Big Magnets, Big Molecules

September 6 2006

University of Utah chemist David Grant -- a pioneer in the use of powerful magnetic devices and a method known as nuclear magnetic resonance (NMR) spectrometry -- stands in front of the new $14 million NMR center named for him and nicknamed for Carl Friedrich Gauss (1777-1855), a mathematician whose name s used for the units that indicate magnetic field strengths. Photo Credit: Dennis Edwards

Magnets strong enough to stop a heart pacemaker, wreck credit cards and yank tools from your hands will be used to probe the structure of big molecules in a $14 million facility that will be unveiled Friday, Sept. 8 at the University of Utah.

The David M. Grant NMR Center initially will house most of the university's existing nuclear magnetic resonance (NMR) devices, which contain magnets that generate fields 23,000 to 138,000 times stronger than Earth''s magnetic field. Within two years, it will hold an NMR magnet with 184,000 times the pull of Earth's magnetic field.

And when the university raises another $5 million, the center eventually could house a 900-megahertz magnet – 207,000 times stronger than the planet's magnetic field – that would be among the most powerful magnets in the world used for NMR research.

"The David M. Grant NMR Center is wonderful for the University of Utah," says university President Michael K. Young. "It will be used by scientists from across our campus to reveal the structure and makeup of molecules, especially large molecules that can be analyzed only by powerful magnets. This new research center will be used by researchers in biology, medicine, biochemistry, chemistry, geology, chemical engineering, physics, materials science and other fields."

"It is a state-of-the-art facility," says Ronald J. Pugmire, associate vice president for research, professor of chemical engineering and NMR spectroscopist (a scientist who studies molecules using NMR spectroscopy).

A dedication and ribbon-cutting for the center will be held at 1 p.m. Friday, Sept. 8 on the outdoor plaza between the two wings of the Henry Eyring Chemistry Building. The center is attached to the plaza. The public and news media are invited.

Speakers will include Young; David M. Grant, the distinguished professor of chemistry and pioneering NMR spectroscopist for whom the new center is named; Pugmire, who secured funding and led the team that designed the new center; and Peter B. Armentrout, department chair and distinguished professor of chemistry.

Guided tours will be given. The building requires finishing touches, so faculty and the chemistry department's existing NMR spectrometers will move into the building after Oct. 2. But the devices will be available for viewing in the Henry Eyring Building.

Cost and Construction of the NMR Center

Construction of the new facility began during the summer of 2005. The building cost $7,567,700, split by the National Institutes of Health and the University of Utah.

Some $4 million worth of existing NMR spectrometers – with strengths ranging from 100 to 600 megahertz – will be moved into the new center from the chemistry department. Also, “the university is committed to purchasing an 800-megahertz NMR spectrometer within one or two years at a cost of $2 million or more,” Pugmire says.

That will bring the total value of the new building, existing NMR devices and the powerful 800-megahertz NMR spectrometer to about $14 million.

Pugmire says the university hopes to raise another $5 million for a 900-megahertz NMR spectrometer in two to three years. That device would have one of the strongest “persistent” magnets – those with a constant magnetic field – now used for research. The strongest are about 940 megahertz. (Much stronger magnets exist, but are not constant. They are “pulsed” to extreme magnetic field strengths for a few thousandths of a second.)

Magnetic fields are measured in units named for mathematician Carl Friedrich Gauss (1777-1855). Earth’s magnetic field is about 1 gauss. A refrigerator door magnet’s field strength is about 100 gauss. The 800-megahertz magnet for the new NMR Center would generate a 184,000-gauss magnetic field – 184,000 times Earth’s magnetic field. A 900-megahertz magnet would be 207,000 times stronger than Earth’s magnetic field.

To work, the cylinder-shaped magnets are chilled with liquid helium and liquid nitrogen to extremely low temperatures of about 452 degrees below zero Fahrenheit.

Pugmire says the “very powerful magnets” in the new center could cause a cardiac pacemaker to malfunction or stop, erase information from the magnetic data strip on credit cards, and yank metal objects from a person’s hands.

For that reason, the magnets will be installed on the restricted underground level of the two-level, 24,000-square-foot building. The upper level contains six chemistry laboratories and 23 offices for faculty and students.

Armentrout says the new center “will form the region’s strongest focal point of NMR research devoted to problems in a variety of fields.”

What is NMR Spectroscopy?

Research scientists at MIT and Stanford first developed nuclear magnetic resonance spectroscopy in 1946. NMR is a phenomenon that occurs when the nuclei of certain atoms are aligned by a stable magnetic field and then exposed to pulses of FM radio waves that generate a second, oscillating magnetic field.

The technique helps scientists determine the arrangement of atoms within a molecule. That, in turn, identifies the molecule, its structure and chemical characteristics.

NMR research is based on magnetic properties of the nuclei of atoms – properties that can reveal chemical information. Subatomic particles such as protons, neutrons and electrons have a property called "spin." In some atoms, the spins cancel each other so the nucleus has no overall spin; in other atoms, the nucleus has an overall spin.

An excellent analogy for NMR is a child's toy top. If the top is not spinning and you stand it on its tip, it falls over due to Earth's gravity. If you spin the top, it does not fall over, but wobbles in a circular fashion. The scientific word for this wobble is "precession," and the spinning of the top gives it "angular momentum."

Because the nuclei of many different kinds of atoms have angular momentum, they act like tiny compass needles and align with a magnetic field the way a compass needle aligns with the Earth's magnetic field.

While a wobbling top makes a circle about once per second, nuclei precess at one hundred million to one billion times per second, depending on the strength of the magnetic field. Scientists characterize these precession rates in units of megahertz, which represents a precession rate of one million times per second.

NMR magnets that make hydrogen atoms "wobble" at 500 or 600 megahertz are common. The strongest existing magnets make hydrogen precess at almost 1,000 megahertz.

The quest for higher magnetic strength is important because the stronger the magnet, the bigger the molecule that can be studied using NMR spectroscopy. The 800- and 900-megahertz spectrometers to be housed in the Grant NMR Center will permit University of Utah scientists to study larger molecules than ever before.

The Man behind the Name

The new center, nicknamed the Gauss Haus, is formally named for

Grant, a U professor who is a world leader in NMR spectroscopy.

"David M. Grant is a true pioneer in the field of nuclear magnetic resonance spectroscopy," says chemist Peter J. Stang, dean of the university's College of Science.

Grant, 75, earned his bachelor's and doctorate degrees in chemistry at the U in 1954 and 1957, respectively. After working a year at the University of Illinois, Grant returned to Utah and joined the chemistry faculty in 1958 as an assistant professor.

By 1962, Grant became chemistry department chair and helped convince the Utah Legislature to authorize planning for new chemistry facilities. Grant oversaw construction of the Henry Eyring Building, which opened in 1968, and then launched a vigorous campaign to hire new faculty. He served as dean of the College of Science from 1976 to 1985, and was named a distinguished professor of chemistry in 1985.

Grant is recognized as an outstanding teacher, and has directed the research of 51 Ph.D. graduates. He has published more than 400 papers and served as editor-in-chief of the John Wiley & Sons definitive, nine-volume "Encyclopedia of NMR."

Source: University of Utah

Citation: Big Magnets, Big Molecules (2006, September 6) retrieved 25 April 2024 from https://phys.org/news/2006-09-big-magnets-molecules.html