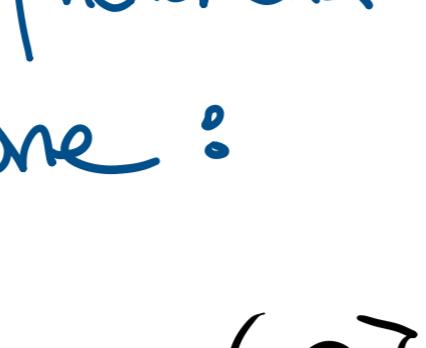


Administrivia.

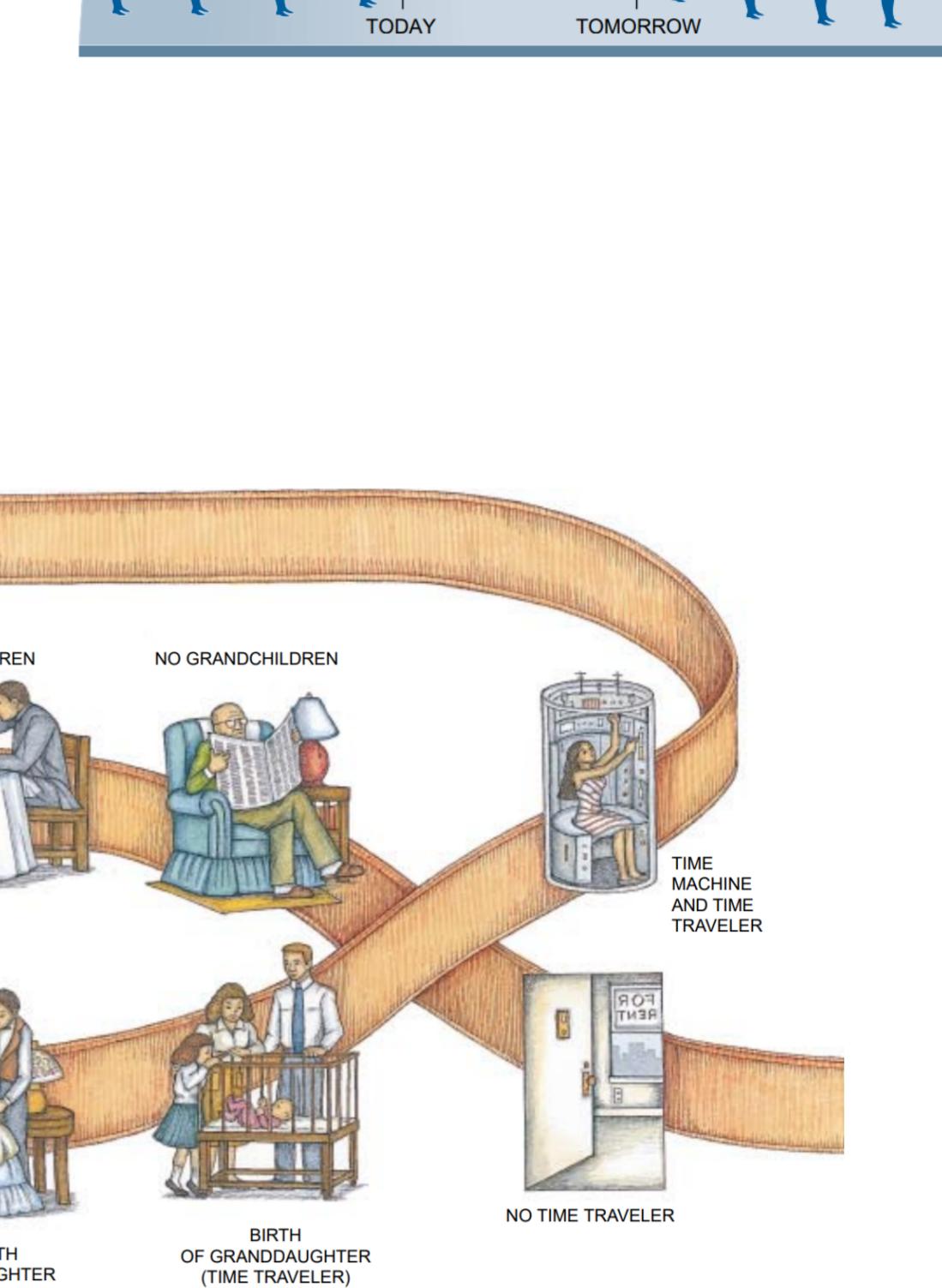
