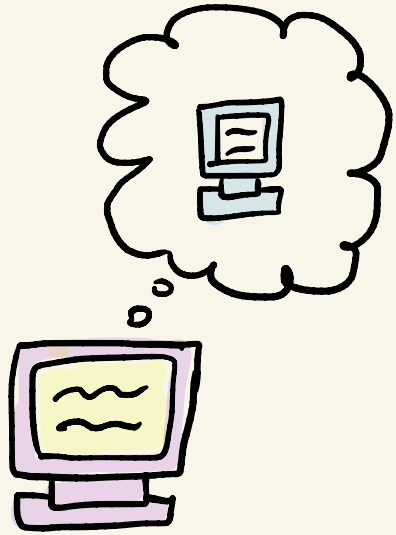
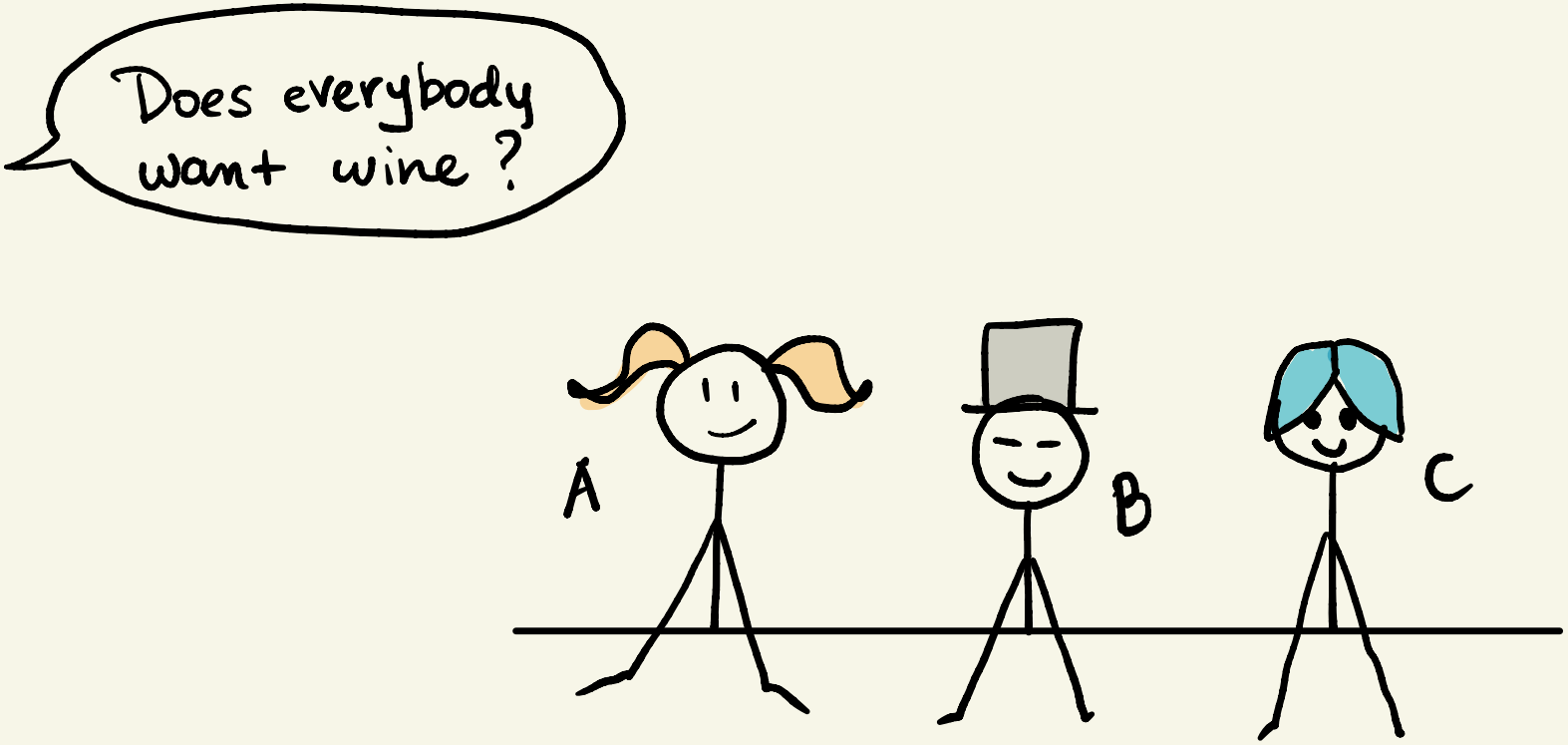
Modeling thought experiments on quantum computer



based on joint work by Simon Mathis, Nuriya Nurgalieva, Lídia del Rio and Renato Renner

