New Alloy Shows Promise as High-Field Superconducting Magnet

An alloy of niobium, germanium and aluminum, $Nb_{0.8}(Al_{0.75}Ge_{0.25})_{0.2}$, has remained superconducting in a 410-kG field at a temperature of 4.2 K. The alloy has the highest known transition temperature, 20.7 K. If the alloy can be made into a wire or tape that can maintain a high current density, it could be used to build a high-field superconducting dc magnet (provided one could make a structure that would hold together under the enormous forces produced by the fields). The best material previously tested, Nb_3Sn, has a critical field of about 220 kG at 4.2 K and has been used in commercial magnets for several years.

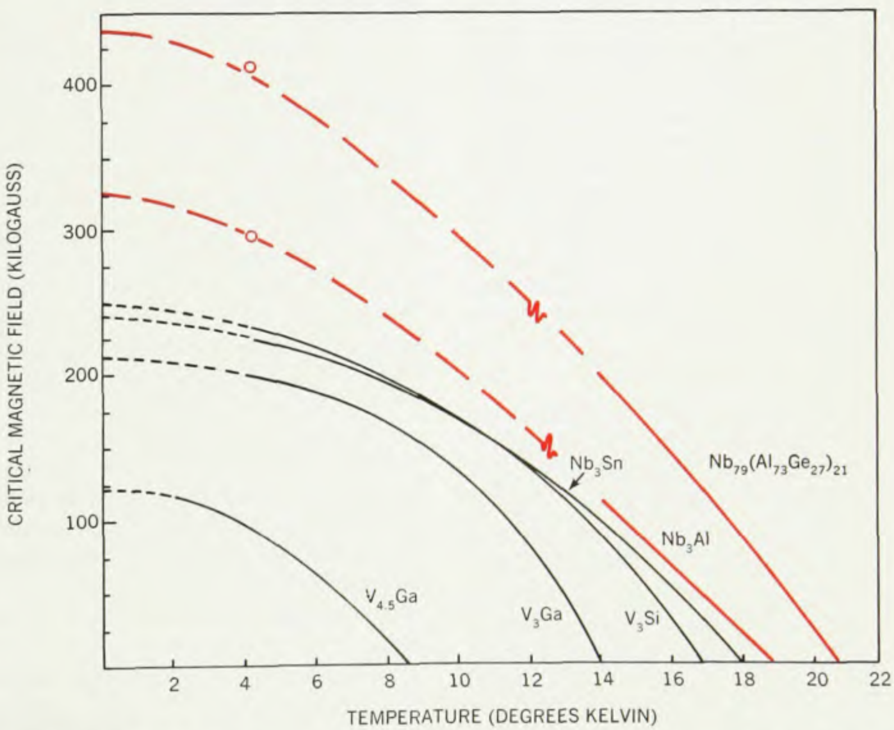
The experimenters, Bernd Matthias (University of California at La Jolla and Bell Labs), Simon Foner and Edward McNiff (MIT), Theodore Geballe (Stanford and Bell Labs) and Ronald Willens and Ernest Corenzwit (Bell Labs), also tested a Nb_3Al sample, whose transition temperature is 18.7 K, and found a critical field of 320 kG at 4.2 K. They reported their results at the March APS meeting in Dallas and in the 6 April issue of *Physics Letters.*

The highest field at which a type-2 superconductor is expected to go normal, known as the Clogston–Chandrasekhar limit (after Albert Clogston of Bell Labs and B. S. Chandrasekhar of Case Western Reserve), is proportional to the transition temperature; it is the field at which normal-state Pauli paramagnetism becomes competitive with superconductivity. The limit is only approximate, however; spin-orbit coupling effects can raise the limit. The paramagnetic limit predicts a critical field for the niobium–aluminum–germanium alloy of 380 kG, rather than the observed 410 kG.

Earlier experiments reported for the niobium–aluminum–germanium with dc fields showed a critical field of 200 kG at 14.0 K. To extend their measurements to 4.2 K, the experimenters used a long-pulse (10-millisec) multilayer copper wire coil, capable of producing 450 kG, and 0.2-mm-thick samples. They remark that, although pulsed fields yield a lower limit for the critical field, the independence of the critical field with sample thickness indicates that their observed values should be very close to that expected for a dc field. The measurements were made with small rf currents; no attempt was made to test high critical current-carrying capacity.

Matthias told PHYSICS TODAY that nobody really knows what the limit on critical temperature, and therefore critical field, will be.

"How does one get still higher transition temperatures?" we asked Matthias. "Purely metallurgically," he said. "The way we have done it in the past. It's not an elegant method; it's not an attractive method either. But it's the only method that has worked so far. I think it's very bad to promise people in technology, who want to use these wires: 'Ah, we may get still higher transition temperatures by new and entirely different methods.' This has been going on for 12 years or longer; there was no result, and now the reaction has set in." Matthias thinks that the highest transition temperature one can hope to achieve is 25–30 K. —GBL



BEHAVIOR OF HIGH-CRITICAL-FIELD MATERIALS. Solid curves in color are dc measurements. Points at 4.2 K are new measurements made with pulsed field. Dashed colored curves are extrapolations assuming no Pauli paramagnetic limiting. Nb_3Sn is available commercially and V_3Ga is being developed for commercial application. $Nb_{79}(Al_{73}Ge_{27})_{21}$ has highest known transition temperature, 20.7 K.

MIT Tokomak Has Anomalous-Resistivity Heating and 130 kG

MIT has started design and construction of a high-field Tokomak-like device called "Alcator." By extrapolation of experimental results, the experiment could achieve confinement times considerably longer than previous Tokomaks, electron temperatures of roughly 5 keV, and electron and ion densities of 10^{14} particles/cm^3. These parameters are of thermonuclear interest and, if achieved would allow the study of plasmas with reactor-like characteristics.

The name "Alcator" is short for "alto campus torus," which means high-field