Validation of a quasi-microgravity space exploiting a high-gradient trapped field magnet (HG-TFM) as a desktop-type magnetic field source

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Abstract:
A strong magnetic field exploiting superconducting technologies is a powerful tool to provide a quasi-microgravity space that can be used for magnetic levitation for any diamagnetic materials such as water, common metals and even cells of the human body. Large-single grain bulk superconductors have shown promising potential to be lightweight, mobile, and cost-effective as so-called trapped field magnets (TFMs).

Recently, the authors presented the concept of hybrid-type bulk magnets: a high-gradient trapped field magnet (HG-TFM), in which conventional TFM cylinders are tightly stacked with "slit ring bulks" that act to modify the magnetic field distribution and its gradient. We firstly demonstrated, numerically, that the HG-TFM, which is magnetized by field-cooled magnetization (FCM) with an applied field of 10 T at 40 K, can generate a maximum magnetic field gradient, $B_z \cdot dB_z/dz$, of up to ~-6000 T^2/m at the intermediate position between each bulk. This $B_z \cdot dB_z/dz$ value is two times higher than that of other large-scale hybrid superconducting coil magnets that generate 30 T. Based on these numerical assumptions, we successfully demonstrated and validated magnetic levitation of pure water and bismuth particles inside a room-temperature bore of 25 mm dia. in the HG-TFM, with which a $B_z \cdot dB_z/dz$ of -1930 T^2/m and a trapped field, B_z, of 8.57 T were achieved by FCM with 8.60 T at 22 K. These results provide a key step forward towards the development of a practical hybrid-type TFM for magnetic levitation.

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