Solstice of Foundations 2022

Motivation



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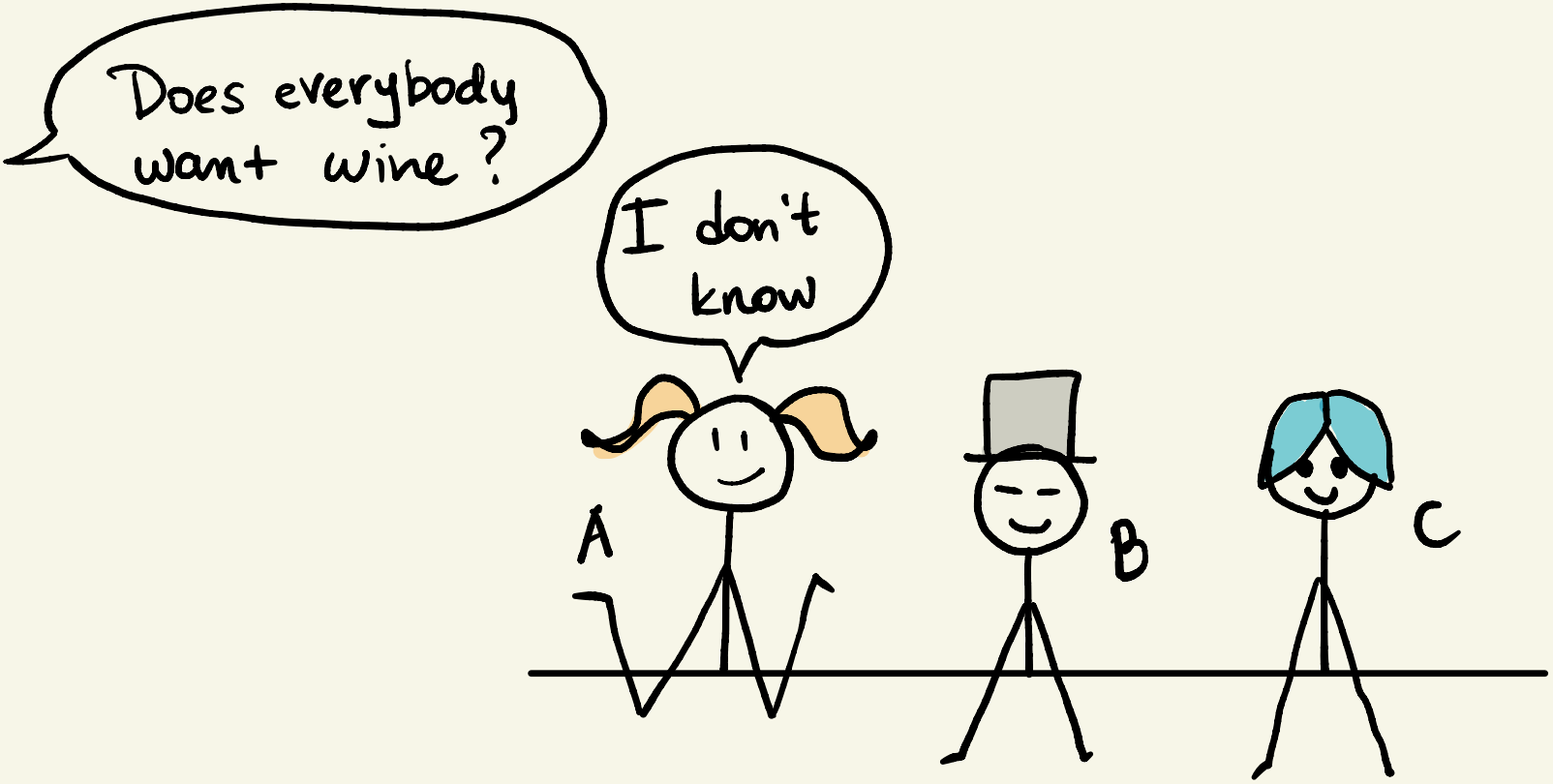
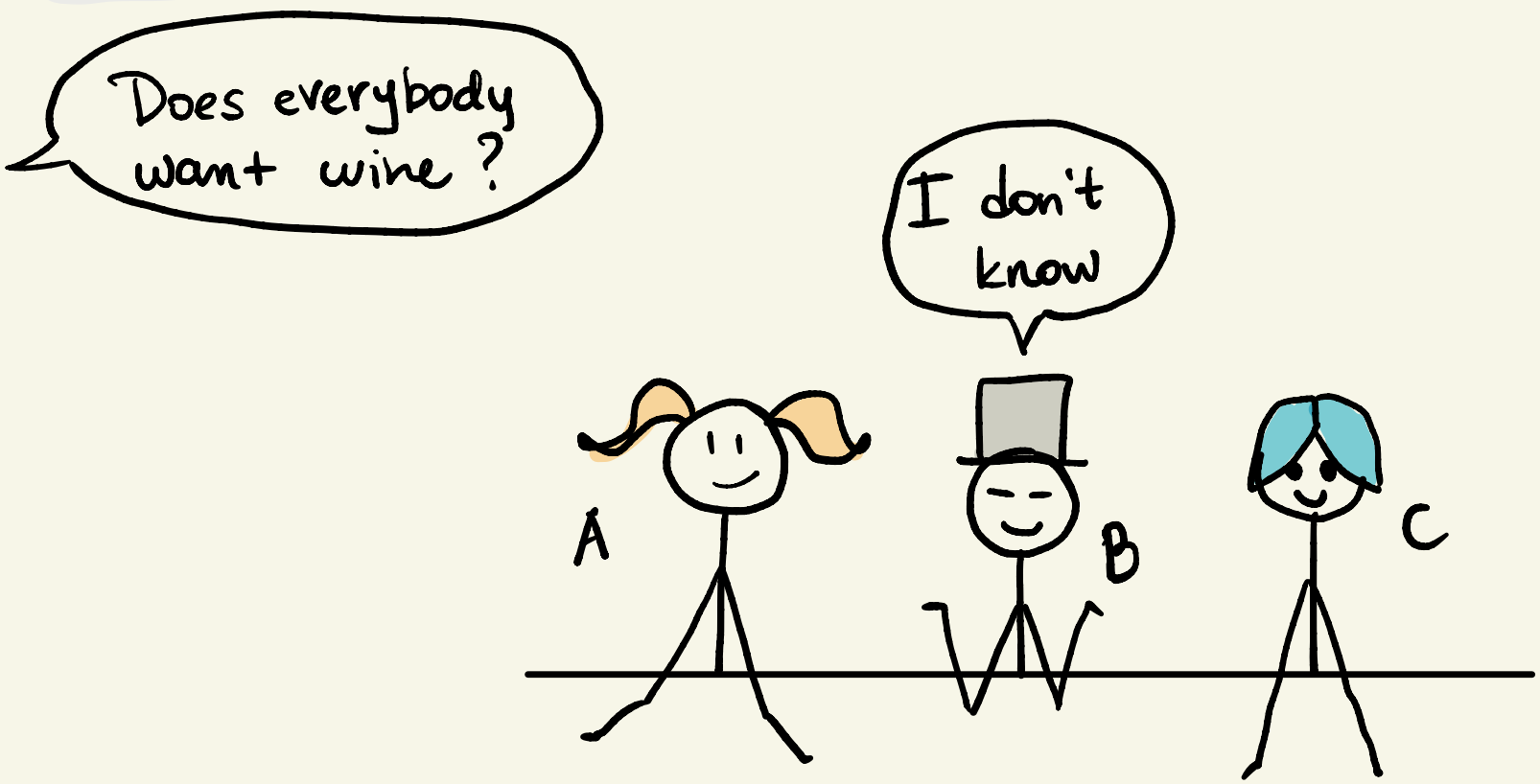
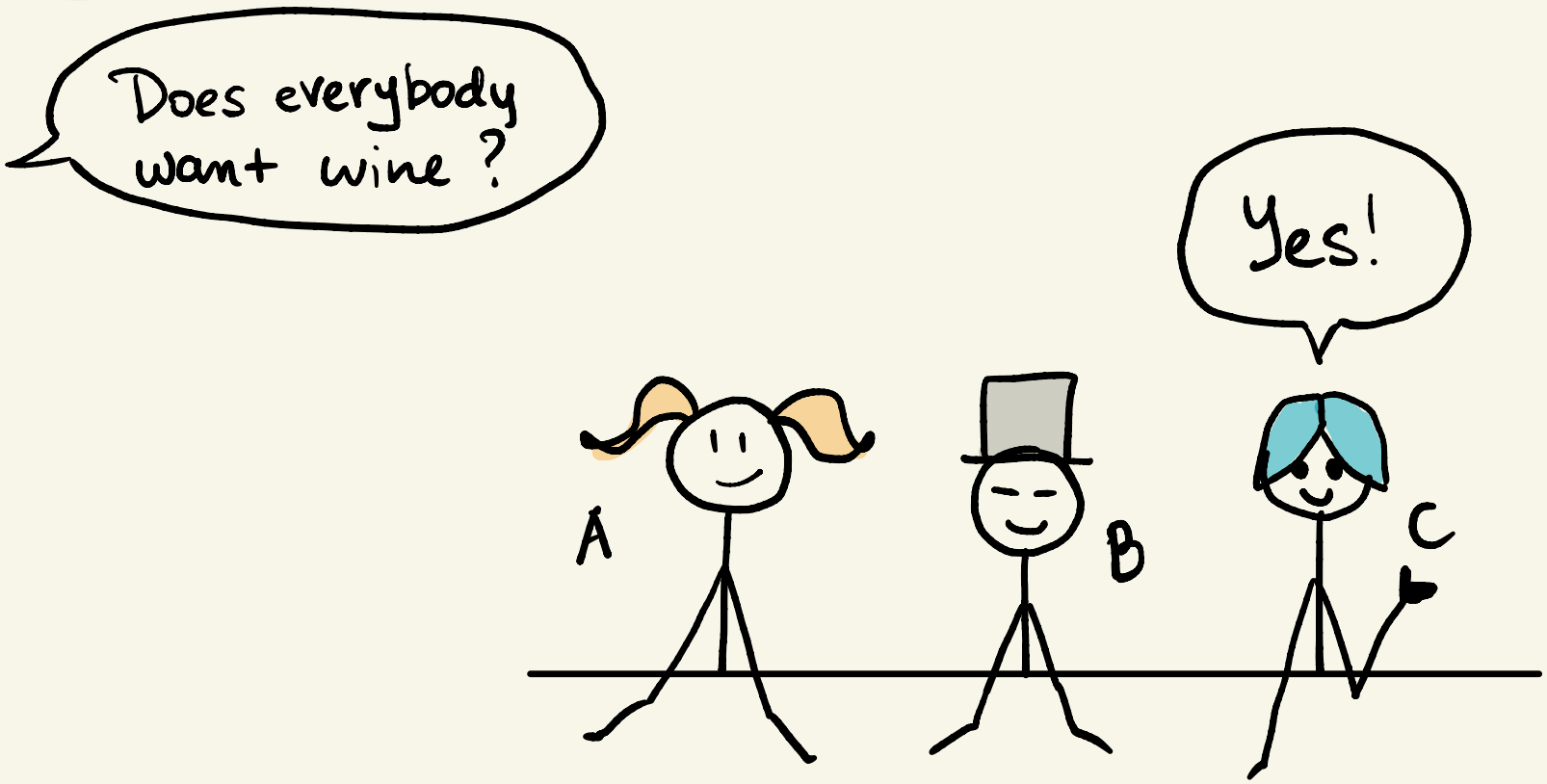


