mired as a *tour de force*. Assuming that all other nonpathological type-Ia supernovae have the same intrinsic luminosity as the two they calibrated against Cepheids, Sandage and his colleagues arrive at a Hubble constant of 52±8 km/sec-Mpc.[4]

Kirshner, now wearing his type-Ia hat, disagrees. He and Harvard colleagues Adam Riess and William Press contend that type-Ia supernovae are not in fact standard candles, but something else just as useful. In a new paper[5] they argue that, although type-Ia supernovae are not monoenergetic, one can deduce the intrinsic luminosity of any one explosion from the time dependence of its observed brightness. Applying this technique to the records of 13 supernovae out to several hundred megaparsecs, they get a Hubble constant of 67 ± 7 km/sec-Mpc.

—BERTRAM SCHWARZSCHILD

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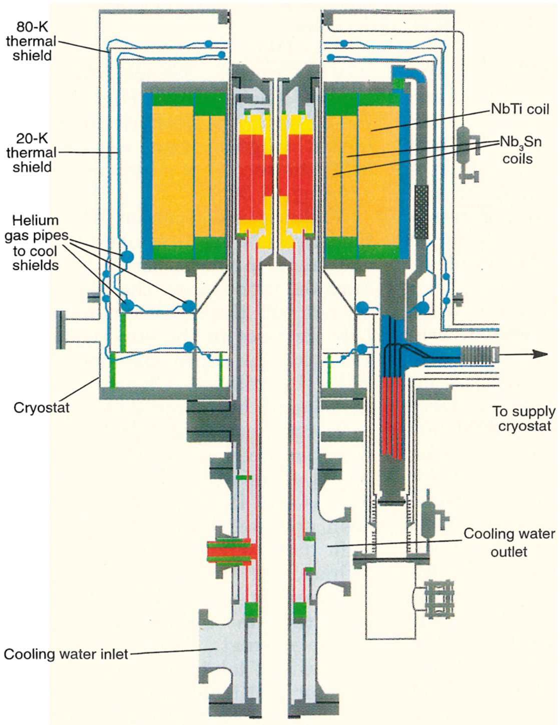
FLORIDA DEDICATES NATIONAL HIGH MAGNETIC FIELD LABORATORY

On 1 October, four years after the National Science Foundation chose to build a new high-magnetic-field laboratory at Florida State University rather than upgrade the existing Francis Bitter National Magnet Laboratory at MIT (see PHYSICS TODAY, January 1991, page 53), the new laboratory was dedicated in Tallahassee.

At the dedication Vice President Al Gore praised the creation of "the world's preeminent magnetic laboratory," whose 300 000-square-foot building was finished on time and on budget. The lab is billed as a partnership of the Federal government, the state of Florida, the University of Florida, Florida State University, Los Alamos National Laboratory and private industry. Gore noted that the National High Magnetic Field Laboratory is an example of the full and equal partnership advocated in the Clinton Administration's recently released white paper on science policy (see PHYSICS TODAY, September, page 79). Former NSF director Erich Bloch, who was largely responsible for the decision to build the new facility in Florida, said that the partnership "gains leverage" for NSF and allows Florida to enhance its prestige.



45-T hybrid magnet being constructed at the National High Magnetic Field Lab in Tallahassee, Florida. The experiment is placed in the center of the magnet, which has a 32-mm room-temperature bore. Because the user platform is at the same level as the top of the cryostat, it is convenient to arrange equipment on and around the magnet. The red indicates water-cooled Bitter coils and superconducting magnet current leads. Dark blue shows liquid helium; light blue shows cooling water. Dark gray shows stainless-steel cryostat, water-cooled magnet housing and support structures.

Once the NHMFL is fully operational, the lab anticipates over 400 users annually. The facility cost the state of Florida $65 million to construct and $11 million for instrumentation. NSF is providing $12 million per year for the first five years to cover operating costs (to power the magnets and support the magnet development group), and Florida is kicking in an additional $7.4 million in operating costs annually.

