Is Fuchs Wigner's Friend?
Or an analysis of Wigner's Friend scenarios in the context of QBism, a comparison to the Relational Perspective and a glance at how an explanation could emerge out of the Many Worlds Interpretation.

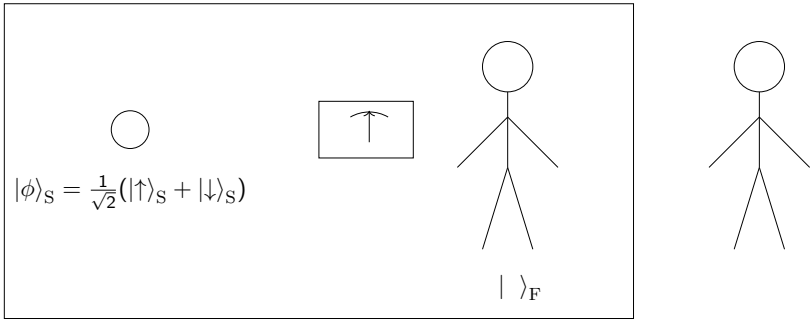
Vishal Johnson

23th Jan 2023

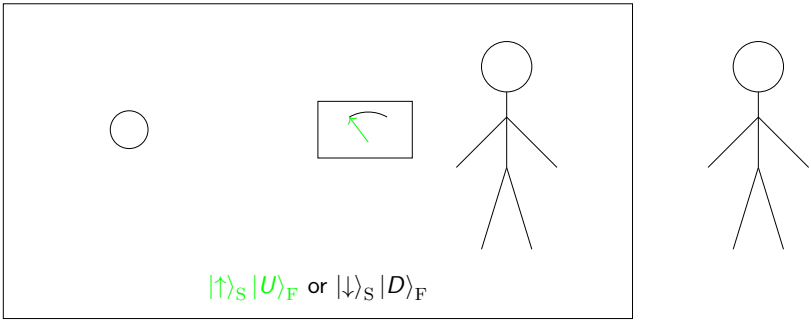
Outline

Wigner's Friend [**wigner-95**]

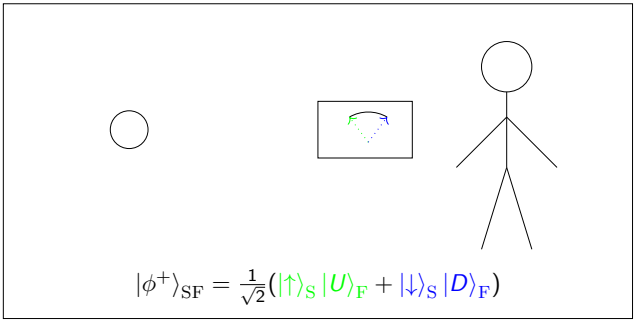
Using the notation of the previous talk [**karla-23**].



Wigner's Friend (Friend's Perspective)



Wigner's Friend (Wigner's Perspective)



Wigner's Friend

- When does collapse take place?
- In superposition for "small" systems.
- Wigner says:

  It follows that the being with a consciousness must have a different role in quantum mechanics than the inanimate measuring device [...] This argument implies that "my friend" has the same types of impressions and sensations as I—in particular, that, after interacting with the object, she is not in that state of suspended animation.

  wigner-95

Baumann Brukner [**baumann-20**]

- Friend considers Wigner's state ($|\phi^+\rangle_{SF} = 1/\sqrt{2}\,|\uparrow U\rangle_{\mathrm{SF}} + 1/\sqrt{2}\,|\downarrow D\rangle_{\mathrm{SF}}$) using observables:

$$\mathbb{M}_{\mathrm{F}} \leftrightarrow \{|\uparrow U\rangle\langle\uparrow U|_{\mathrm{SF}}\,, |\downarrow D\rangle\langle\downarrow D|_{\mathrm{SF}}\}.$$