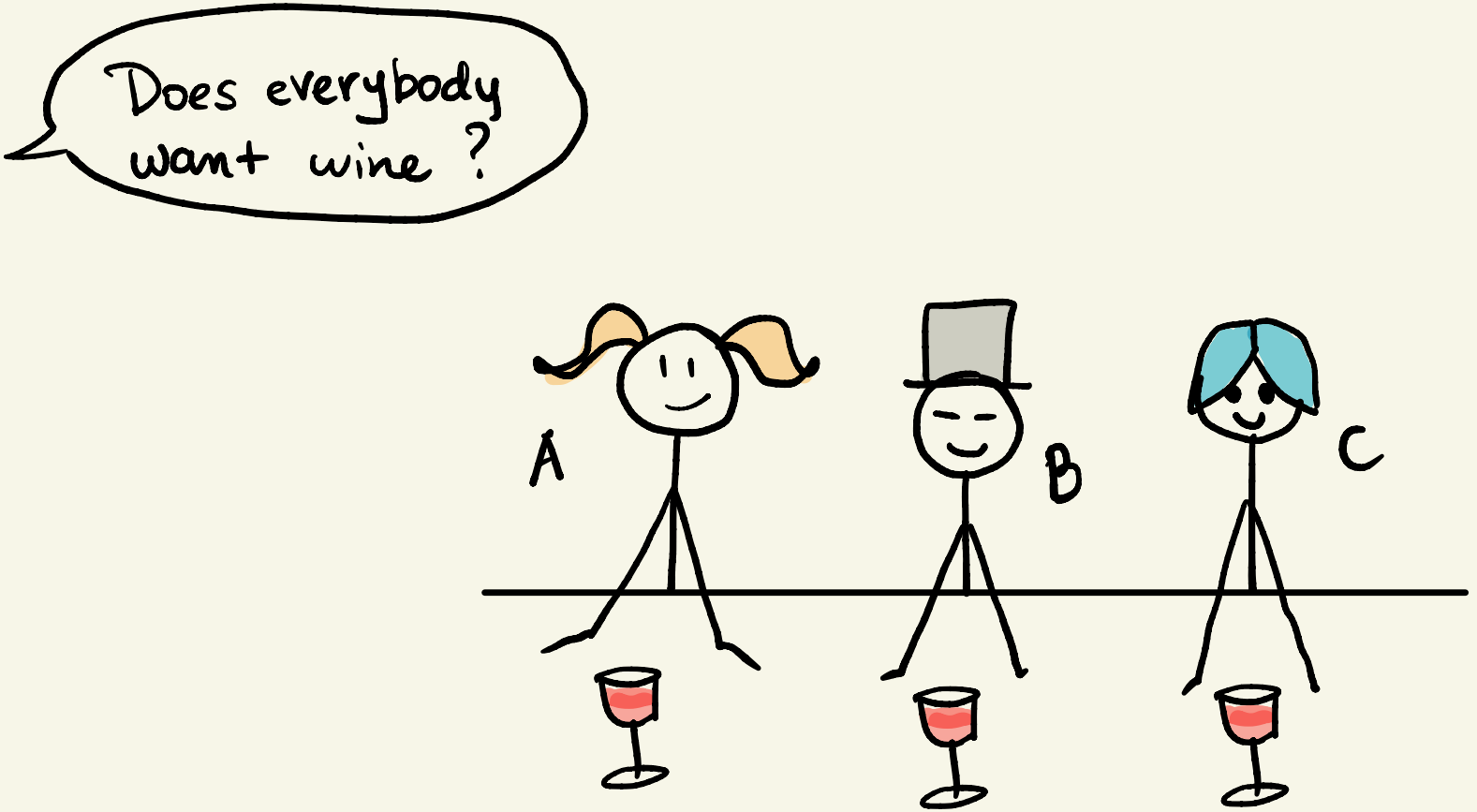
Motivation



Motivation

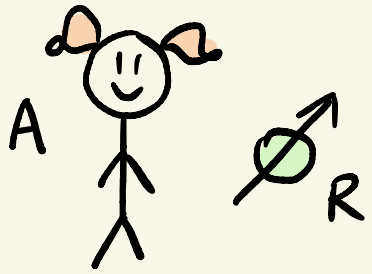


Motivation



Contents

Reasoning agents : example



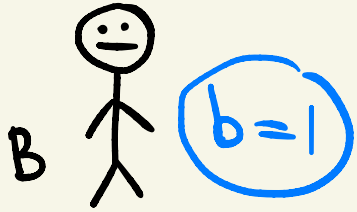
$$\frac{1}{\sqrt{3}}|0\rangle_R + \sqrt{\frac{2}{3}}|1\rangle_R$$

if $a=0$

if $a=1$

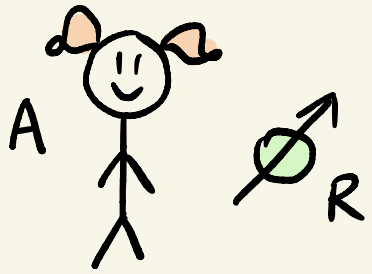
$|0\rangle_S$

$\frac{1}{\sqrt{2}}|0\rangle_S + \frac{1}{\sqrt{2}}|1\rangle_S$



if $b=1$ what did Alice measure?

