Quantum Tic-Tac-Toe

A Game of Entanglement

This doozy of a game has circulated for years among quantum physics teachers. They use it as a teaching tool for concepts like “entanglement” and “superposition,” but it’s a stunning game in its own right. I consider it the trickiest, subtlest, most headache-inducing form of tic-tac-toe around: in other words, a worthy avatar of the quantum realm.

How to Play

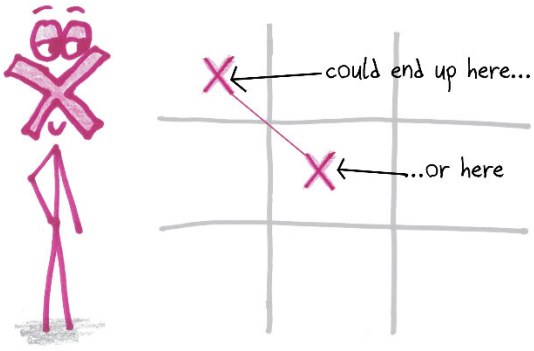
What do you need? Two players, each with their own color, and plenty of paper.

What’s the goal? It’s just like classical tic-tac-toe: place your entangled particles so that, when the waveform collapses, you’re left with three in a row.

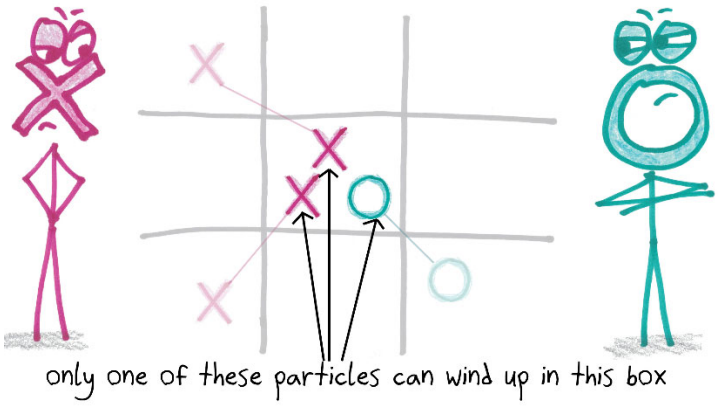
Okay, maybe not *just* like classical tic-tac-toe…

What are the rules?

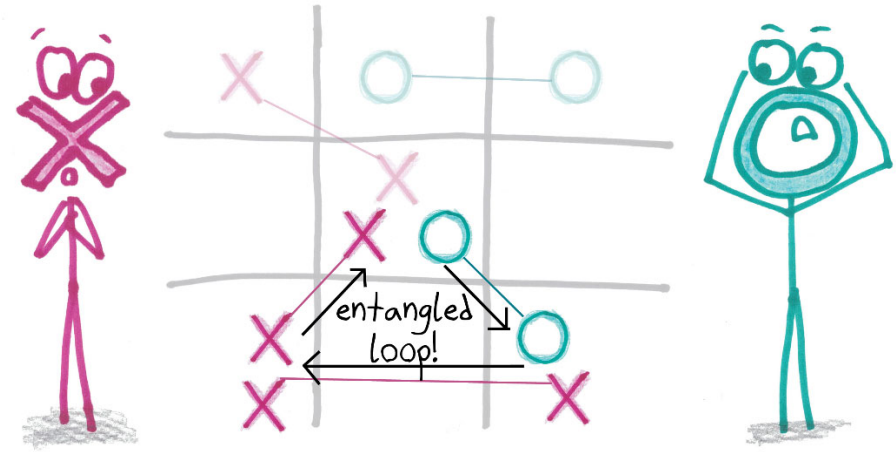
1. Take turns placing quantum X-particles and quantum O-particles. To do this, **mark a pair of boxes**, **connecting them by a thin line**. We call the two boxes “entangled.” Your particle is **possibly in one, possibly in the other**. You won’t know until later.