The National High Magnetic Field Laboratory will have a variety of high-field magnets and advanced instruments for research in condensed matter, biology, chemistry and materials science, most of which will be done in Tallahassee; the lab's other facilities are at Los Alamos and the University of Florida, Gainesville.

The 45-tesla hybrid

At Tallahassee the most dramatic equipment is a 45-tesla hybrid magnet system, intended to provide users with a world-record steady field of 45 T in a 32-mm bore. The hybrid magnet consists of a Bitter resistive magnet, a cryostat and three nested superconducting solenoids. It's being built by a collaboration between NHMFL and the Bitter Laboratory. MIT is building the Bitter insert and one of the solenoids, made of NbTi. Florida State has overall responsibility for design and administration and is building the other two solenoids, made of Nb_3Sn, as well as the cryogenic system and the control electronics.

The present record for a continuously operating magnet is held by the Bitter Lab. In May MIT achieved 35.2 T in the 32-mm bore of its Hybrid III magnet. With the incorporation of cylindrical holmium pole pieces separated by a 2-mm gap, the field was enhanced to 38.7 T. Several experiments have been performed in that configuration at temperatures as low as 0.5 K, according to Larry Rubin of MIT.

The 45-T hybrid solenoids are being made by a relatively new "cable-in-conduit" technique, which was initially developed for the magnetic fusion program and is expected to be used in the International Thermonuclear Experimental Reactor solenoids. A stainless-steel conduit supports the big forces generated in the cable. The sheath arrangement plus the confined superfluid helium are expected to produce higher stability and to suppress the quenches encountered with other hybrid magnets.

According to John Williams, who heads magnet technology at the Bitter Lab, the NbTi in the solenoid is arranged in 135 strands, each 0.8 mm in diameter. That cable is put in a stainless-steel tube, squared off and then compressed. The MIT group is experiencing delay in getting a smooth, clean finish on the stainless-steel sheath.

In Tallahassee, according to John Miller, who heads the 45-T hybrid project, the two Nb_3Sn solenoids also use multistrand cables. NHMFL's industrial partner, Intermagnetics General Corporation, has fabricated 800 m of dummy cable-in-conduit (using copper instead of a superconductor for the cable) and a half-length model coil. Miller says a problem looms with the high-strength, iron-based superalloy selected for the conduit. After winding, each coil must be heat-treated to form Nb_3Sn within the cable strands. This conduit alloy can become brittle or crack, he says, because of the manufacturing and heat treatment. So two tons of a new conduit material need to be procured. Miller expects this procurement might delay full operation of the 45-T hybrid system from September to December 1995.

A total of 17 companies, ranging from Alpha Scientific Electronics to Teledyne Wah Chang, are involved in the design and manufacture of major components, critical materials and systems for the hybrid.

Other high-field labs

Only a handful of places have high-magnetic-field labs. The Francis Bitter Lab at MIT, in operation since 1960, has a 10-MW power supply (a motor generator set) and, according to lab director Robert Griffin, the largest selection of high-field magnets to offer its users, with maximum fields ranging from 8 T to the record-breaking hybrid with 38.7 T. The lab's 30-T hybrid has accumulated 4000 hours of running time in 11 years. Some of the magnets provide access perpendicular to the field, and the lab also has a large effort in magnetic resonance. The Bitter Lab expects to submit a proposal to NSF to secure funding past October 1995 as a collaborative research lab centered around the use of high magnetic fields.

Japan has two high-field magnet labs. The National Research Institute for Metals in Tsukuba, near Tokyo, has a hybrid that is expected to reach 40 T this month. Tohoku University in Sendai has a 31-T hybrid magnet built by Toshiba.

The High Magnetic Field Laboratory in Grenoble, France, has a 31.4-T hybrid. The Nijmegen High Magnetic Field Lab in the Netherlands has two hybrid magnets that were built at MIT, the second of which is currently running at 30 T.