Reasoning agents : example



$$\frac{1}{\sqrt{3}}|0\rangle_R + \sqrt{\frac{2}{3}}|1\rangle_R$$

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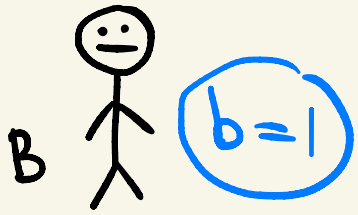
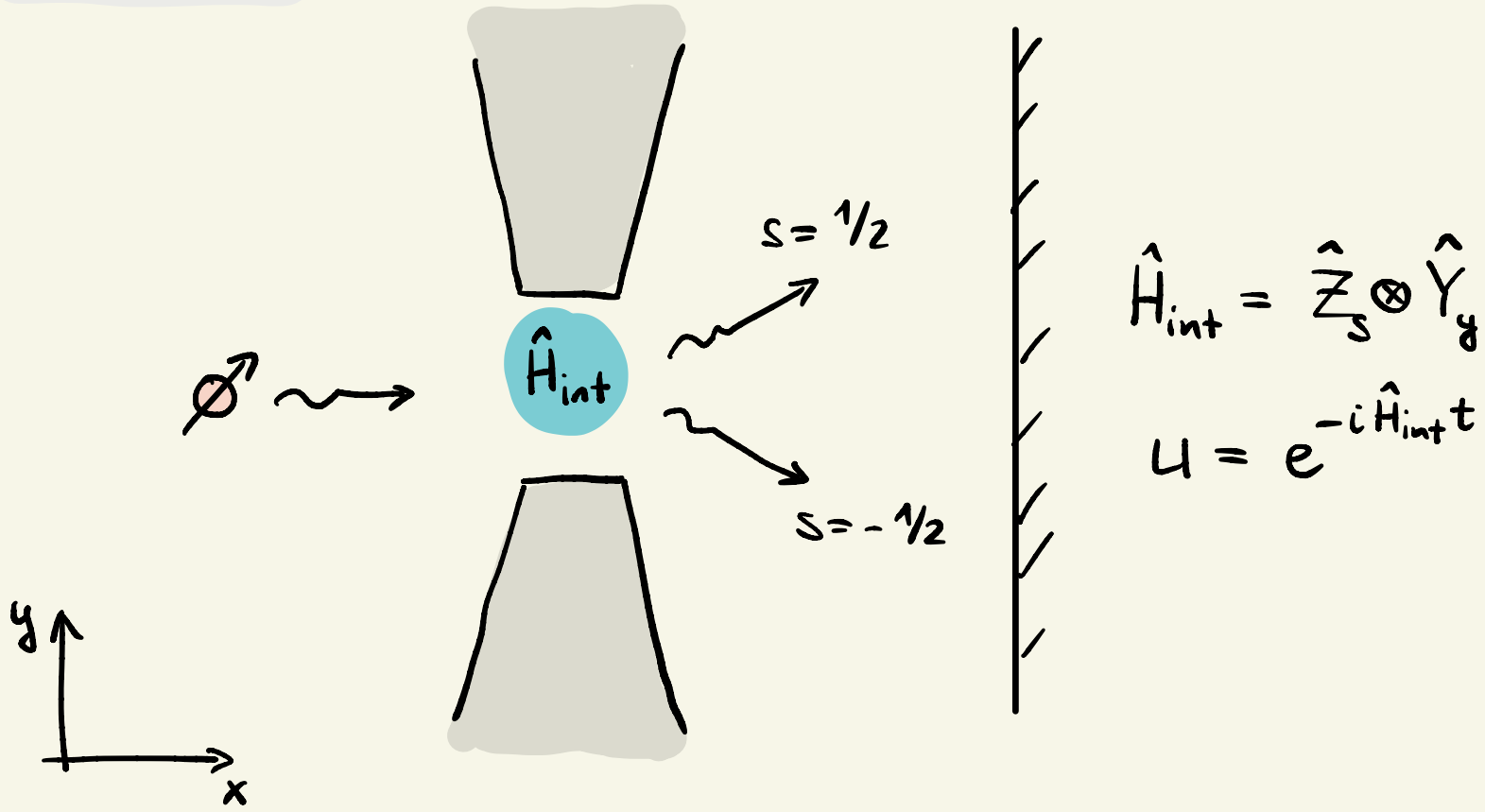


if $b=1$ what did Alice measure? $a=1$

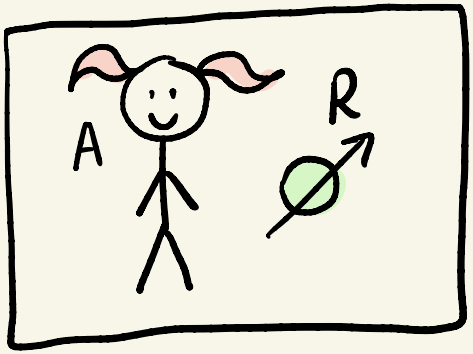
Example: Stern-Gerlach experiment



$$\hat{H}_{int} = \hat{Z}_s \otimes \hat{Y}_y$$

$$U = e^{-i\hat{H}_{int}t}$$

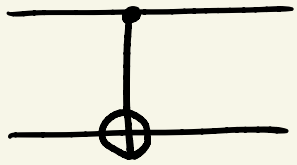
Example : CNOT as memory update



Alice : R $\alpha|0\rangle_R + \beta|1\rangle_R$

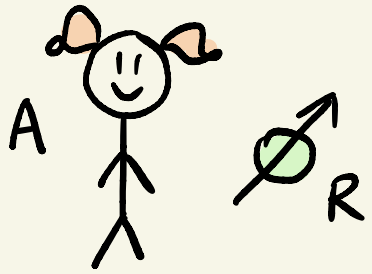
Wigner: R $\alpha|0\rangle_R + \beta|1\rangle_R$

A $|0\rangle_A$



$\alpha|00\rangle_{RA} + \beta|11\rangle_{RA}$

Reasoning agents : example



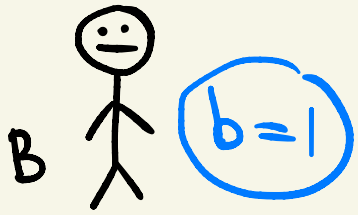
$$\frac{1}{\sqrt{3}}|0\rangle_R + \sqrt{\frac{2}{3}}|1\rangle_R$$