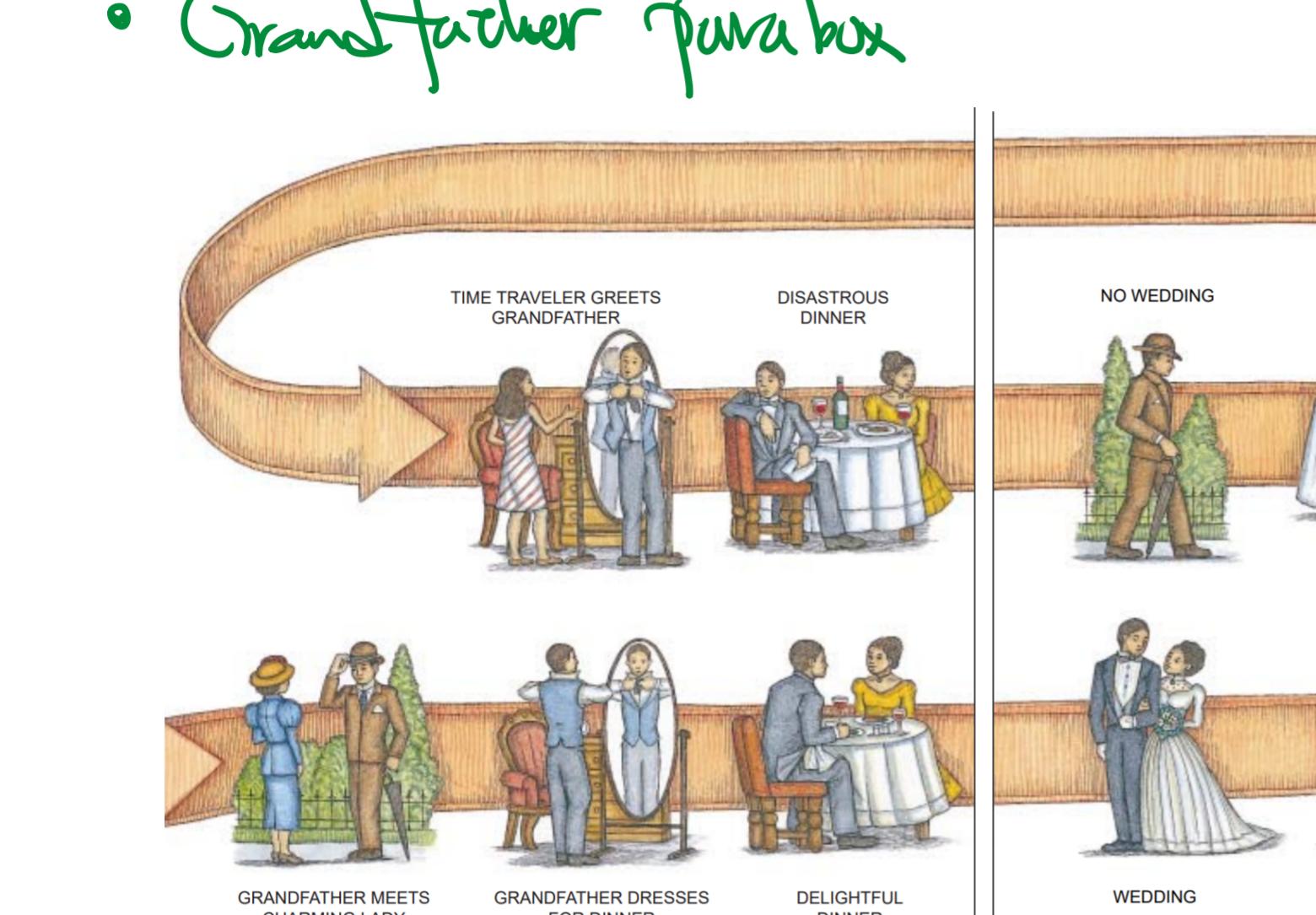
- Final should be out by today



