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Design of a 14T cryogen-free physical property measurement system magnet

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A 14T physical property measurement system (PPMS) magnet with cryogen free is being developed in Institute of Electrical Engineering, Chinese Academy of Sciences (IEE, CAS). Unlike steady-state magnets such as NMR, MRI, the PPMS magnet is required to be excited frequently and the excitation rate usually needs very high, for example in 30min to reach the full magnet field. The fast excitation rate accompanying with cryogen-free cooling method is a great challenge for the stability of the superconducting magnet. The magnet design adopted a combination of Nb₃Sn and NbTi superconducting materials to reach the target magnetic field strength 14T within a cold bore 50mm. In order to raise the safety margin, the innermost magnet coil used high-J_c Nb₃Sn superconducting wire, and the maximum magnetic field strength in the outside NbTi magnet coils was strictly restrained to be a much low level, for example, less than 5.5 T. With a series of balance, the final critical temperature was at 6.3K, which corresponds to a large power output of the refrigerator about 5W. Another rigorous requirement of the magnet design is a relatively larger homogeneous area 5cm (z)×1cm (d) with homogeneity 0.1% than a common demand Φ1cm, upon which the magnet must use compensating solenoids to elevate the magnetic field homogeneity of the main coils. The overall magnet design pursued a compact coil structure in order to reduce the inductance and thus increase the excitation rate as well. The magnet will be fabricated and assembled into the PPMS system in the future.

Primary authors: WANG, Yaohui (Institute of Electrical Engineering, Chinese Academy of Sciences); Prof. WANG, Qiuliang (Institute of Electrical Engineering, Chinese Academy of Sciences); LIU, Hui (Institute of Electrical Engineering, Chinese Academy of Sciences); CHEN, Shunzhong (Institute of Electrical Engineering, Chinese Academy of Sciences); CHENG, Junsheng (Institute of Electrical Engineering, Chinese Academy of Sciences)

Presenters: WANG, Yaohui (Institute of Electrical Engineering, Chinese Academy of Sciences); Prof. WANG, Qiuliang (Institute of Electrical Engineering, Chinese Academy of Sciences)

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