if $a=0$

if $a=1$

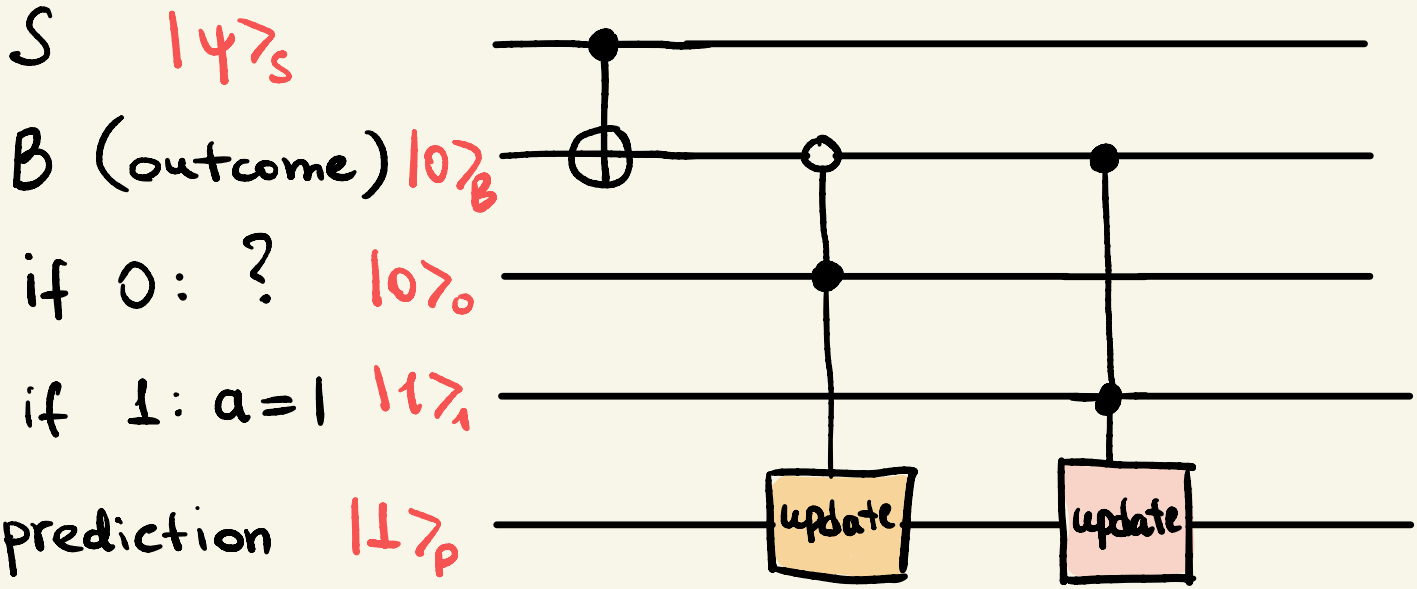
$|0\rangle_S$

$\frac{1}{\sqrt{2}}|0\rangle_S + \frac{1}{\sqrt{2}}|1\rangle_S$



if $b=1$ what did Alice measure? $a=1$

Example : reasoning as a circuit

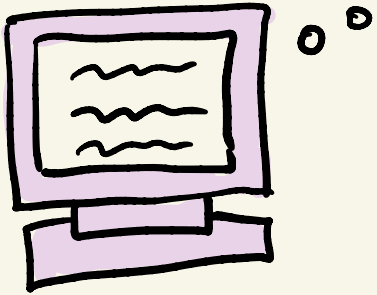


Software package

Logic

Agent

Interpretation

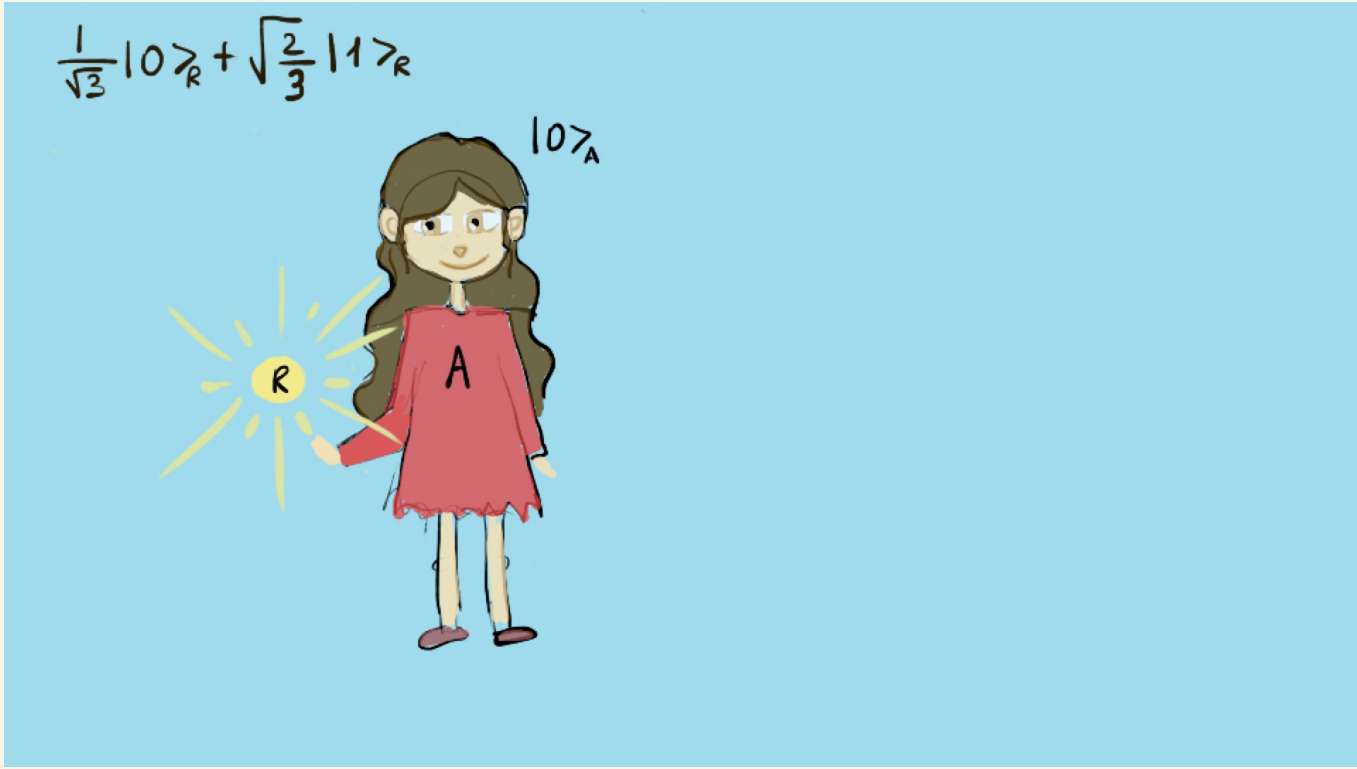


Protocol

1. . . . .
2. . . .
3. . . . .

conclusion!

Testing example : FR thought experiment



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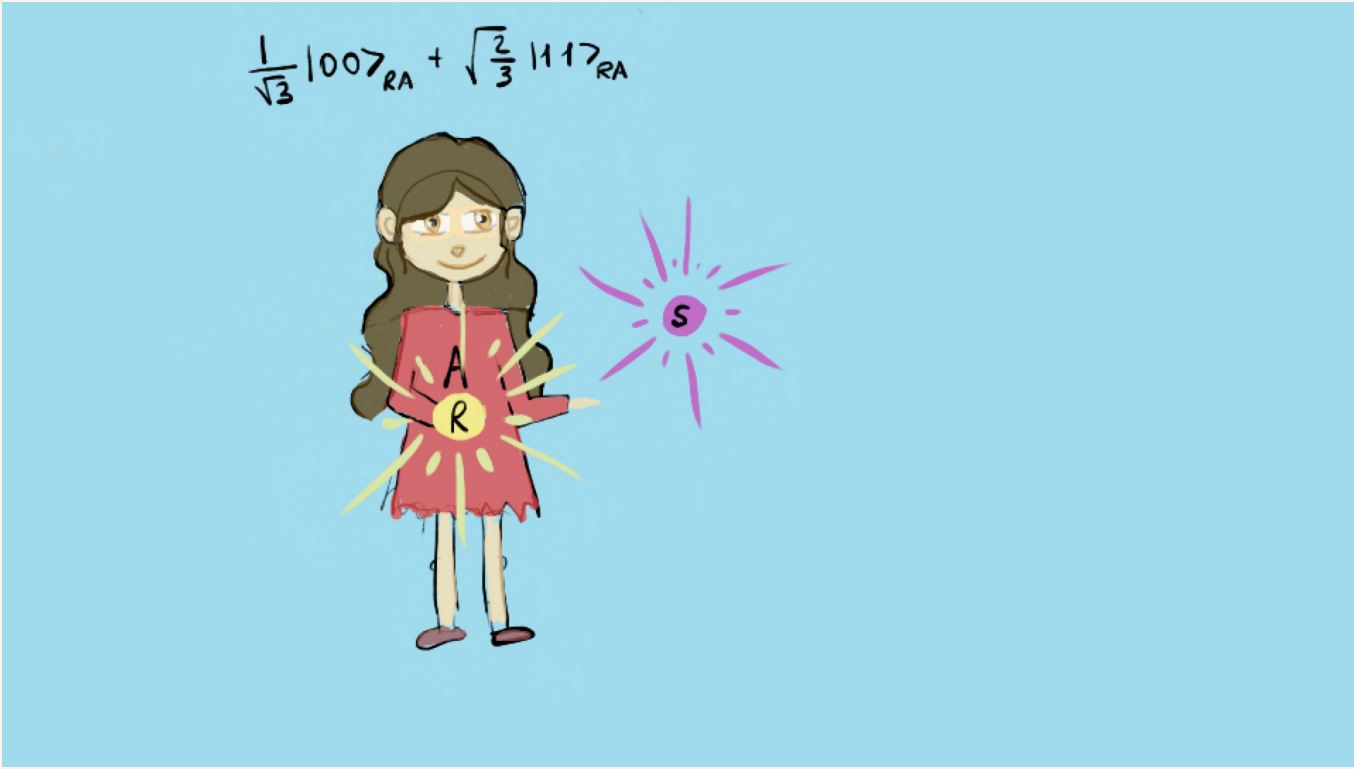

