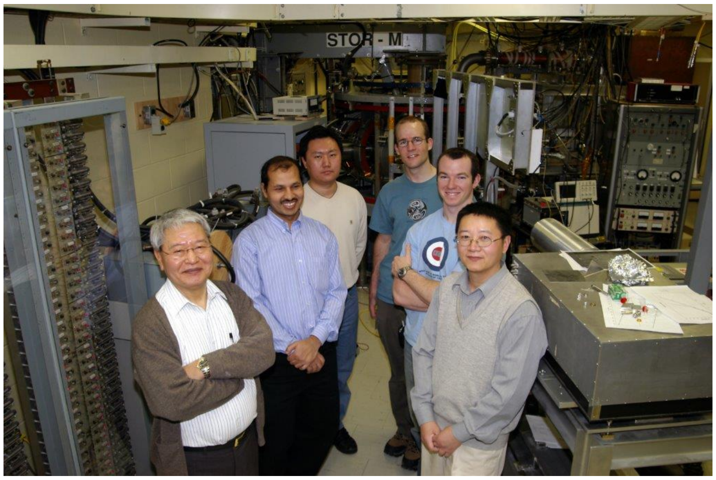
Research



Akira Hirose (front left) and Prof. Chijin Xiao (front right) with students, and tokamak in the background.

Harnessing nuclear fusion power key to future

With Canada's only tokamak fusion reactor, the University of Saskatchewan has long been on the front lines of nuclear fusion experimentation.

By SARATH PEIRIS
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Fusion is what powers the sun, where massive gravitational forces fuse together 600 tons of hydrogen nuclei every second to form helium. Fusion releases more energy than is expended to create the reaction. The tokamak, in effect, creates a miniature sun under controlled conditions.

One kilogram of fusion fuel is capable of producing the same energy as burning 10 million kilograms of coal. Climate change is driving interest in harnessing fusion power for carbon-free electricity production.

Today, the university is part of a consortium of academic, industry and non-profit organizations advocating for making fusion a national priority. Participants in British Columbia., Alberta, Saskatchewan, Ontario and Quebec have drafted a report, *Fusion 2030: Roadmap for Canada*, designed to accelerate fusion energy research and development.

It all began in the 1950s, when physicist Harvey Skarsgard initiated a plasma physics research program at the U of S. He developed the world's first plasma betatron which enabled accelerating and studying electrons.

Skarsgard's experiments with plasma—ionized gas in which electrons have been freed from the nuclei of hydrogen atoms by heating the gas to temperatures in the range of 100 million degrees Celsius needed for a fusion reactor—led to the creation of the Plasma Physics Laboratory (PPL) at the U of S in 1959.

Akira Hirose, a physicist attracted to the university in 1971 by the innovative research at PPL, contributed immensely to keeping the U of S at the fore of plasma physics research until his death in November 2017.

"It was my privilege to work with this great physicist," said professor Chijin Xiao, who joined the U of S as a postdoctoral fellow under Hirose 27 years ago. "Akira was really passionate about fusion research in both experimentation and theory. He was inspirational, and he had great ideas."

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PPL is the academic leader in Canada for research and training related to fusion and plasma physics, thanks in part to Hirose's work. He trained about 30 PhDs in plasma physics and worked with close to 20 postdoctoral fellows and collaborators over the past five decades.

Hirose was appointed Canada Research Chair in Plasma Science at U of S in 2001. Among his many accomplishments was designing and building two tokamak fusion reactors— STOR-1M in 1983 and STOR-M in 1987 — to study plasma heating and confinement.

Tokamaks are doughnut-shaped devices that generate plasma and contain it safely within an invisible "cage" created by a strong magnetic field. Nuclei of hydrogen isotopes within the plasma are squeezed in attempts to fuse them together.

STOR-M experiments are carried out using hydrogen gas. Although STOR-M is a small reactor, its contribution to understanding plasma physics has been considerable.

"The beauty is it doesn't matter if the tokamak is big or small," said Xiao. "The fundamentals of physics are the same. In that way we have contributed to the larger programs and developed ideas that make a difference."

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The eventual goal internationally is to produce deuterium from water and combine it with tritium in a large reactor to cause fusion. Currently, 35 nations are building a giant International Thermonuclear Experimental Reactor (ITER) in Cadarache, France, to test the feasibility of generating fusion power on a commercial scale.

The aim of ITER is to generate 500 megawatts of fusion power from 50 MW of input power. The ITER experiment isn't designed to turn that energy into electricity, but to open the door for reactors that can.

The federal government cancelled Canada's national fusion program in 1997, but U of S researchers are continuing with research that contributes to ITER.

Hirose and Xiao led a PPL team at the U of S that advanced tokamak technology by developing ways to use alternating current to maintain the machine's complex magnetic configuration. Their experiments also led to producing two Compact Torus Injection (CTI) systems for fuelling plasma reactors without disruption.

"This kind of technology has been identified by an ITER working group as the only promising method to directly fuel the reactor core," said Xiao.

Under Hirose the U of S began collaborating on fusion research with General Fusion in Burnaby, nuclear scientists at several Canadian universities, and with small fusion research programs around the world through the International Atomic Energy Agency.

"We will work hard to continue Akira's legacy," said Xiao. "We need to build up the capability to participate in a significant way."

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