Research News

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Physicists create first "spin dynamo"

BY FRANK NOLAN
Research Promotion

Thanks to advances in nanotechnology and microelectronics, we can now make complex devices that are invisible to the naked eye. A major challenge is finding a way to power these tiny systems, and a team of University of Manitoba researchers may have found an answer.

Based in the department of physics and astronomy, the group has created a microscopic device that can convert microwave energy into electrical current. Called a "spin dynamo," it generates current from the spin of electrons, rather than their charge, and it represents a major leap forward in our understanding of spin dynamics and magnetism.

Led by Can-Ming Hu, the team includes physics professor Gwyn Williams, research associates Yongsheng Gui and Xuezhi Zhou, and Nikolai Mecking, a visiting PhD student from the University of Hamburg.

The team's findings were published in the March 9 edition of *Physical Review Letters*, the journal of the American Physical Society.

Hu said most of the electrical current we use everyday is produced by dynamos based on a principle first demonstrated by English physicist Michael Faraday in 1831. Faraday's dynamo produced electrical current by rotating a copper disk inside a magnetic field.

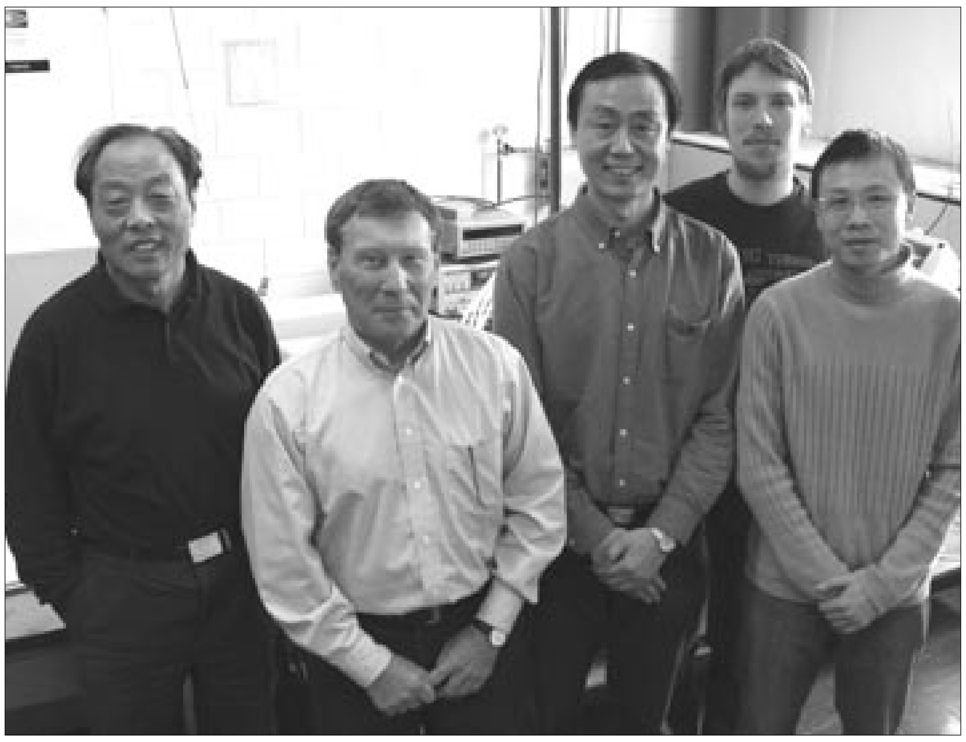

Photo by Frank Nolan

From left, the spin dynamo research team includes Xuezhi Zhou, Gwyn Williams, Can-Ming Hu, Nikolai Mecking, and Yongsheng Gui.

"Electrons are charged particles, and when the copper plate is rotated in the magnetic field, electrons are deflected off, resulting in current," Hu said.

Unlike Faraday's model, the new spin dynamo produces current from the rotation of the electrons themselves. The process still involves placing a piece of metal in a magnetic field, but the metal does not move. The spin dynamo can also be made very small.

"In our case, the metallic plate is actually a ferromagnetic strip that is thinner than a human hair," Hu said. "When we expose them to microwaves, the electrons on the strip dance like little tops, behaviour we call 'spin precession,' and in the magnetic field, this spin precession produces electrical current."

Hu's team has shown that it is possible to produce electrical current from electron spin, and that microwave energy is all that is needed. In theory, Hu said, this principle could be refined to the point where it might one day be possible to generate electrical current from the ambient microwaves that are all around us as a result of modern communications technology.

Hu said there is still a lot of work to be done before the new device could be used as a power source in practical applications. In the meantime, though, the spin dynamo will be a valuable tool for studying the nature of spin precession.

"Understanding electron spin is a fundamental question related to the origin of magnets, or why a compass is a compass," Hu said. "By measuring current, this device will give us a new way to detect electron spin, which is very exciting indeed."

