Evanescent Waves

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Air Power
By Stephen Cass

Wireless data connections are common?now scientists are working on wireless power
Wish you didn?t have to plug in your laptop and cellphone? A team of researchers from MIT may have just the thing for you. Yesterday, at the American Institute of Physics? Industrial Physics Forum in San Francisco, Marin Soljacic, Aristeidis Karalis, and J.D. Joannopoulos described a scheme that would let devices get their power the same way they get their data: through the air.

Of course, transferring energy wirelessly is nothing new in itself. Electricity is routinely transferred in this way in transformers using induction; radio frequency identification chips are energized by radio waves emitted from RFID readers; and for years, researchers have worked on transferring energy over long distances using microwaves. But there are obvious limits. Although a lot of power can be passed through a transformer, the energy typically can be transmitted only a few millimeters inside the transformer. RFID readers do have a longer range, but little power can be transmitted to the chips. Microwave systems can transmit fair amounts of power over long distances, but they are bulky and have to use a tightly focused beam that must be precisely pointed at the receiver to keep the energy from being hopelessly dissipated.
Although it?s only a theoretical analysis, what?s important about the MIT team?s work is that it could open the door to transmitting enough energy to power electronic devices efficiently over a middle range?several meters?without having to worry about exactly where the receiver is in relation to the transmitter.

To understand how the MIT idea works, we first have to look at how a regular omnidirectional radio transmitter works. Electrical energy is pumped into such a transmitter, and the energy is then carried away by radio waves that radiate in every direction. So the amount of energy that can be picked up by a receiver located at any given point away from the transmitter?s antenna is only a fraction of the total amount of energy being put into the transmitter.

Now, in the MIT scheme, instead of familiar radio waves, energy is carried by ?evanescent waves,? which owe their existence to a wrinkle in the laws that govern electromagnetism. The most important feature of evanescent waves is that although they carry energy, they don?t radiate it away. Rather, they borrow energy from the transmitter and then promptly return it. The reason evanescent waves are unfamiliar to most people?though they do have applications in the fiber−optic cables that carry most data today?is because the laws of physics dictate that they must typically have short ranges; their intensity decays exponentially with distance. That makes them unsuitable for many uses, such as carrying data signals over long distances through the air.

However, the MIT team claims that it?s possible to build a transmitter capable of setting up a field of evanescent waves with an effective range of several meters. The evanescent field doesn?t get absorbed by nearby objects, because only objects that are precisely tuned to resonate with the emitted field can absorb energy from it. An analogy is to ?imagine a hundred glasses filled with different levels of water,? Karalis says, and then turn on a speaker set to ?generate sound at a particular frequency. Most of the glasses won?t feel anything?but one [if it happens to be at the resonance frequency] might even break.?

A suitably resonant receiver ?senses the field and literally sucks it, drains it out,? says Karalis, who estimates that over a distance of a couple of meters, the scheme could approach a power transmission efficiency of 50 percent. ?So if I want to feed something with 10 watts, I just supply 20 watts from my source,? he says.

?Even if that?s too optimistic, and the efficiency is as low as 10 percent,? he adds, ?for any practical purpose, that?s very good?but we expect much more than that.? Despite the potential for high efficiencies, the strength of the magnetic fields involved is very low. Initially, the MIT team believed that the magnetic fields required would be similar to those used in MRI medical imaging machines, with field strengths of about 1 tesla. But when they finished their calculations, they were pleasantly surprised to find that to transmit a few watts over a few meters (enough to power a cellphone or to recharge a laptop), the required magnetic field should be about 10 000 times less, around the same strength as the earth?s magnetic field.

The exact design and size of the transmitter has yet to be worked out, but for home applications, a room could be energized with a loop antenna, about a meter across, mounted on the ceiling.
Still, before we all start putting in our orders for wireless power transmitters to go with our Wi−Fi access points, the MIT scheme has a few practical hurdles to overcome. ?In concept, it?s not out of the question,? says James Lin, an IEEE Fellow and a professor in the electrical and computer engineering department at the University of Illinois at Chicago. Lin, who is also an expert on electromagnetic radiation and its interaction with biological systems, is concerned that in practice it will be impossible to stop the system from radiating at least some energy into the surrounding environment, where it could be absorbed by objects?including people and other biological organisms. Lin also doubts it will be possible to completely prevent objects from absorbing some of the nonradiating evanescent fields, even if they resonate with them only weakly.

It?s ?very early days,? admits Karalis, acknowledging the limitations of the current theoretical analysis. But he says, ?Our initial estimates for the magnetic field and the radiated power densities are encouraging in that they fall below the threshold of the FCC [U.S. Federal Communications Commission] safety regulations.?

The MIT team is planning physical experiments to confirm its analysis. ?We strongly believe this is going to work, but we want to verify that objects around us don?t disturb the system a lot, and that the method is safe. You never know what the real−world surprises are going to be,? Karalis says. But he adds firmly, ?We would not design something that?s going to harm people.?

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