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Cryogenic developments for very high field magnets

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Oral presentation (20 min) + Q&A (10 min)

Very high permanent magnetic fields, i.e., over 20 T, are produced by superconducting magnets made partially, or fully, with high-temperature superconducting (HTS) conductors. These specific magnets generally operate at liquid helium temperatures to take full advantage of the HTS properties. Very high-field magnets, usually immersed in a saturated liquid helium bath, experience an excessive temperature increase in working conditions above 20 T. Beyond this threshold, it has been demonstrated that the magnetic force is strong enough to interact with helium molecules due to their diamagnetism. The magnetic field distribution can cause this body force to compensate for gravity, creating zones of levitation around the magnet. It either degrades the boiling heat transfer, preventing bubbles from developing freely and leaving the magnet surface, or traps helium vapor structures on the magnet surface, thus creating a film at the liquid and the magnet interface. To avoid jeopardizing the long-term operation of superconducting high-field magnets cooled by liquid helium at 4.2 K beyond 20 T, heat transfer in liquid helium under these conditions must be fully understood and quantified. An alternative solution is to use a non-gravity-assisted cooling system, such as a capillary heat pipe. This talk presents the recent experimental studies carried out at CEA Paris-Saclay on the helium pool boiling heat transfer under reduced gravity and the development of gravity-independent heat pipes for cooling a 10T class HTS magnet.

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