SUPERFERRIC MAGNETS

With the Energy Saver well along in construction, some people are casting their thoughts on to the step beyond. Work is going on at a number of laboratories to develop the next generation of superconducting magnets. The goal is to reach 10 Tesla, more than twice the fields of the Energy Saver. But at the same time, there is also a move in the opposite direction, to consider a low-field, low-cost superconducting magnet for a multi-TeV hadron accelerator. There is new design work and new experimental work to report.

The superferric magnet has conventional iron poles to shape the field, but it is powered by superconducting coils. The iron is cold in order to minimize the magnet cross section and stored energy. The maximum field is 2 to 3 Tesla. At this level, the refrigeration requirements are modest and, of course, the actual magnet power is minute. A concept of a 20-TeV ring was developed at the recent DPF Summer Study in Snowmass by Robert Wilson.[1] It is clear that any multi-TeV device using superferric magnets will require a very large site; a 20-TeV ring with 2-Tesla magnets will have a diameter of approximately 50 miles. In Wilson's concept, the ring would be built in modular sections in a very small tunnel--almost a sewer pipe. The tunnel would be very close to the surface and access would be through periodic manholes. It is planned to make use of robots for installation, alignment, and minor repair; the tunnel would be too small for human beings, except at periodic access points. Major repairs would be accomplished by digging up the appropriate tunnel section and replacing it. Each dipole magnet might be 100 or more meters long (built of smaller sections) and each quadrupole might be 7 to 8 meters long. Straight bars of superconductor would be used for the coils. The tunnel might be used to return vented helium.

In addition to Wilson's technical considerations at the Snowmass meeting, Richard Lundy and Paul Mantsch[2] have made a scaling of cost from the Energy Saver experience. Their preliminary result is that a 20-TeV ring could be built for less than $1 billion, which appears to compare well with what a higher-field ring might cost. These results are all highly speculative, but they point to interesting directions for the future.

The superferric magnet is not a new concept. It was discussed by Gordon Danby in the 1960's, although mostly in the context of higher fields. The low-field, low-cost superferric magnet was discussed (and named) by Robert Wilson in 1967. At that time, superconducting magnets were in a primordial stage of development, but the 15 years since then have seen substantial advances in the art, and it is natural to consider superferric magnets as a possible design for the next generation of hadron accelerators.

As a first try at an experimental realization of a superferric magnet, a model 7 inches by 5.5 inches in cross section and 2 feet long was built[3] and tested[4] at Fermilab. The magnet reached its design field of 2 Tesla with no training and reached 3 Tesla with an acceptable amount of saturation. This saturation means that there will be a sextupole component and its magnitude has been calculated.[5] The presence of the iron gives the additional advantage that there the sextupole can be corrected in more-or-less traditional ways, such as, for example drilling cleverly placed holes in the iron. From this saturation, for example, by drilling holes in the poles. No actual measurements of field quality have been made at this writing, but they are now in progress. Less than a week was needed to carry out this construction and testing.

Thus an alternative superconducting ring design has now been advanced to the point where it must be considered seriously for the next generation of high-energy accelerators and storage rings.

References

1. Robert R. Wilson, Superferric Magnets for 20 TeV, in Proceedings of the 1982 DPF Summer Study (to be published).

2. R. Lundy and P. Mantsch, Cost Considerations for a 20 TeV 2 Tesla Superferric Magnet Ring, **ibid.**

3. J. R. Heim, H. Hinterberger, and J. Jagger, Construction of a Fermilab Superferric Magnet, Fermilab TM-1122, July 1982.

4. A. D. McInturff, Performance Testing of a Super Fe Magnet, Fermilab M-1121, July 1982.

5. K. Ishibashi, Calculation of Super "Fe" Magnet Parameters, Fermilab TM-1123, July 1982.