Adiabatic shortcuts: Short and sweet in the quantum world

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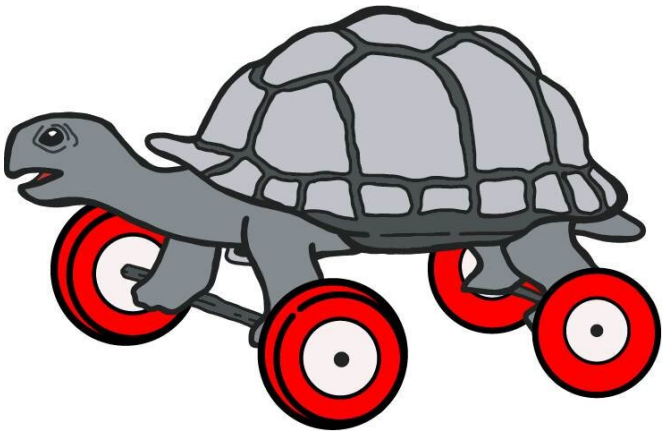

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Completing a task slowly and carefully may provide us with a high-quality product. It can be summed up by the popular adage "easy does it." But what if a high price has to be paid for slowness? Time is a scarce resource and, what is more, a good result is not guaranteed, since we may be easily disturbed or interrupted by various matters and events if we take too long. So it is clear that we are often interested in doing things well but also quickly. A contradictory adage illustrates this for us once again: "short and sweet." This everyday notion can also be applied in physics laboratories and especially when handling systems, such as natural or artificial atoms, that physicists and engineers use to try and create new quantum technologies designed to make calculations that are currently impossible; or to achieve secure, spy-proof communications, sensors with unprecedented sensitivities, and ultra-precise measurements of time and other physical quantities.

In the quantum world 'adiabatic' processes are those in which the system controls are modified slowly. Although they are widespread in setting up or changing states without exciting the system we intend to control, they are affected by the same problems referred to in the previous paragraph: lack of time and a considerable likelihood of being disturbed. They are serious problems in this context since quantum system states tend to be highly delicate, they degrade rapidly and lose those very valuable, strange quantum properties, such as the possibility of exploring various paths at the same time. To make matters worse, in an excessively long period of time an atom may end up escaping from the trap that contains it.

"Adiabatic shortcuts" are techniques designed to get round the difficulties that have just been referred to: this involves achieving the same results as slow adiabatic processes but within a short time. The term appeared for the first time in 2010 in a paper published in the *Physical Review Letters* by researchers at the UPV/EHU with collaborators from Germany and France. Since then, these ideas have been developed by the authors of the paper and by many other groups and many experiments have been run with all kinds of quantum systems. The fact that in 2018 alone the shortcuts were mentioned or used in over 1,500 papers gives an idea of the exponential growth in applications. The concept of "adiabaticity shortcut" has also spread beyond the quantum domain towards fields such as optics, to manufacture more compact devices; or engineering where, surprisingly, it can enable a mechanical crane, for example, to be accelerated without safety being compromised.

More information: Xi Chen et al. Fast Optimal Frictionless Atom Cooling in Harmonic Traps: Shortcut to Adiabaticity, *Physical Review Letters* (2010). DOI: 10.1103/PhysRevLett.104.063002

D. Guéry-Odelin et al. Shortcuts to adiabaticity: Concepts, methods, and applications, *Reviews of Modern Physics* (2019). journals.aps.org/rmp/abstract/ … RevModPhys.91.045001

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