Nematodes tell a lot about soil health

BY FRANK NOLAN
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If you want to know how healthy your soil is, just ask a nematode. These tiny worms are found in every type of soil, and they are active at every level of the soil food web, making them excellent "bio-indicators" of soil health.

"Working with bio-indicators means basically peering into soils and having the organisms that are present talking back to us," said soil scientist Mario Tenuta, Canada Research Chair in Applied Soil Ecology. "I find nematodes particularly useful because different nematodes are active in different parts of the web, with some species eating plants, some eating bacteria or fungi, and other groups being carnivores or omnivores."

Soil nematodes range in size from about a quarter of a millimeter to three millimeters. The biggest are the omnivores, which can be up to ten times larger than the ones that feed on bacteria.

"The number of different kinds of nematodes you find says a lot about the diversity of the soil food web in general," Tenuta said. "For example, a sample of 200 grams of native prairie soil can contain anywhere from 40 to 70 different taxa of nematodes. In contrast, soil that has been altered by management, like that in a potato field, might contain only 15 different taxa."

Tenuta said that because of their sensitivity to changes in the soil environment, nematodes are ideal tools for studying the impact of different agricultural management practices, as well as pollution and contaminants.

"Our major goal is to identify which practices are the most beneficial to soil health," Tenuta said. "We're looking at the whole range, from conventional practices to alternative agricultural practices, from systems that include pesticides and fertilizers to those that don't."

Part of the research includes nematodes that can be harmful to crops. For example, some potato producers have been concerned about the presence of a genus of nematodes that can kill potatoes (Pratylenchus), so PhD student Amro Mahran is screening potato fields across the province. So far, he has not found the very harmful species of this nematode in any of his samples.

Tenuta is also studying nematodes in northern Manitoba, where the focus of his work is climate change. His lab is trying to determine how changing air temperatures might affect things below the surface of the soil, particularly the structure of the soil food web, which has implications for carbon and nitrogen cycling in the environment. This stream of research begins this spring with the addition of visiting scholar Cunyu Zhou and MSc student Rhea Lumactud to the Soil Ecology Laboratory. They will be studying how carbon and nutrients move through the soil food web under warmed soil conditions.

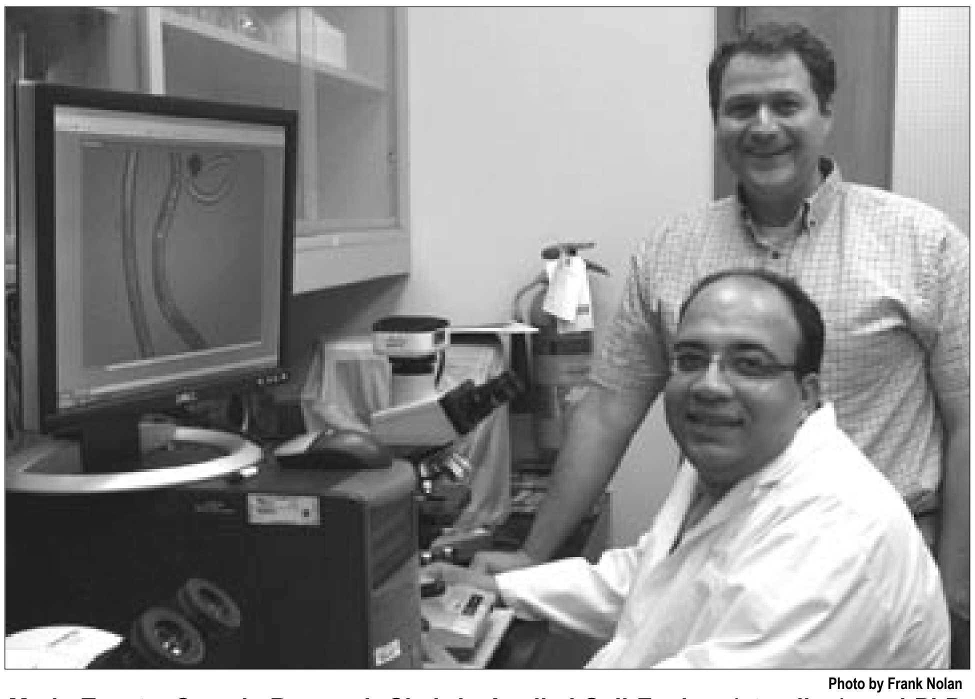

Photo by Frank Nolan

Mario Tenuta, Canada Research Chair in Applied Soil Ecology(standing), and PhD student Amro Mahran are studying the nematodes found in soil.

"Right now the study of climate change and its effect on the soil food web is still in its infancy," Tenuta said. "We're really interested in feedbacks and connections in the system so that we can understand what happens when there is a shift in soil temperature. For example, are there frozen soils that might have methane stored in them that could suddenly be released? It's a serious question, and it's all part of the big picture. To properly understand these things, scientists need to study systems in the soil, above ground, in the water, all over the place. In terms of the soil ecosystem, nematodes have a prominent spot in our toolbox of bio-indicators."

Bringing Research To Life

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