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World's Most Powerful Magnet

MAGNETS

It casts enough magnetic force to slow a locomotive from a quarter-million miles away—the distance of the Earth from the moon. The “magnetar,” or magnetic neutron star known as Soft Gamma Repeater 1806–20, is the most powerful known magnetic object in the universe. Only 10 of these unusual objects have been discovered. With a magnetic-field strength of 100 billion teslas, it dwarfs that of the Earth, whose magnetic field measures just 0.00005 tesla. While it's unlikely anything manmade will ever come close to the power of a magnetar, it's not for lack of trying. For reasons that range from the basic “What if?” of pure science to the need to improve medical imaging devices, tremendous efforts are under way to develop more powerful magnets.

Researchers at the National High Magnetic Field Laboratory (NHMFL) in Tallahassee, Fla., currently hold the record with a hybrid magnet system they put into operation in December 1999. Weighing 34 tons and standing 22 ft. tall, it has a magnetic field of 45 teslas, about a million times more powerful than the Earth's magnetic field. That's enough to make conventional electronic and magnetic materials behave very differently than they do normally.

The magnet developed by the NHMFL represents an engineering milestone on the order of building the space station, says NHMFL director Jack Crow. “It's quite an engineering feat.”

No Horseshoe

If you're envisioning a giant horse-shoe, you will be disappointed. The Florida system, shown here, essentially consists of two giant magnets working together. A supercooled, super-conducting magnet forms the outer layer. It's the largest cable-in-conduit magnet ever built, and must remain chilled to near absolute zero. This is done using a superfluid helium cryogenic system—the only such system in the United States specifically created for magnetic use. In the center of the complex contraption sits a massive electromagnet—that is, a very large resistive magnet.

Despite the size of the NHMFL system, the target area for conducting experiments is extremely small. A typical project may involve a test sample with the diameter of a No. 2 pencil. The sample would be contained in a thermos-like bottle to keep temperatures down.

Strange things happen when materials are subjected to extremely high magnetic forces. Electrons, for example, have been shown to dance in their orbits. When magnetic fields exceed 35 teslas, normal properties of materials may morph. Semiconductors may switch back and forth between conducting and nonconducting states.

Crow says the power of the Florida magnet will be increased to 47 or 48 teslas within the next two years and will reach 50 teslas within five years. The research benefits of the magnet have exceeded Crow's hopes.

“It has met all of our expectations and then some,” he says. “The [research community's] demand has been incredible.”

Medical Applications

While the NHMFL may focus on pure research, much of the development work going into high-powered magnets is being driven by medical needs. The University of Florida Brain Institute lays claim to having the largest magnet used for body imaging, a 24-ton behemoth that can explore a long list of injuries and diseases of the brain and spinal cord. At 11.7 teslas, it is 234,000 times more powerful than the Earth's natural magnetic field.

The higher the magnetic field, the more precise and detailed the results that can be rendered by technologies such as magnetic resonance imaging (MRI). “This new magnitude of imaging capability will strengthen studies of brain and spinal cord injuries,” as well as strokes and diseases such as Alzheimer's, explains Dr. William Luttge, executive director of the Brain Institute. One project under way will use functional imaging of live animals to see how strokes damage brain tissue over time, and how drugs may affect that deterioration. A functional MRI (fMRI) images chemical uptake by individual brain cells.

MRI and fMRI technology uses a powerful magnetic field to line up the body's cellular nuclei like compass needles. Another, less powerful magnet then spins the nuclei—like toy tops—generating a measurable signal that computers can read and transform into a 3D visual image. The more powerful the magnets are, the more nuclei that respond. Unlike X-rays, which provide images of bones and hard tissues, MRIs primarily focus on soft tissues.

The expanding medical uses of magnets raises an obvious question: Are magnetic fields good or bad for the human body? There has been plenty of debate in recent years over the effects of living near high-voltage power lines. But since magnetic-field strength falls off rather rapidly, someone living just 50 ft. from a transmission line would likely experience no more than 2 milligauss. The latest research finds no reason to believe that this level of exposure could have a deleterious impact on the body.

Conversely, researchers have found no positive impact from the wearable magnets commonly sold as cure-alls for numerous ailments, including arthritis. But that hasn't prevented people across the globe from buying them as remedies.

PHOTO (COLOR): Ultralow temperatures are needed to create ultrahigh magnetic fields.

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By Paul Elsentein

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