Failures are common when high-field hybrids are first operated: The coil stack in the resistive insert can burn out or collapse; the helium supply can fail; the cryostat can leak; the Lorentz force in the superconducting solenoid can cause the helium passages to collapse. Clearly Murphy's Law hasn't been repealed.

Horst Stormer of AT&T Bell Labs, who has been involved with experiments at the MIT lab for many years, told us that the MIT 35-T hybrid has been operated only a few times and that its technology continues to be refined. At this stage, he says, experimenters are still hesitant to operate their most elaborate equipment in the magnet. Bruce Brandt, who left the MIT lab to be NHMFL associate director and head of instrumentation and operations, says that once the 45-T hybrid does start running in Tallahassee, "it'll probably take a while 'til our hybrid operates with no hitches."

Meanwhile NHMFL has three resistive magnets up and running. The lab proudly announced in June that it had set a record for purely resistive magnets operating continuously—27 T. Two more 27-T magnets and a 30-T resistive magnet are scheduled to be running by the end of this year. The highest-field superconducting magnet in operation is a 20-T unit sold by Oxford Instruments for $500 000. Two of these magnets have been installed in Tallahassee; one has a dilution refrigerator in it and the other will be used for experiments in the 500 mK to 300 K range.

Users at work

One noteworthy feature of the NHMFL facility at Tallahassee is the size and high precision of its dc power supply, which is a solid-state rectifier. NSF had required the new lab to build a 20-MW power supply. Instead NHMFL built a 40-MW supply, giving the lab the possibility of upgrading the 45 T to 50 T later on. The power supply can operate at three maximum power levels, with its four component power supplies running in parallel. At 24 MW it can operate continuously, allowing, for example, two high-field magnets to operate in parallel. The power supply can also operate at 32 MW for 12 hours at a time and at up to 40 MW for an hour. Brandt explains that two errors typically occur in power supplies: the lack of repeatability or setability of the current and the ac hum produced in the range 1 to 2000 Hz.

Donald Gubser of the Naval Research Lab, who has worked at both the MIT and Florida State labs, says that sitting in the Tallahassee lab, "I couldn't tell whether I had zero magnetic field or 20 T. I couldn't hear the hum typical of high power. And my electronics didn't get a lot of pickup from the noise." So one can in principle resolve much smaller effects. The ripple in the Florida power supply is 2 parts per million.

The cooling circuits are also designed to reduce noise in the magnets, by having large-diameter water pipes and large radius bends.

Another recent user at NHMFL is David Awschalom of the University of California at Santa Barbara. He studied the magnetic properties of ferritin proteins from horse spleen in fields up to 27 T. Awschalom is interested in ferritin for a variety of reasons; for one, he thinks these nanometer-scale structures (as well as artificially engineered proteins) are an excellent way to study macroscopic quantum tunneling of magnetization. He and his collaborators, from Santa Barbara, the University of Bath and NHMFL, found that at high magnetic fields a "spin flop transition" with a strong orientation dependence occurs in natural ferritin. Awschalom says this transition provides direct evidence of antiferromagnetism in ferritin, a state that had only been inferred previously.

Florida recruits

The first faculty appointment to NHMFL was J. Robert Schrieffer, the condensed matter theorist who is the S in BCS theory. He left the University of California at Santa Barbara three years ago to become chief scientist of NHMFL and University Professor with a joint appointment at Florida State University and the University of Florida. Schrieffer was impressed by the commitment that Florida showed to the new lab when Governor Lawton Chiles personally sought to convince him to move; since then Chiles has continued to be involved in helping build the lab. Schrieffer later recruited his old friend Lev Gor'kov, one of the founders of the Landau Institute of Theoretical Physics in Moscow, to become head of the theory group at NHMFL. Recently experimenter Zachary Fisk joined the lab, coming from the University of California at San Diego and Los Alamos. Hans Schneider-Muntau, the leading magnet designer at the Grenoble magnet lab, came to NHMFL as deputy director and director of the magnet development and technology program.

