Quantum wave and particle track

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Quantum theory is strange. It is often acclaimed as the most successful of all theories in physics, but at the same time it leads to never ending debates about its meaning and its ontology. Philosophers like to draw our attention to the fact that not all is quantum, that there are also tables and chairs. Wave-particle duality can be described mathematically, but are we completely satisfied with this description? Evidently not all physicists are happy. Louis de Broglie, one of the founders of quantum theory, in his later years returned to the beginnings and tried to find a better solution in non-linear theories. CERN physicist John Bell was unhappy, not only just unhappy, he was literally angry at the status of quantum theory and the misleading terminology that is being used by his fellow physicists in order to hide the real problems.

How Nature does what it does? Is it a reasonable question at all? If it is, then how can we go about it?

Physics builds models of reality. Some of these models pretend to be fundamental, some other just phenomenological. Here is one such model. There is quantum wave, there are tables and chairs (red detectors, there are events when tables are overthrown, when red becomes white. And there are wave collapses. It all can be modelled mathematically. Probably the model is not realistic, yet it does its job. The wave is moving, it overthrows tables and chairs, and it leaves a real and visible track like those that can be seen in nuclear emulsions or cloud chambers. Each such even is accompanied by collapse of the wave and its rejuvenation. The process is governed by partly deterministic and partly random laws well known in this branch of the mathematical theory of random processes that deals with earthquakes and financial markets.

The animation (see `https://www.youtube.com/watch?v=ndIopfN_zzk`) presents one such history: a sequence of collapses and the track that we interpret as that of a passing particle, for instance an electron. A different

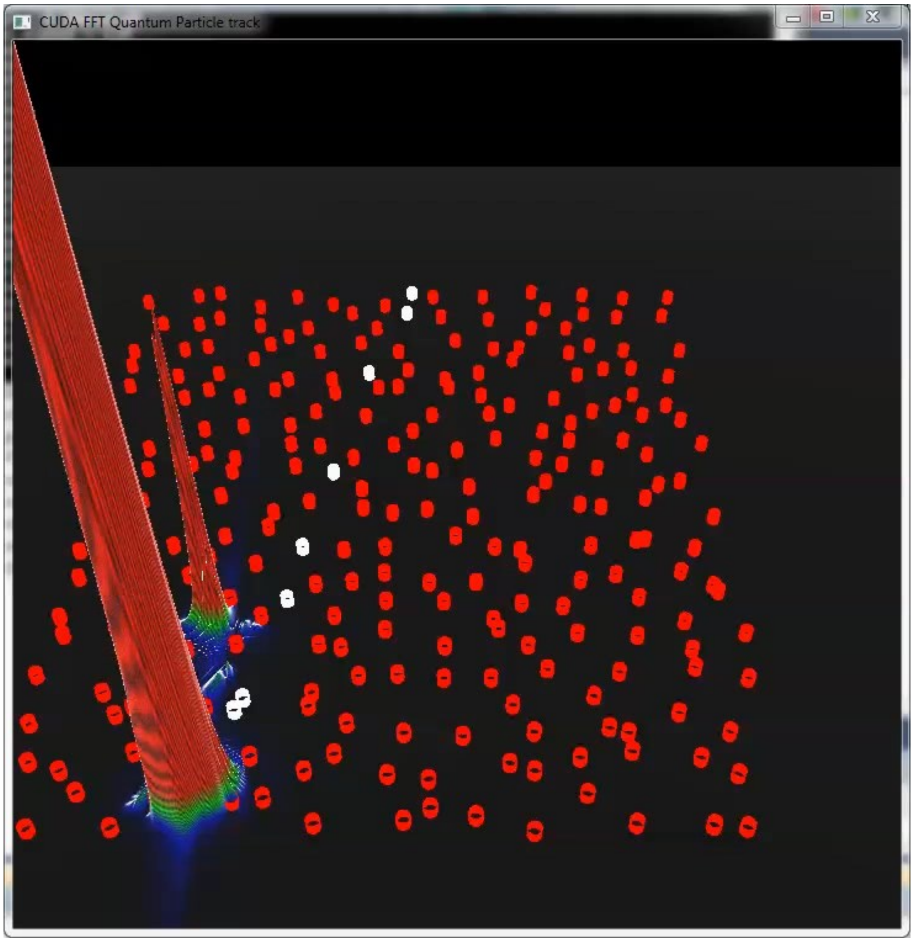

Figure 1: Particle track left by a collapsing quantum wave

run of the same experiment would produce somewhat different track. During the animation the wave travels across the field of somewhat randomly distributed particle detectors. Detectors fire using a (tamed) random algorithm . Those that have fired change their color from red to white and become non-active. All the data, including sensitivity of the detectors are on the atomic scale. We notice that there is a certain angle between the direction of the wave (directly towards the camera) and the track that is left. This is not unexpected, owing to the random nature of the whole phenomenon. The coupling between the wave and the detectors that is being modeled here does not include energy and/or momentum transfers between the wave and the detectors. Only information-theoretical exchange, I tell you where I am, and you will collapse me in exchange, is taken into account.

Tools used in this animation: parallel implementation of the time-dependent Schrodinger equation with complex potentials (CUDA), with Fast Fourier transform, OpenGL, piecewise-deterministic algorithm of EEQT.