# Superposition without the superstition: Is quantum mechanics really *that* weird?

*"If you think you understand quantum mechanics, you don't."*

*"I think I can safely say no-one understands quantum mechanics."*

*"Quantum mechanics makes absolutely no sense."*

Read almost any pop-sci account of quantum mechanics – with a few recent notable exceptions -- and you'll be told time and again that the subject is so weird and incomprehensible that the best we can do is put aside the deep philosophical questions about what it all means and just "shut up and calculate" [1]. Yet there is, of course, much about the physics of the ultrasmall that is well understood – otherwise, for one, it would not be possible to teach undergraduate courses in quantum physics.

I'll discuss quantum mechanics from the perspective of the scanning tunnelling microscope (STM), a groundbreaking instrument that celebrates its 40th birthday this year and which allows us to image and manipulate matter down to not just the atomic level but with a resolution defined by the ripples of electron waves [2]. Measurements that before the birth of the STM would have been considered to be *gendankenexperiments* forever – possible only in our imagination – are now routine in many labs across the world. Electrons can be confined, corralled, and cajoled in a wide variety of exciting ways; the STM not only directly images the resulting quantum waves but, via manipulation of atoms and molecules one by one, can control just how those electron waves scatter off matter on nanoscopic lengthscales. This gives us the facility to build what are known as artificial atoms – a route to designer materials whose properties we define and "dial in".

Quantum mechanics is indeed weird, and there is much that we still don't understand. But there's a great deal that we *do* understand and can exploit. Moreover, despite QM being painted as an exceptionally complicated theory, quite a number of the core concepts are understandable at a high school level, not least because there are many parallels with the physics of waves in the big, bad world around us [3].

[1] This well-quoted phrase is very often attributed to Richard Feynman but its source is almost certainly David Mermin. See https://aeon.co/essays/shut-up-and-calculate-does-a-disservice-to-quantum-mechanics

[2] https://muircheartblog.wpcomstaging.com/2015/08/01/wake-up-and-smell-the-quantum/

[3] https://muircheartblog.wpcomstaging.com/2021/10/26/superposition-without-the-superstition/