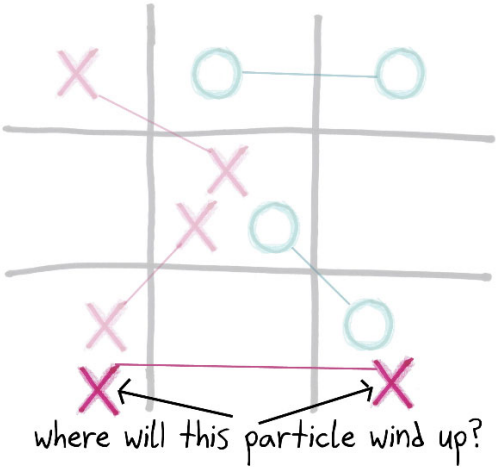
   As you play, it may seem that multiple particles share the same box. That’s temporary. **Later, every box will wind up containing just one “classical” X or O.**



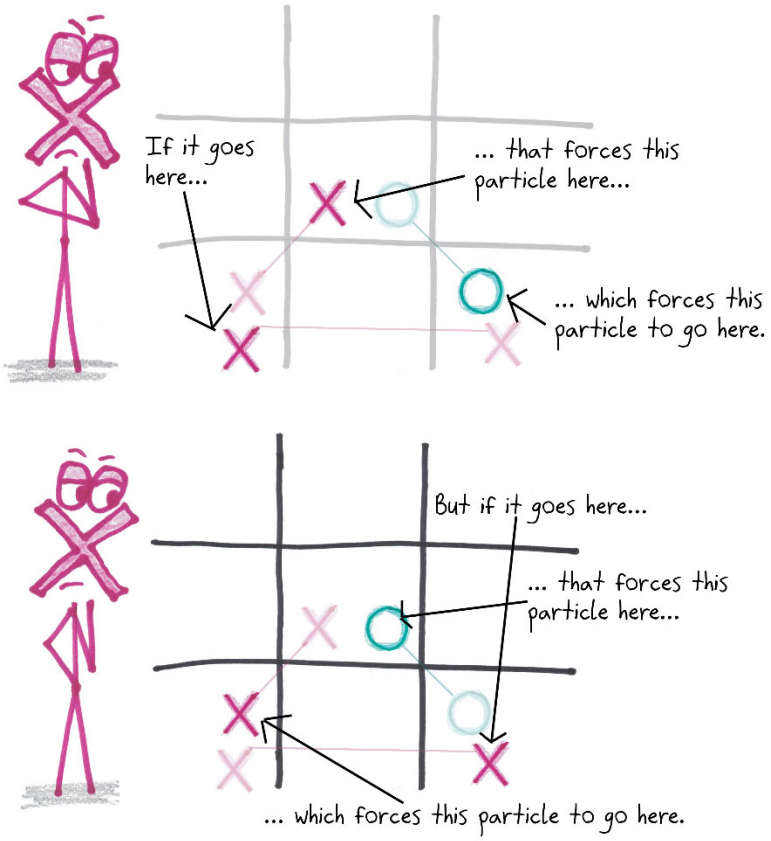
2. At some point, the **entanglements will form a loop**: for example, one box is entangled with another, which is entangled with another, which is entangled with the first.



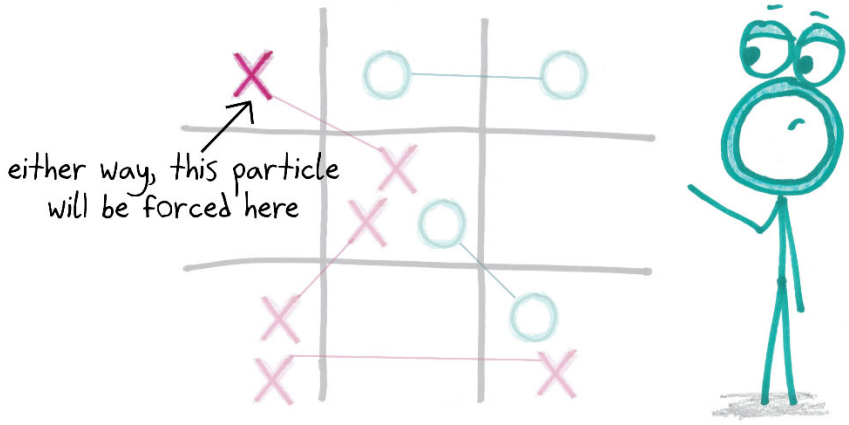
At that moment, the **quantum particles "collapse" into classical X's and O's**. This can unfold in two ways: one for each possible location of the most recently placed particle.



Whichever way that particle goes, it will **force some other particle out of its box, and into another box**.

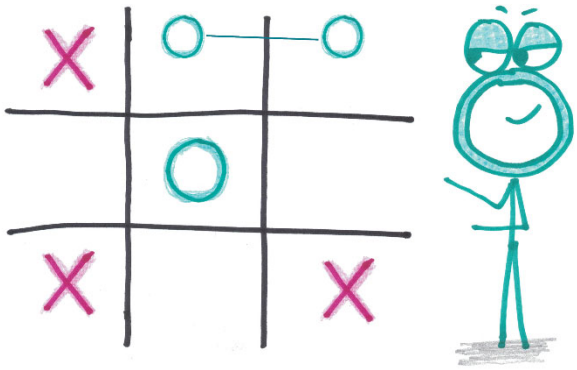


This forcing process continues, until every particle in the loop (and possibly some particles that are only "half" in the loop) have resolved into a single box.

