Solitons: Next wave in electronics?

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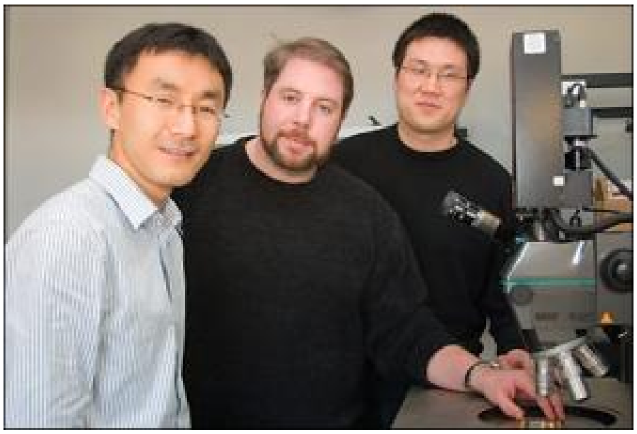

Those making waves with solitons at DEAS are Donhee Ham (from right), assistant professor of electrical engineering, and Ph.D. students David Ricketts and Xiaofeng Li. (Photo courtesy of DEAS)

Harvard scientists have solved the puzzle of how to generate a special form of wave in small electronic devices, allowing the electrical equivalent of the pulses of light that carry signals through optical cables.

The advance, highlighted in the March 2 issue of the journal *Nature*, occurred in the Harvard lab of Donhee Ham, assistant professor of electrical engineering in the Division of Engineering and Applied Sciences.

The special waves, called solitons, are valuable in commercial and engineering applications because they are single, stable waves that don't lose strength as they travel large distances. Soliton waves in optical fibers, for example, have transferred large amounts of information over thousands of kilometers with no errors in the signal.

Solitons can occur in many kinds of materials. They were first discovered in water by Scottish engineer John Scott Russell in 1834. Russell was watching a team of horses tug a barge along the Union Canal in Edinburgh when the rope to the barge broke. The barge's bow suddenly dipped into the water, creating a wave that set off up the canal with little change in shape. Sensing he was watching something he hadn't seen before, Russell rode his horse along the canal's banks for several kilometers watching the wave's steady progress.

Solitons have since been used in solid-state crystals, where they were rediscovered in the 1950s by physicist Enrico Fermi. In the 1960s, solitons were generated along fiber-optic cables as stable pulses of light. Optical solitons now form the backbone of the information technology industry.

Electrical solitons, stable pulses of electrical energy, were discovered in the 1960s at IBM, but their use in small electronic devices was limited by the need for a high-frequency input until the discoveries at Ham's lab at Harvard.

Ham, working with two Ph.D. students, David Ricketts and Xiaofeng Li, got around the need for a high-frequency input by building an electrical system that self-generates solitons.

"Self-generating stable electrical solitons was a significant challenge," said Ham. "Our initial circuits always exhibited chaotic oscillations."

Once the electrical solitons were generated, the problem was figuring out how to control them, which Ricketts and Li solved.

"David, a true trailblazer, joined my group in 2003 and within a year he invented the breakthrough stabilizing amplifier and implemented several successful prototypes," Ham said.

Li arrived soon after and chose to analyze the prototype circuit as a "hobby." In just two weeks, Li's casual interest developed into a "crystal-clear insight" that borrowed concepts from the tried-and-true optical version, Ham said.

Their new ability to tune the electrical soliton oscillator mirrors the robust optical system and allows them to generate waves readily in electronic circuits.

"Once further developed," said Ham, "the oscillator will open the door for ultrafast electronic measurement now only possible in expensive lasers. It can be also used for ranging radars and pulsed communication systems."

Source: Harvard University, by Michael Patrick Rutter

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