

Teaching an Old Wave New Tricks



Almost a century ago, Louis de Broglie invented pilot waves – which were soon forgotten. Forty years ago, physicist John Bell resurrected the concept. Today, Antony Valentini's version may revolutionize quantum mechanics.

by **MIKE MARTIN**

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Walking up a flight of stairs at a physics conference, a reporter once told renowned cosmologist Lee Smolin that he was “so smart” he made her nervous.

At the top of the stairs, Smolin pointed to another man. Antony Valentini, Smolin said, “makes me nervous.”

FQXi recently awarded Valentini a grant worth \$84,293 to study an idea that might make a lot of physicists nervous.

Uncertainty About Uncertainty

The most fundamental and widely known aspect of quantum mechanics is that uncertainty reigns. But by viewing an old theory in a new light, Valentini disputes that claim.

Relic particles from the very early universe could be used to perform currently impossible tasks such as communicating faster than the speed of light; cracking quantum codes; and possibly outpacing quantum computers.

– *Antony Valentini*

“My project,” he explains, “re-examines physics and cosmology from the viewpoint of hidden-variables theories, in which the apparently random outcomes of quantum experiments are determined in advance, by hidden parameters presently outside our control.”

Einstein – who was never comfortable with uncertainty – would like Valentini's ideas, up to a point. That's because along with killing quantum uncertainty, Valentini also dispatches with relative time, one of Einstein's most cherished notions.

In his famous theory of relativity, Einstein said nothing moves faster than light. But Valentini's work would revise relativity to allow distant observers to communicate instantaneously by replacing relative time with a universal clock.

For example, if I phone an alien at 2 P.M. Eastern time on planet Earth, the alien would answer at 2 P.M. Eastern time on planet Zeta – even if Zeta were 4 million light years away. If such a universal clock exists, it would represent the best-kept secret in the Universe – and the biggest hidden parameter of all. The old gripe, “I don't have control over my own time,” would become the happy circumstance, “Now I have control over my time – and everyone else's, too!”

“Of course,” says Valentini, who is currently at the Centre for Theoretical Physics in Marseilles, France, “some people don't like this idea.”

Riding the (Pilot) Wave

In his quest to demystify quantum physics, Valentini is like the Scarecrow who came seeking knowledge. He sees not the sorcery of Oz, but a guiding force behind the shroud – a figurative “Wizard of All” who controls the hidden parameters that control everything else.

But where to find this wizard? Valentini suggests looking far back in time and far out in space, toward light from the early universe. That is where, he

says, an old idea from the 1920's called “pilot wave theory” might make today's theories obsolete.



Scanned at the American Institute of Physics
CREATOR OF WAVE MECHANICS Louis de Broglie

Valentini has spent nearly 17 years “doing the most interesting and important work” on pilot wave theory, says Lee Smolin, a researcher at Perimeter Institute and member of the FQXi Scientific Advisory Panel.

A concept with a sound pedigree from the Roaring Twenties, pilot waves originated with one of the godfathers of quantum mechanics, French physicist Louis de Broglie.

Thirty years later, in the comparatively staid 1950's, American quantum physicist David Bohm tinkered with de Broglie's pilot wave project. But he drifted into a metaphysical netherworld with the idea, effectively killing it for several decades.

In its resurrected form, pilot wave theory rethinks standard quantum theory, which according to Rutgers University philosophy of physics professor Tim Maudlin, “only has the wave function and nothing else.”

On the other hand, “perfectly coherent” pilot wave theory gives the old wave function a new trick by adding “the simplest things one could imagine – actual particles for the wave to guide,” explains Maudlin, an expert on hidden variable theories. “Far from being invisible, the particles are the very things you see: the things that make up tables and chairs and cats and so on.”

In pilot wave theory, Valentini sees a way to explain the seemingly random actions of actual particles such as electrons. Everything seems based on what an electron might do, given a certain set of potential outcomes, some more probable than others.

As a result, quantum mechanics “doesn’t give a clear explanation of what’s happening,” Valentini explains. But if the wave function actually guides particles rather than just doing what old-fashioned quantum theory says it does – representing probabilities and collapsing once it’s observed – a clearer explanation emerges.

But so does another question. While physicists have examined plenty of wave function evidence over the years, where can they find evidence of the particles?

The Un(speakable) Lightness Of Being

Calling pilot waves a “new kind of physical entity,” Valentini suggests looking for evidence of their activity in “relic particles” from the very early universe, shortly after the Big Bang. This idea slowly unfolded for him after he read physicist John Bell’s *Speakable and Unspeakable in Quantum Mechanics*. In this book, Bell gave an account of

de Broglie’s pilot wave theory, and reprinted Bell’s famous 1964 paper proving that any hidden-variables theory must be non-local. Bell concluded that pilot wave theory combined quantum uncertainty with definite reality.



RE-EXAMINING BASIC PHYSICS AND COSMOLOGY **Antony Valentini**

“I went back and read the original papers and I realized he was right,” Valentini said. Pilot wave theory was back on the map.

But what truly excited Valentini was how pilot wave theory might explain a troubling anomaly of cosmology.

“In the early universe, space expanded so fast that distantly separated particles couldn’t interact if those interactions were limited by the speed of light,” he says. “But observations suggest such distant interactions did happen.”

Pilot wave theory permits particles to interact faster than light. “In fact,” Valentini says, “they can interact instantaneously.”

Cosmo-archaeologist

The old quantum wave function reborn as a pilot wave guides particles in a multi-dimensional “configuration

space.” The detailed motions of these particles should have been visible in the early universe, Valentini claims.

Big Bang relics such as old gravitons, leftover chunks of dark matter, or other particles “floating around in space now which were left over from that very early time” should provide plenty of pilot wave evidence.

If cosmologists can find these relics, Valentini suggests they might be used to defy contemporary physics, much like bringing ancient dino-DNA to life defied Darwinian evolution in *Jurassic Park*.

“Relic particles from the very early universe could be used to perform currently impossible tasks such as communicating faster than the speed of light; cracking quantum codes; and possibly outpacing quantum computers,” Valentini says.

Philosophical Fallout

Fallout – not only from the Big Bang, but also from the rise of German idealist philosophy in the nineteenth century – greatly influenced the physics Valentini wants to change. He explains that philosopher Immanuel Kant left people saying, “you can’t really know the world as it is,” opening the door to quantum uncertainty.

By the early 20th century, Austrian and German physicists, Valentini says, “had this idea that you shouldn’t speculate about what might be hidden behind appearances.” They effectively closed the door to questioning quantum uncertainty.

Today, working without all of the philosophical rabble, Valentini will have to study what Maudlin terms “virgin particles” from the earliest nanoseconds after the Universe was born.

But until Valentini touches them, those particles will have to be “untouched,” Maudlin says. “By the hands, as it were, of man.”