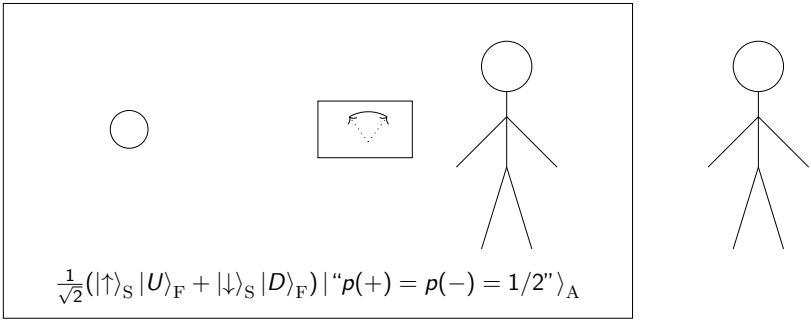
- Probability for $+$ ($|\phi^+\rangle_{\mathrm{SF}}$) and $-$ (not $|\phi^+\rangle_{\mathrm{SF}}$) given either $|\uparrow U\rangle_{\mathrm{SF}}$ or $|\downarrow D\rangle_{\mathrm{SF}}$

$$p(+|\uparrow U) = \left|\langle\uparrow U|\phi^+\rangle\right|^2_{\mathrm{SF}} = \frac{1}{2} = p(+|\downarrow D)$$

recorded as $|\text{“}p(+) = p(-) = 1/2\text{”}\rangle_{\mathrm{A}}$ on some device A (for all outcomes).

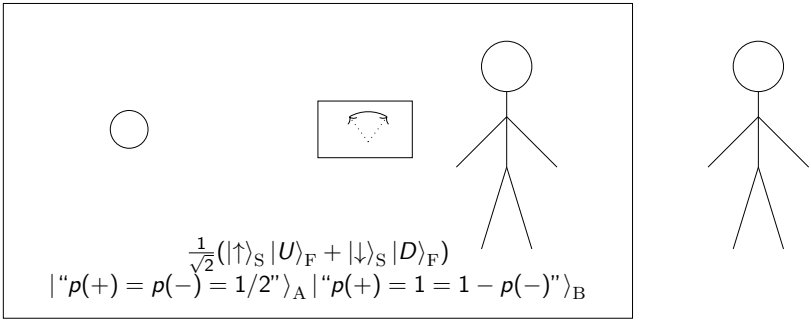
- Wigner measures the same state using the observables $\mathbb{M}_{\mathrm{W}} \leftrightarrow \{|\phi^+\rangle\langle\phi^+|_{\mathrm{SF}}\,, \mathbb{1}_{\mathrm{SF}} - |\phi^+\rangle\langle\phi^+|_{\mathrm{SF}}\}$ recorded on a device B.

Baumann Brukner



The state recorded onto A indicates a “fact” of the world as it is recorded. However, it does not change the state of the laboratory and therefore “fact”orises.

Baumann Brukner



In the measurement basis $\{|\phi^+\rangle\langle\phi^+|_{SF}, \mathbb{1}_{SF} - |\phi^+\rangle\langle\phi^+|_{SF}\}$, $p(+) = |\langle\phi^+|\phi^+\rangle|^2_{SF} = 1$.

Baumann Brukner

- Significant statistical deviation.
- Even "facts" are relative to observer!

Some Preliminaries (Agents)

Qbism's view on agents:

"

- Agents are entities that can take actions freely on parts of the world external to themselves, so that the consequences of their actions matter for them.
- A user of quantum mechanics is an agent that is capable of applying the quantum formalism normatively.