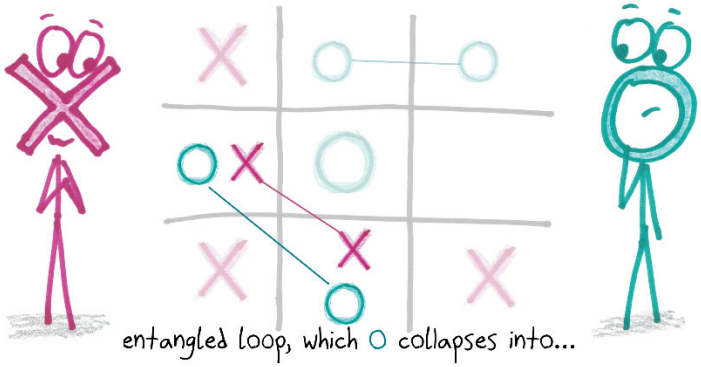


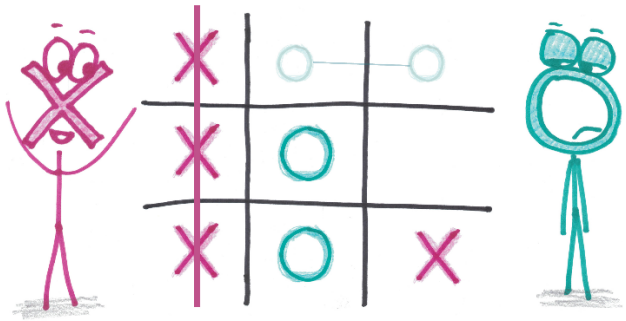
3. Someone must choose between the two ways that the collapse can unfold. **This choice falls to the person who *didn't* complete the loop**.

   When the collapse is over, your board will be a total mess, so **redraw it** and continue from there.

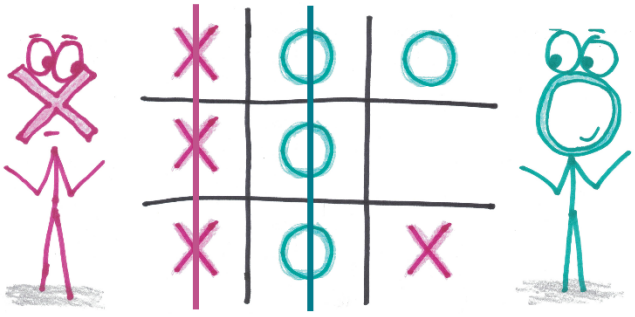


4. If you achieve **three classical particles in a row**, then you win!

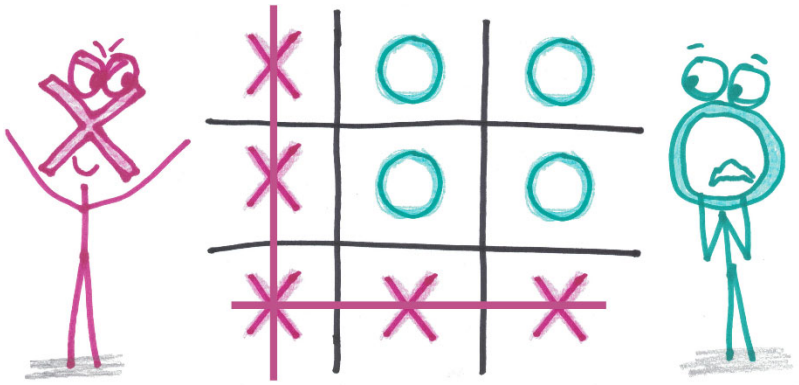




5. **Two players may achieve three-in-a-row** as part of the same collapse. If so, then the game is a draw.



6. It's also possible that **one player may achieve a pair of three-in-a-rows** as part of the same collapse. If so, then this win counts double (if you're keeping score of games).



Variants

MULTI-GAME MATCH-UP: As in classical tic-tac-toe, X enjoys a first-player advantage, so you may wish to play a pre-set number of games, alternating back and forth between X and O.

RANDOM WORLD: For a game with a greater element of randomness, determine which version of each collapse occurs not by letting one player choose, but instead by flipping a coin.