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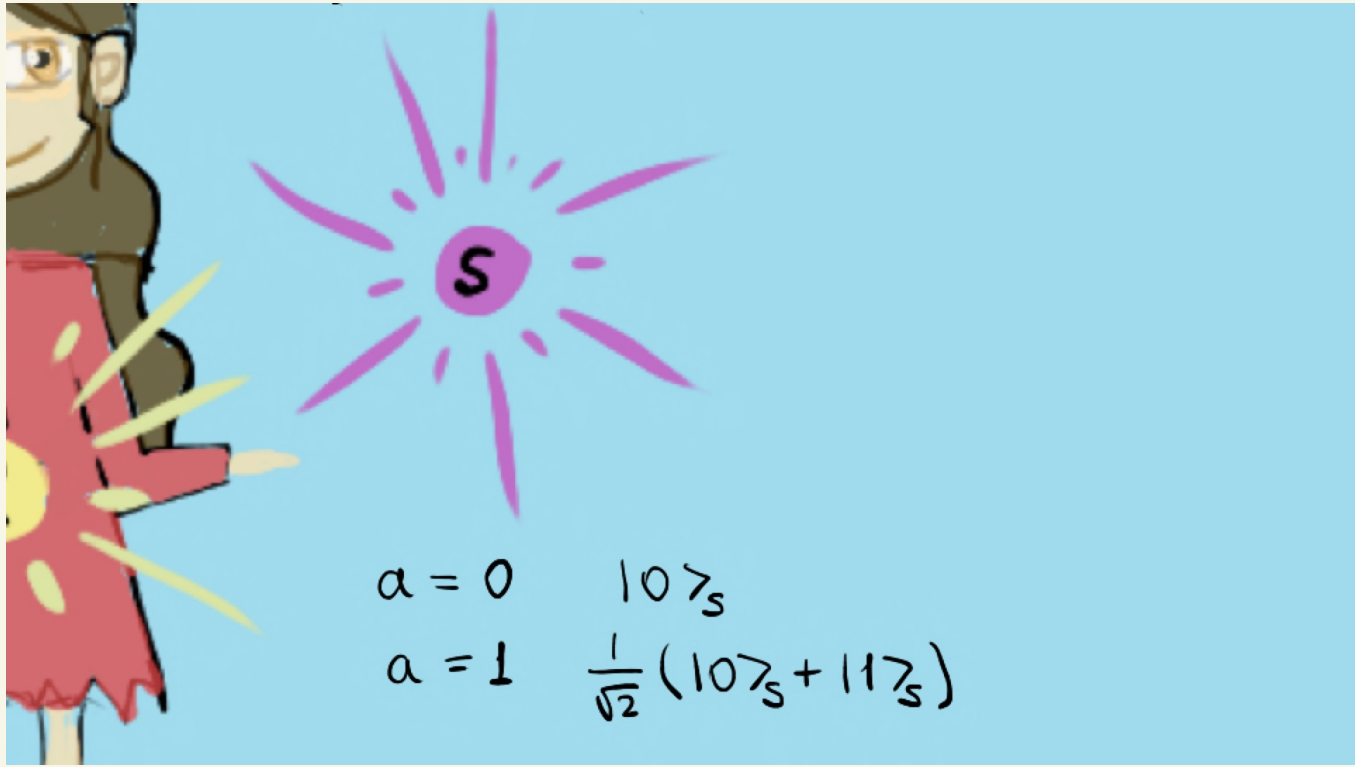
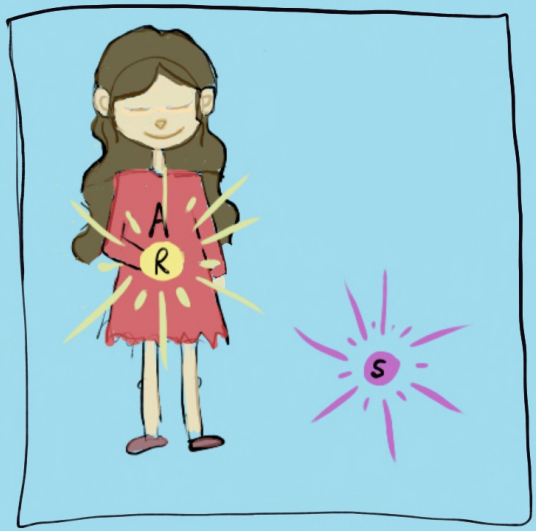
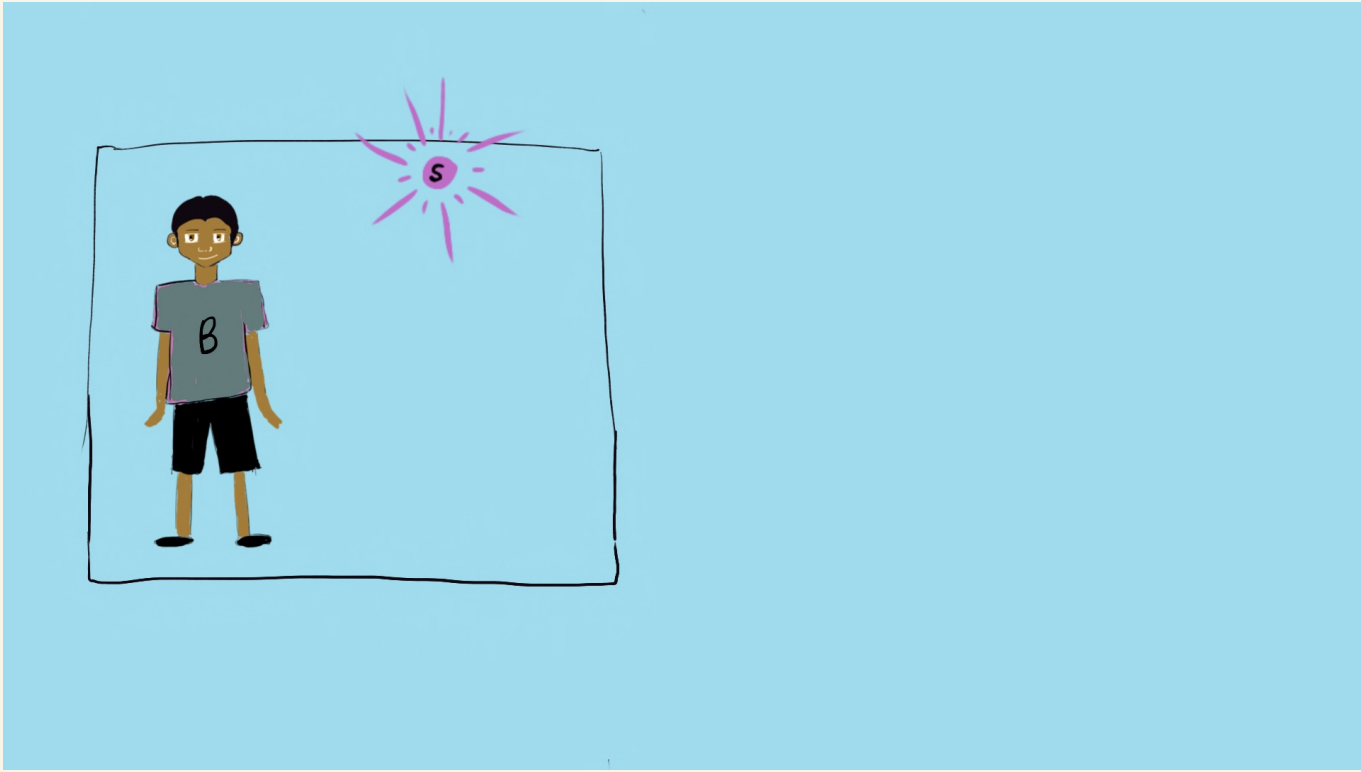