" **debrota-20**

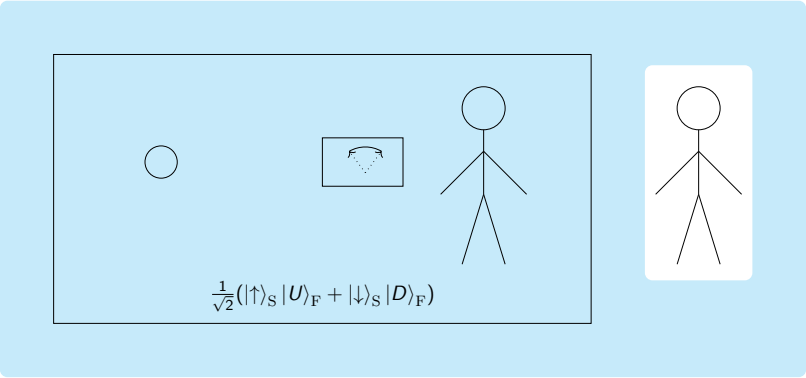
Some Preliminaries (Tenets)

- Qbism: "A measurement is an action of an agent on its external world, where the consequences of the action, or its outcomes, matter to the agent." **debrota-20**
- Measurement outcomes as well as quantum states are personal. Requirement of different agents to agree with one another restricts the freedom of description.
- Quantum description is normative not descriptive.
- Probability-0,1 judgements are also judgements. Quantum descriptions do not have an ontic hold on the world.

Qbism on Wigner's Friend

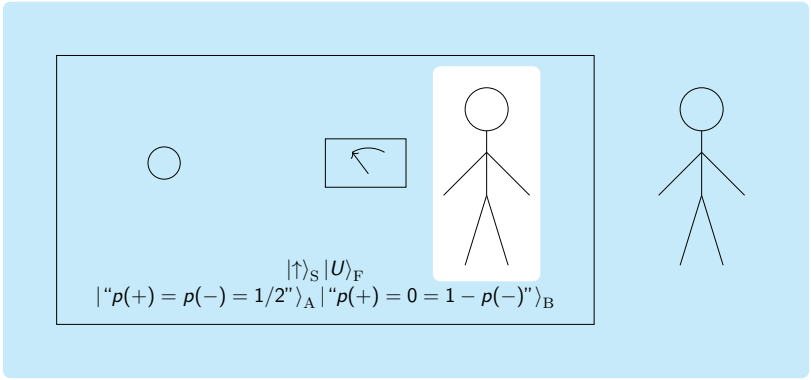
- $|\phi^+\rangle_{\mathrm{SF}}$ is not descriptive. It rather serves to allow Wigner make informed gambles (and it seems to work!).
- Similarly $|\uparrow U\rangle_{\mathrm{SF}}$ serves the Friend in making informed gambles.
- These states do not have an ontic hold on the world.
- However, it does matter if Wigner asks its Friend what the Friend sees before measuring $\mathbb{M}_{\mathrm{W}}$.

Qbism on Baumann Brukner (Wigner's Perspective)



The quantum description applies to everything outside Wigner's box.

Qbism on Baumann Brukner (Friend's Perspective)



$|\text{“}p(+) = p(-) = 1/2\text{”}\rangle_A$ and $|\text{“}p(+) = 1 = 1 - p(-)\text{”}\rangle_B$ are now objective facts about the world! How to reconcile this picture in Qbism?

Qbist Answer

- Friend cannot use $|\uparrow U\rangle_{\mathrm{SF}}$ (or equivalently $|\downarrow D\rangle_{\mathrm{SF}}$) to describe itself as there must be a "clear separation between [user] and measured system."
- The Qbists say:

  But since [the Friend] is a free agent, she has control over the answer to this question. It is up to her whether she replies "up", "down", or by sticking her tongue out. Since she has at least partial control over these measurement outcomes, the above quantum-state assignment cannot form a reliable basis for guiding her actions.

  debrota-20
- Instead the Friend should perform the entire analysis from its own perspective, assigning quantum states, observables and probabilities (which might get updated over several rounds) from scratch.