How do we use new phenomena as resource?

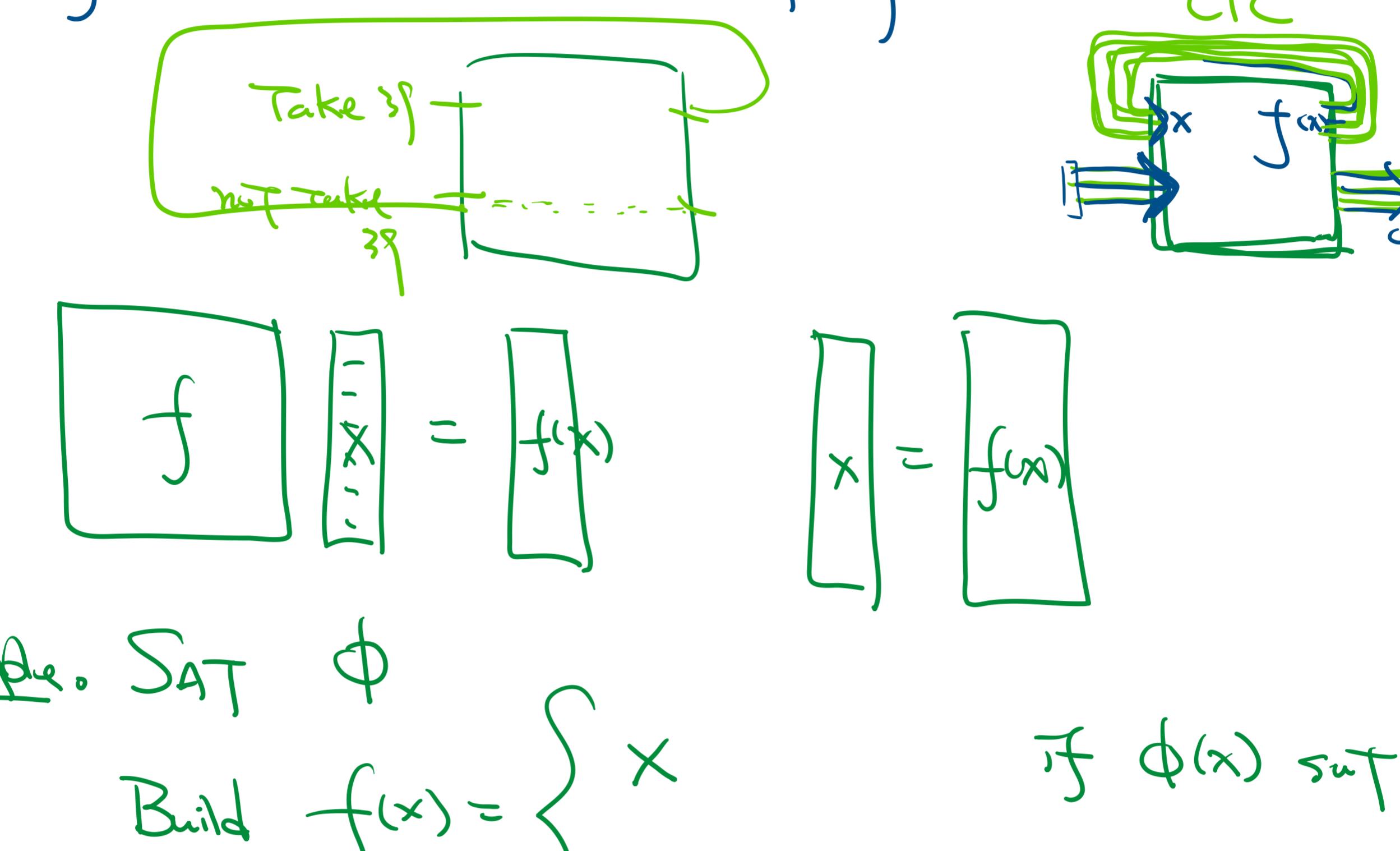
Start w/ a basic one:

### Closed Timelike Curves (CTCs)



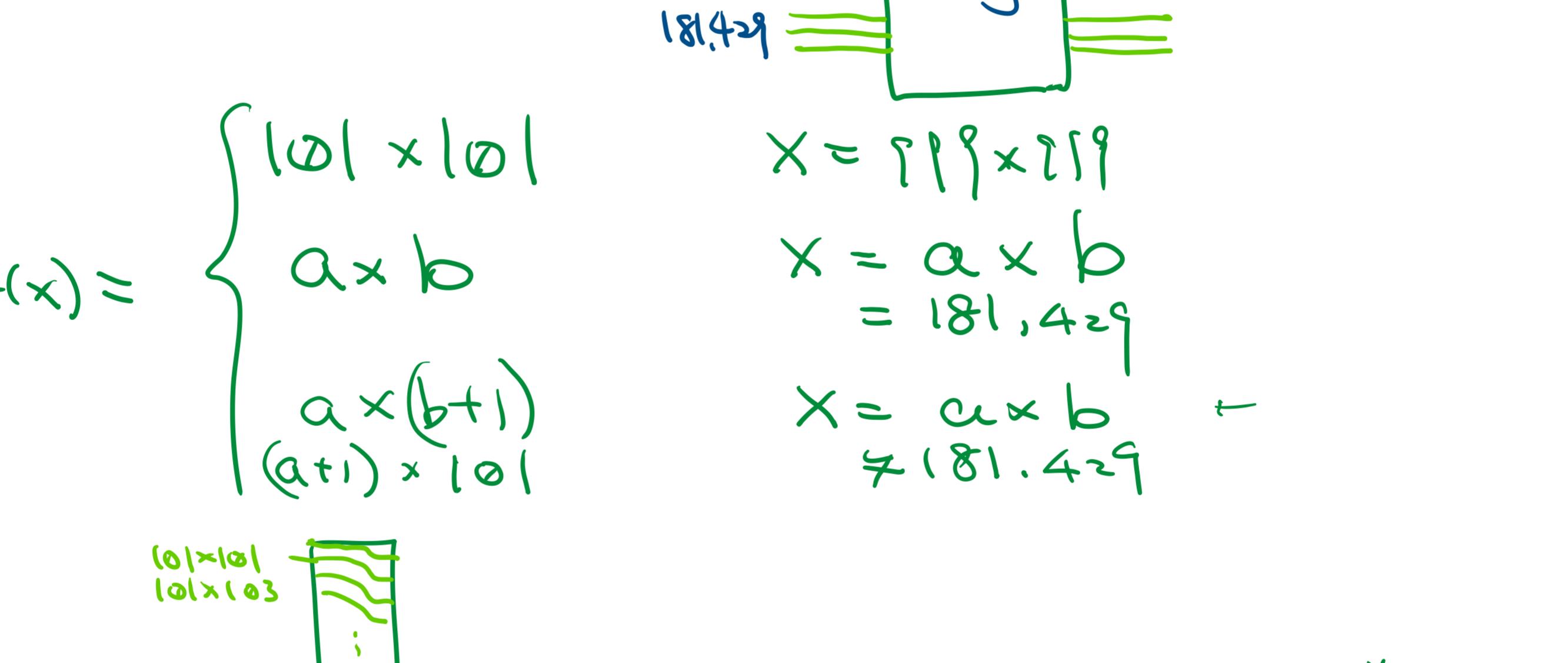
### Obvious Problems:

- Grandfather paradox



### Deutsch Model [Deutsch '91], [Bruun '03], [Bacon '07] [Aarøsen-Watson '08]

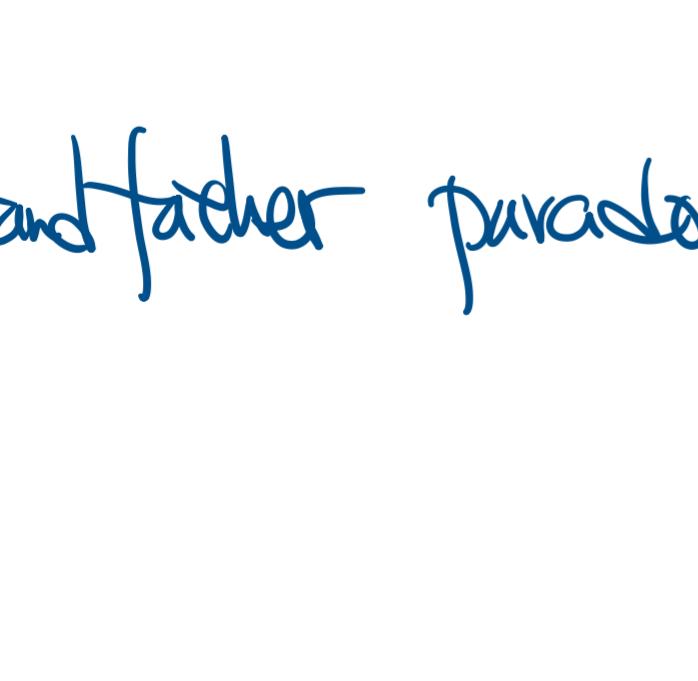
- key idea: causal consistency.