Jack Crow, director of the NHMFL, has an infectious enthusiasm about his new facility. Crow envisions the NHMFL as a broad lab, supporting biological and chemical research as well as materials studies. NHMFL has hired three researchers to build up the lab's magnetic resonance capability: Geoffrey Bodenhausen from Lausanne for nmr, Alan Marshall from Ohio State University for ion cyclotron resonance and Louis-Claude Brunel from Grenoble for electron magnetic resonance.

The highest-field nmr magnetic spectrometers produce 750 MHz precessional frequency for protons, corresponding to a 17.5-T magnet. That class of magnets has just been introduced in the last year by two English companies, Oxford Instruments and Magnex Scientific.


Vice President Al Gore speaks at the dedication of the National High Magnetic Field Laboratory in Tallahassee on 1 October. From left: Former NSF director Erich Bloch, Congressman Pete Peterson, Lieutenant Governor Buddy McKay, Senator Bob Graham and current NSF director Neal Lane. Governor Lawton Chiles is behind Gore.

Industry commitment

Martin Wood, founder of Oxford Instruments, told us at the dedication, "The existence of this lab will give impetus to the development of new and improved industrial products. High magnetic fields and superconductivity are so much a part of the technology of the next 25 years or so that having this lab around is a terrific help to industry."

Crow feels the best way to get industry involved is to say, "Why don't you come on down and work with us?" To initiate the development of the 45-T hybrid, he organized a vender's workshop to elicit proposals. The laboratory initiated a collaboration with Intermagnetics General Corporation that led to a collaboration with Gibson Tube to develop the first fabrication line for long cable stainless steel conduit.

Crow also encourages companies to give a gift to the lab, to provide them with a sense of ownership. "We want them to commit to the technology. That's why we get them to bleed a little to ensure their commitment." Oxford Instruments has given NHMFL a 720-MHz nmr spectrometer, whose magnet alone is worth \$1.5 million. Varian is donating \$500 000 worth of electronics to go with the Oxford spectrometer. Intermagnetics General has given the lab \$1 million toward its 900-MHz magnetic spectrometer project. Keithley Instruments has given \$200 000 worth of equipment and engineering services. As Crow says, "Keithley gets the exposure and the users get the brand-new equipment." And as the researchers use the equipment, the company will get ideas for new instruments.

Although the National High Magnetic Field Laboratory appears to be exceptionally well funded by both the public and private sector, at least part of its private-sector funding comes from a highly unconventional source. Michael Davidson, a Florida State researcher, has made such beautiful micrographs of crystals that his images have appeared on more than 350 magazine covers, including the one for PHYSICS TODAY's special issue on high-temperature superconductivity in June 1991. These micrographs are also being marketed to industry and have been printed on men's neckties, stationery and exercise apparel. Davidson has turned over his share of the royalties to Florida State University. He says the ties alone have generated about \$175 000 in royalties, all of which has gone to the magnet lab. Future royalties will be divided so that most of the money goes to the magnet lab and some goes elsewhere.

Los Alamos and Gainesville

At the NHMFL site at Los Alamos, one of the pulsed magnets uses a chemical explosive to compress flux; the explosion is generated by capacitor discharge into a small volume. The magnet produces 100 to 220 T in a pulse that lasts less than 10 microsec. Los Alamos also has a collection of capacitor-driven magnets; its capacitor bank provides 1.1 megajoules at 20 kV. Fields range from 45 to 75 T, for the higher fields; pulse lengths are typically 20 millisec.

The University of Florida at Gainesville, which also houses part of the NHMFL, is developing an ultrahigh B/T facility that will allow studies of materials in fields up to 20 T and at temperatures to 500 microkelvin simultaneously. In addition, according to Neil Sullivan, chairman of the University of Florida physics department, the University of Florida's advanced mri center will provide a unique 12-T, 40-cm-diameter system for imaging small animals.

—GLORIA B. LUBKIN ■