Fermi's Golden Rule and Puzzles of Quantum Theory

Advanced

- Fermi's golden rule in a qualitative form says that the transition probability for particles from some state **1** to some state **2** depends on the density of occupied states **1** times the density of unoccupied states **2**. *This is actually a bit strange*. Let's see why:
  - Consider yourself up on the jumping board in a very crowded swimming pool (state **1**). Some "friends" are wiggling the board pretty hard, so you are in danger of falling off and to plunge in the pool below (state **2**).
  - You will try hard not to fall off, i.e., not to make the transition from **1** to **2** if there is no free space in the water, while you let yourself shake off if there is a hole in the water, i.e., an unoccupied state **2**.
- But in such a case *you* have eyes to see and a free will to decide what you are going to do (or at least want to do). Now imagine the same situation for wood spheres swimming in the water and one sphere in a shallow bowl above, which is jiggled (by some form of energy).
  - The wooden sphere will fall over the edge with a probability that only depends on its mass, the shape of the bowl, the amount of jiggling – whatever – but certainly *not* on anything down in the water.
  - For the probability of the transition, it does not matter at all if there is room in the pool, if there are spheres there at all, or how the sphere got out of the pool and in the bowl.
- For classical particles, Fermi's golden rule thus does *not apply*. It is deeply rooted in quantum mechanics and just another expression of the "QED – The Strange Theory of Light and Matter" (to quote the title of a well-known [and highly recommended] book by **Richard Feynman**).