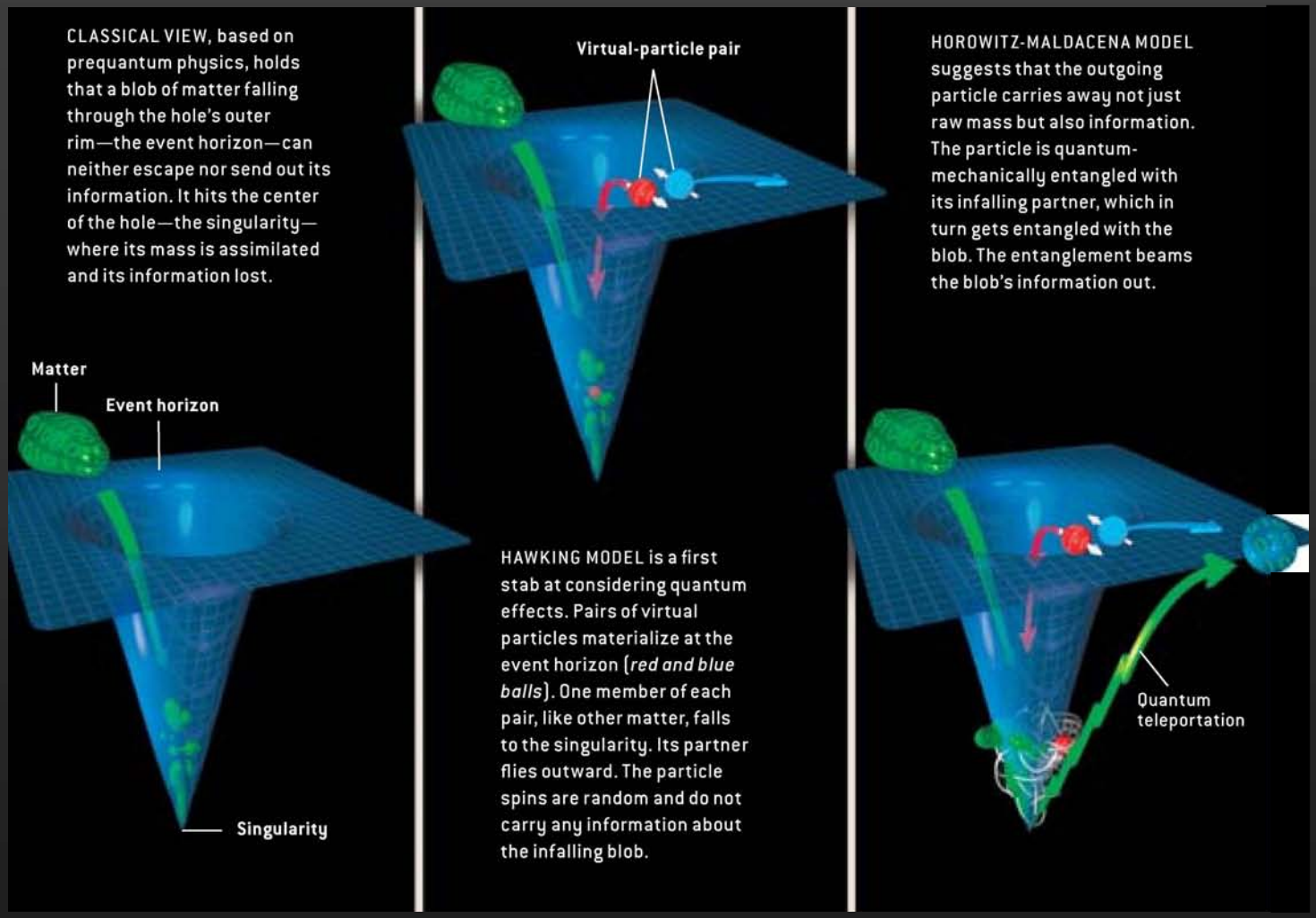


- (quantum-) entangled state

-Measurement at location of one particle immediately known at partner particle

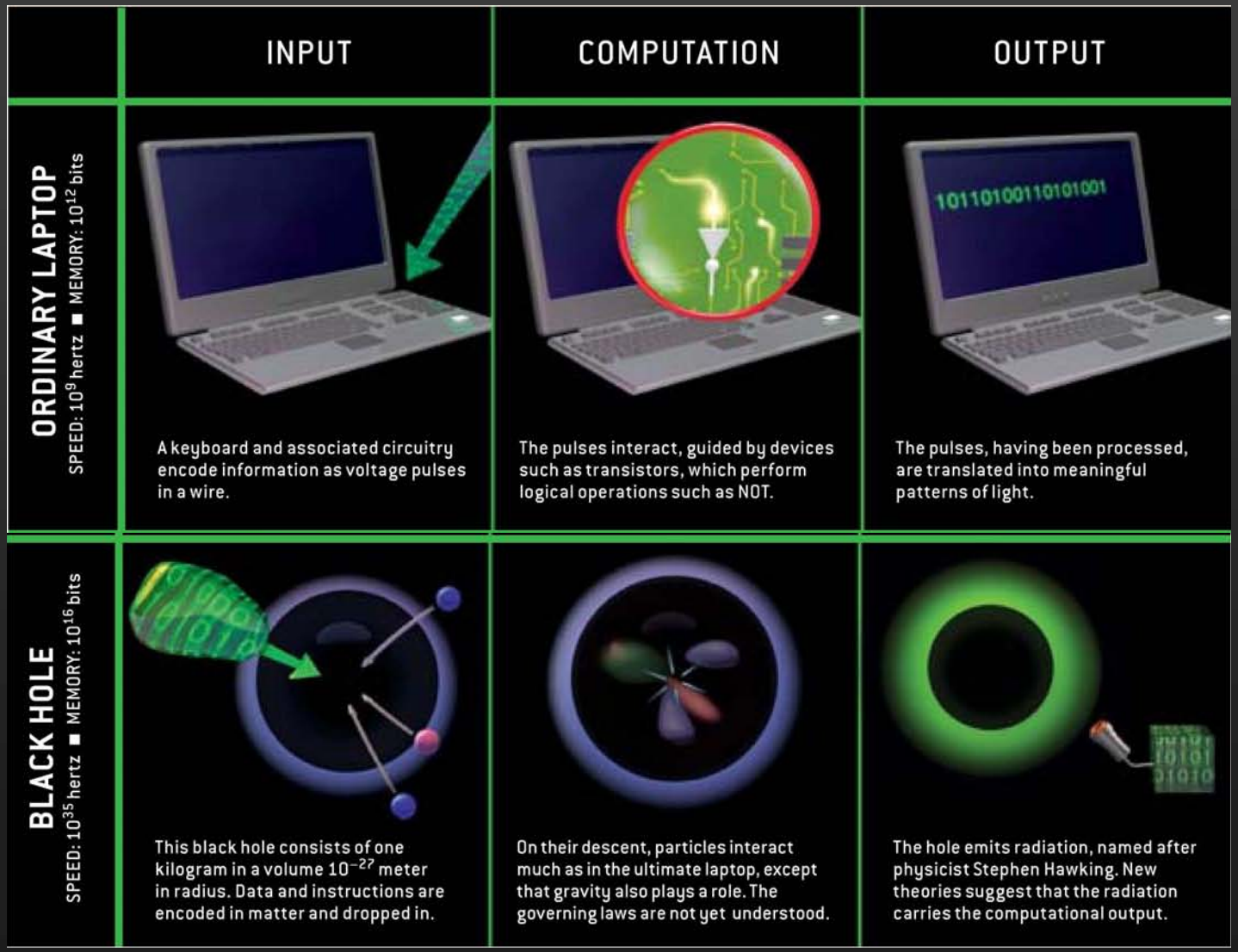
à “Quantum teleportation”

Black Hole Computers

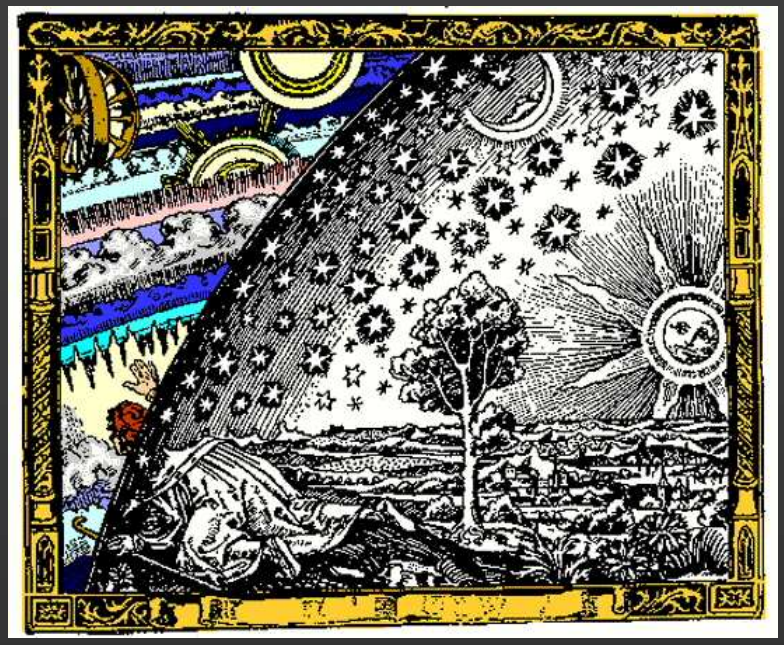


Black Hole Computers

Three steps of computation



Perspectives:



- Astrophysics is a fantastic subject!
- Black holes lead us to the frontier of modern physics
- First Stars lead us to the frontier of cosmology
- We are entering a golden age of discovery