Testing example : FR thought experiment

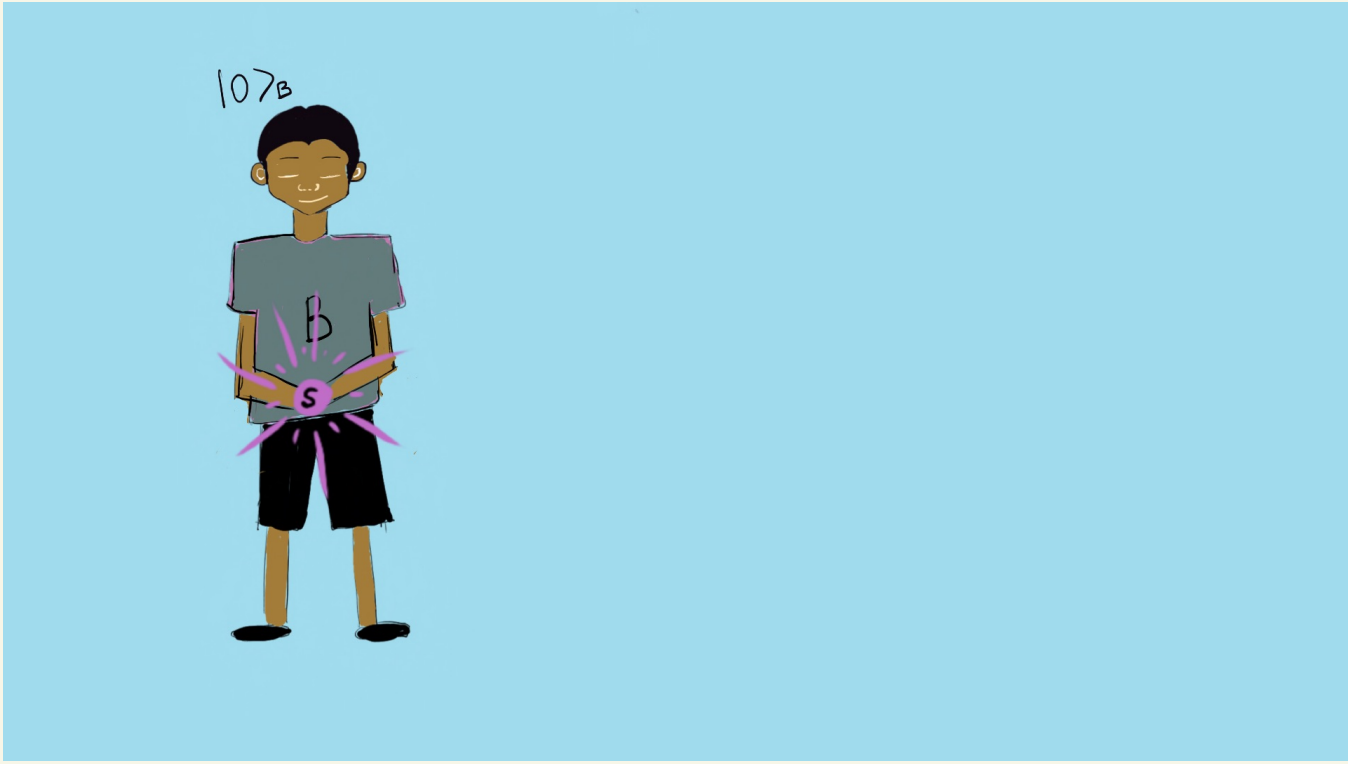


$$\frac{1}{\sqrt{3}}|00\rangle_{RA}|0\rangle_S + \frac{1}{\sqrt{3}}|11\rangle_{RA}|0\rangle_S + \frac{1}{\sqrt{3}}|11\rangle_{RA}|1\rangle_S$$

Testing example : FR thought experiment



Testing example : FR thought experiment



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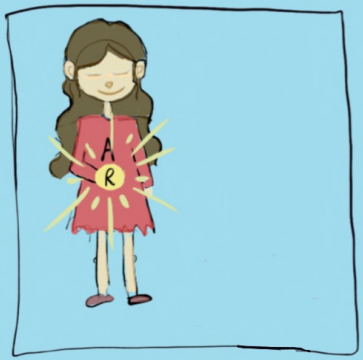
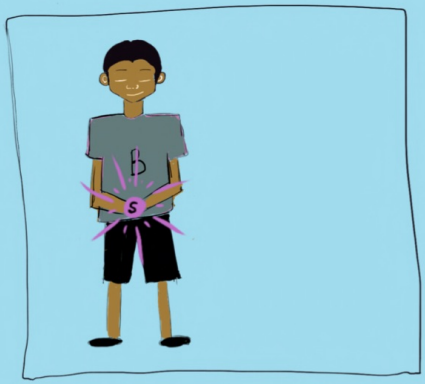
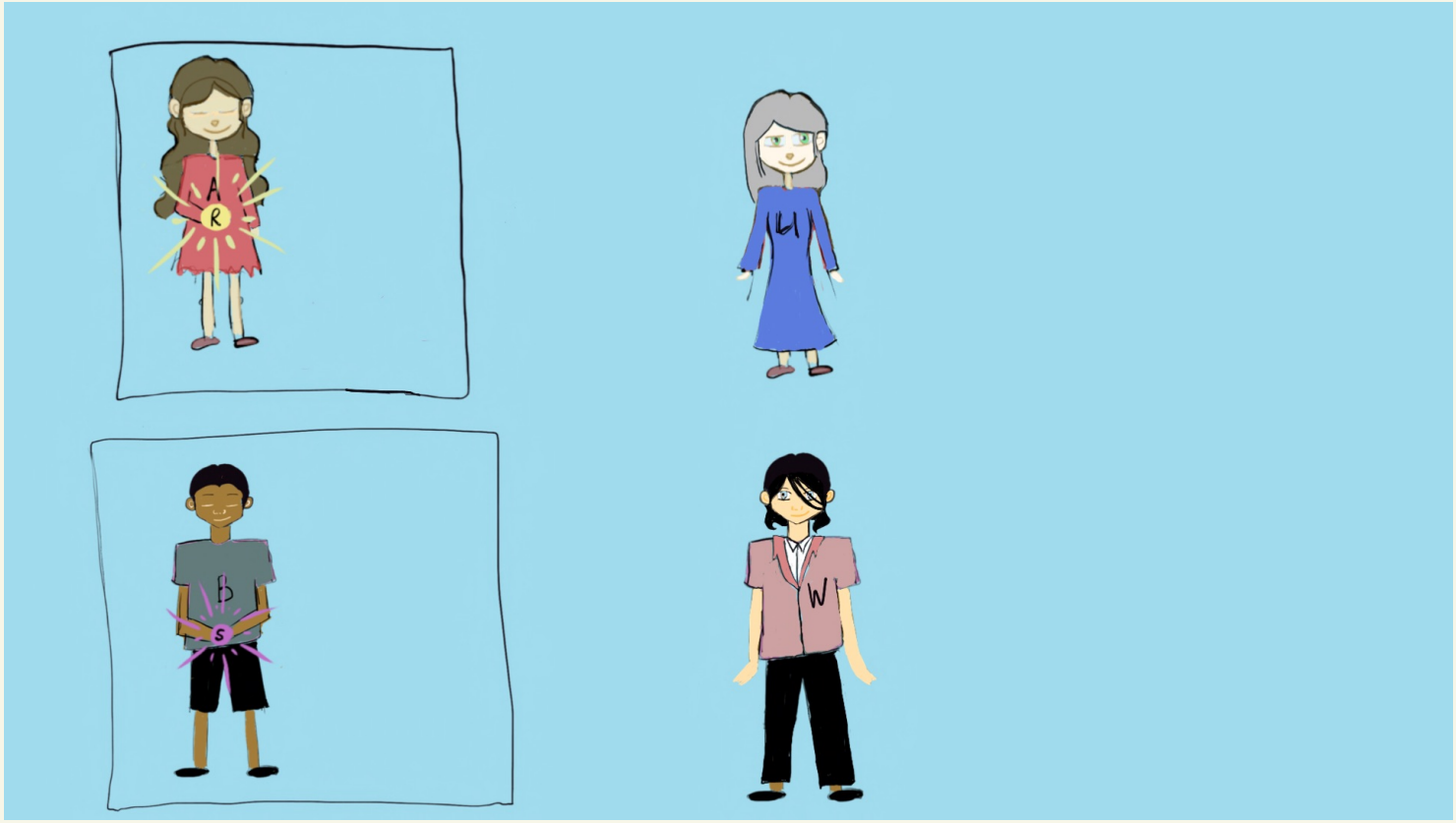