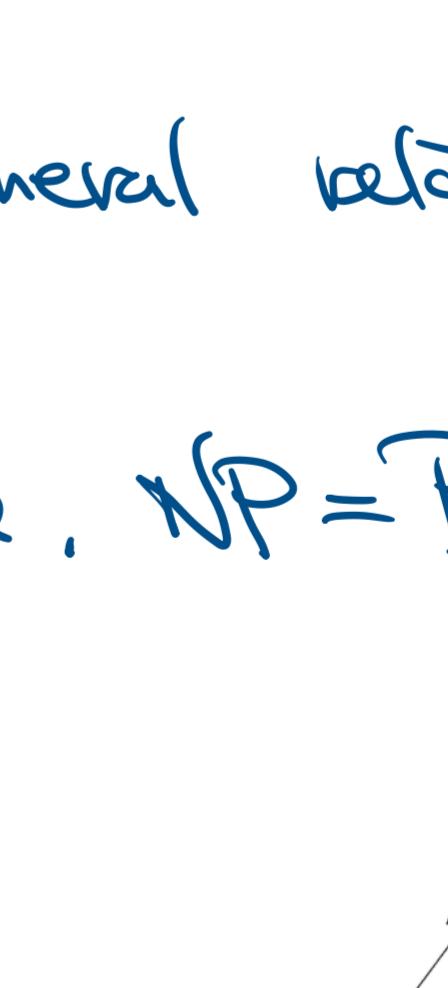
### Example. SAT $\phi$

$$\text{Build } f(x) = \begin{cases} x & \text{if } \phi(x) \text{ sat.} \\ (x+1) \bmod 2^n & \text{if } x \text{ not sat.} \end{cases}$$

yes-list ( $\phi$  sat).



no-list ( $\phi$  no-sat).



### Example. [CHPMOR, Ch17].

$$181,429$$

$$f(x) = \begin{cases} 101 \times 101 \\ axb \\ a \times (b+1) \\ (a+1) \times 101 \end{cases}$$

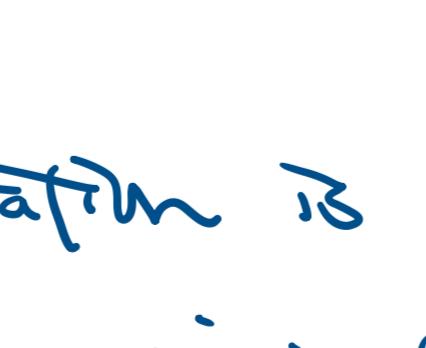
$$x = 119 \times 259$$

$$x = a \times b = 181,429$$

$$x = axb \approx 181,429$$

$$(101 \times 101) \times (101 \times 103) = \frac{axb}{181,429}$$

$$\text{DO NOT MESS W/ TIME}$$



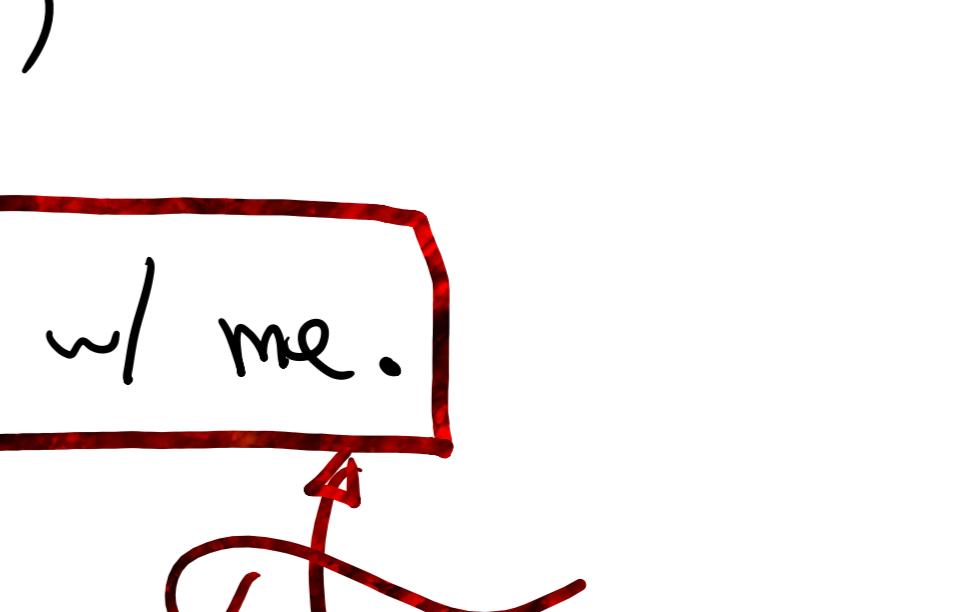
I wish I could talk about quantum.

$$BQP = QMA$$

$$BQP_{AC} = P_{AC}$$

$$MIP = NEXP$$

$$MIP^* = RE$$



Conclusion.

- Universal Computation is (one of) the greatest innovation.
- Challenges how to view the world.
- Can be modeled & studied.
- Sharpens thinking skills.

Where to go from here? (Onward!)

Thank you for learning ToC w/ me.



Fin