  This implies that the friend's probability for "+" cannot be derived from the details provided in the BB thought experiment [...] We thus explicitly reject Baumann and Brukner's claim that standard quantum theory requires the friend to base her probability assignments on [$|\uparrow U\rangle_{\mathrm{SF}}$ and $|\downarrow D\rangle_{\mathrm{SF}}$].

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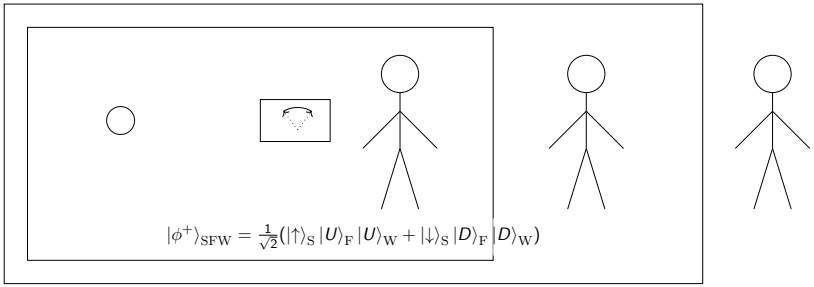
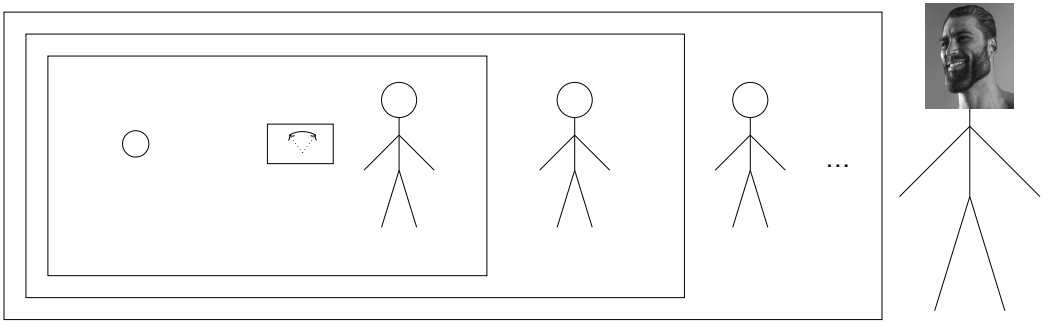
- Can something else be done?

Observing the Observer



To the hyper observer, even if Wigner (super observer) learns the state of the quantum system, the whole subsystem is in a superposition state.
What if this procedure was continued further?

The Giga Observer



The Giga Observer

- An observer lying outside the entire universe and never receiving any information from inside it would use unitary dynamics to describe the whole system and this reduces to the many worlds interpretation!
- Would it be valid to consider such a universal wavefunction in order to explain Wigner's Friend scenario in the Baumann Brukner version?
- It would be incorrect from the Qbism perspective as the free observer now includes itself in the quantum description. However, the BB scenario can be explained successfully.
- The difference between Qbism and many worlds might simply be the difference between a first person and third person perspective:

  At the root of this is one of the most distinguished differences between Everett and QBism. "QBism don't do third-person!" For QBism, all of quantum theory is first-person for the person who happens to be using it.

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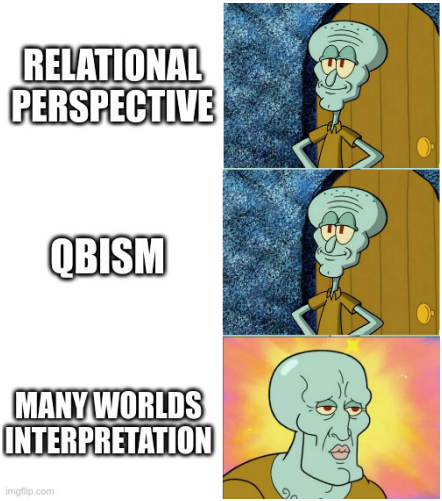
Conclusion

In conclusion:



Thanks

Thanks for listening! Any questions?

References