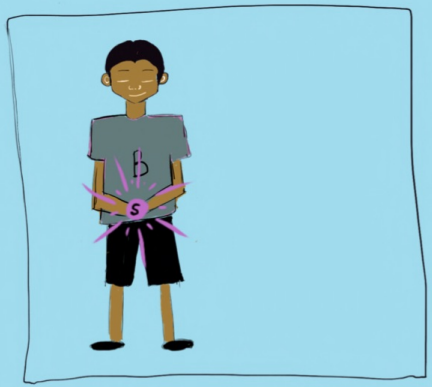
$$\frac{1}{\sqrt{3}}|00\rangle_{RA}|00\rangle_{SB} + \frac{1}{\sqrt{3}}|11\rangle_{RA}|00\rangle_{SB} +$$

$$+ \frac{1}{\sqrt{3}}|11\rangle_{RA}|11\rangle_{SB}$$

Testing example : FR thought experiment



Testing example : FR thought experiment



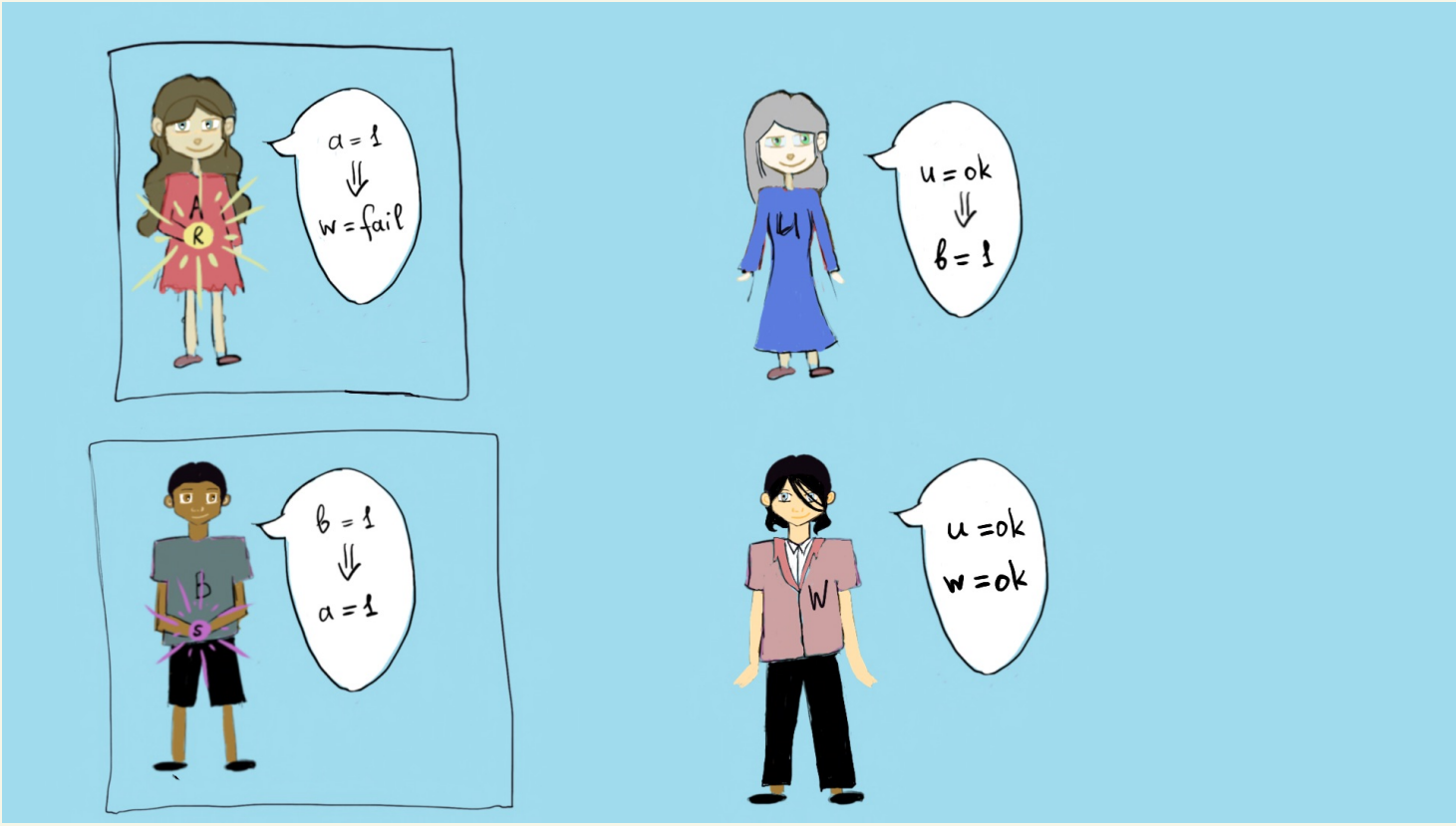
$$|ok\rangle_{RA} = \frac{|00\rangle_{RA} - |11\rangle_{RA}}{\sqrt{2}}$$

$$|fail\rangle_{RA} = \frac{|00\rangle_{RA} + |11\rangle_{RA}}{\sqrt{2}}$$

$$|ok\rangle_{SB} = \frac{|00\rangle_{SB} - |11\rangle_{SB}}{\sqrt{2}}$$

$$|fail\rangle_{SB} = \frac{|00\rangle_{SB} + |11\rangle_{SB}}{\sqrt{2}}$$

Testing example : FR thought experiment



Testing example : FR thought experiment

Testing example : FR thought experiment

Come and test:

your favorite axiom system

Logic

- modal logic
- paraconsistent
- ...

your model for

Agent

your preferred

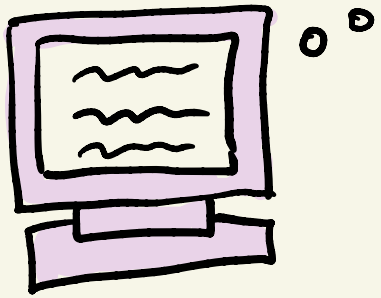
Interpretation

- (neo) Copenhagen
- collapse theories
- ...

desired communication

Protocol

1. ....
2. ...
3. ....



conclusion!

[consistent or inconsistent]

Github repo →

Thank you for your attention!