Unexpected Benefits of Harnessing Star Power

The reaction that fuels the stars – fusion – would be a source of energy that is unlimited, safe, environmentally benign, available to all nations, and not dependent on climate or the whims of the weather. In fusion, two hydrogen isotopes – deuterium and tritium – fuse to form a helium nucleus, releasing a large amount of energy carried by a neutron. Significant resources – most notably from the U.S. Department of Energy's Office of Fusion Energy Sciences – have been devoted to pursuing that dream, and significant progress is being made. However, that is only part of the story.

Many basic science discoveries, while important by themselves and foundational in their fields, also yield spinoff applications or enabling technologies not envisioned by the scientists doing the original work. This is what makes investment in science like fusion energy research so powerful – the impact extends well beyond the laboratory.

In the quest for fusion energy, numerous new scientific frontiers and technologies have been, and are being, created. Many of these innovations and insights are proving to be invaluable in applications far afield from fusion energy research.

Spinoff technologies from fusion investments have had a transformative effect on society, with the public benefiting greatly in areas such as electronics, lighting, communication, manufacturing, and transportation. Owing to its interdisciplinary nature, many different fields of study have benefited from fusion research.

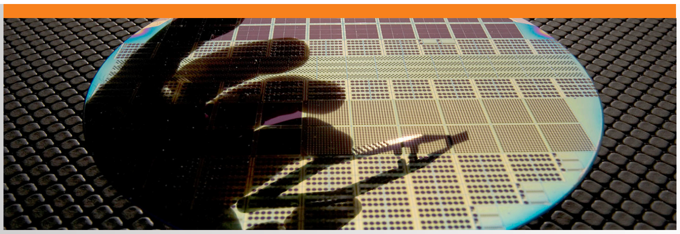

Photo credit: Fermi National Accelerator Laboratory

Silicon Wafers

Plasmas are used to etch and deposit materials on thin silicon wafers in a series of steps that result in tiny transistors and capacitors, and the tiny wires that connect them into circuitry. Advances in plasma technology have improved the performance of electronics, doubling the number of transistors on a chip every two years or so. This translates into smaller, lighter, and more energy-efficient electronics.

Photo credit: U.S. Navy

Electromagnetic Aircraft Launch System

The USS Gerald R. Ford was the first aircraft carrier to use an electromagnetic catapult, enabled by fusion science. Developed with fusion knowledge from General Atomics, the Electromagnetic Aircraft Launch System, or EMALS, is now replacing the Navy's steam catapults. The use of electromagnetics lowers operating costs and improves catapult performance. The enabling innovation came from fusion research that resulted in a precise control of sequencing magnets. For EMALS, that precision enables enormous propulsion capacity and expands the range of aircraft that carriers can now launch.

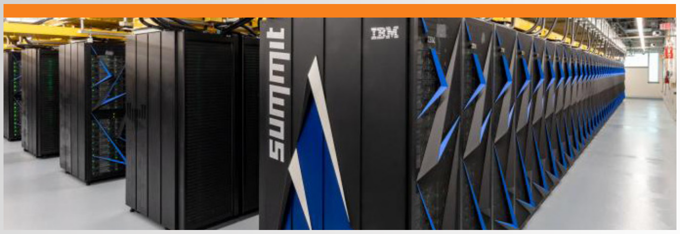

Photo credit: ORNL

Driving Innovation in Computing

Understanding and controlling the complexities of fusion plasmas is one of the key areas of inquiry for DOE's supercomputing program. This quest has been a key driver for advances in high-performance computing such as the Summit supercomputer at Oak Ridge National Lab, capable of 200,000 trillion calculations per second.

Making GPS More Reliable

The faint signal transmitted by GPS satellites to your car or cell phone can easily be scattered by disturbances in the ionosphere, which is the dense plasma layer between GPS satellites and the Earth's surface. Research into the stability of plasmas has advanced our understanding of the formation of instabilities in the ionosphere and the potential disruption of satellite signals and communication.

Spinoff Technologies from Fusion Energy Research

Photo credit: Andreas Beutel

Making Lights Brighter

Plasma research has led to low-profile, micro-plasma lights that combine strong illumination with energy efficiency. In domestic settings, these mercury-free lights have been fashioned into almost any shape, blending function with aesthetics, and making them ideal for seamless integration into wall or ceiling surfaces.

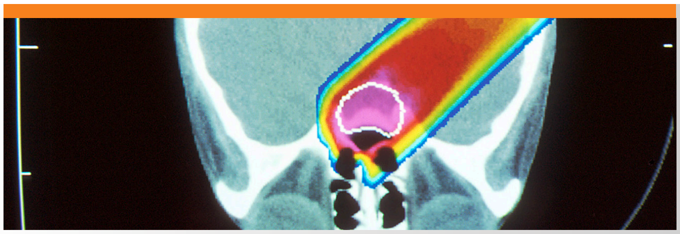

Photo credit: National Cancer Institute

Annihilating Tumors

Plasma beams have promise to improve cancer therapy. A designer plasma beam, known as an antiproton beam, is four times more effective than conventional proton beam therapy at destroying tumors. The antiproton beams annihilate on impact, releasing much more energy into the tumor.

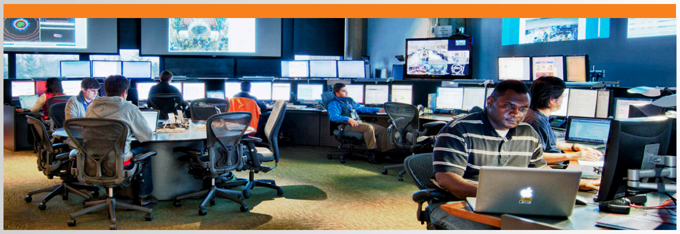

Photo credit: Fermi National Accelerator Laboratory

Understanding Our Universe

The scientific instruments, computational tools, and knowledge to generate and control intense fusion plasmas have led to new discoveries about the phenomena occurring in the universe around us. For example, scientists developed the Warp simulation code for fusion research. A revised and expanded version of Warp was used at CERN to improve the Super Proton Synchrotron, which provides beams for the Large Hadron Collider, an engine for discovery about the fundamental structure of matter and elementary particles.

Photo credit: Ad Astra Rocket Company

Spacecraft Propulsion

In chemical rockets, the energy is stored in the fuel's chemical bonds and is thus energy-limited; in plasma rockets, the energy and fuel are separate, allowing one to add more energy and achieve greater velocities – 10 to 100 times that of chemical rockets. These plasma engines are being used to keep a spacecraft in an assigned orbit, maintaining the proper position of orbiting platforms such as the Boeing Direct TV communication satellites.

Photo credit: Howard Slutsken, Wingborn Ltd.

Safer, More-Efficient Jet Engines

To handle the extreme heat inside a jet engine, turbine blades are typically spray coated with ceramic particles. The coating is done by injecting ceramic powder into a flowing plasma jet. The plasma jet melts the particles and carries them to be deposited as splats on the blades. Fueled by fusion studies, research into creating and melting these injected particles has been vital in understanding and optimizing the process.

Cleansing Water

Ozone is increasingly replacing chlorine in treating municipal drinking water, due to its effectiveness at destroying viruses and bacteria with minimal ecological impact. Large-scale ozone generation is based on plasmas, an ionized gas made of positive ions and free electrons, created in pure oxygen. Plasma research has enabled recent advances in efficiency and in cost reductions for ozone treatment.

All information courtesy of the U.S. Department of Energy's Office of Fusion Energy Sciences

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