Tue-Af-Po2.23-02: A Hybrid Trapped Field Magnet Lens (HTFML): concept and realisation

Mark D. Ainslie[1], Devendra K. Namburi[1], Hiroyuki Fujishiro[2], Sora Namba[2], Yun-Hua Shi[1], Tony Dennis[1], John H. Durrell[1]

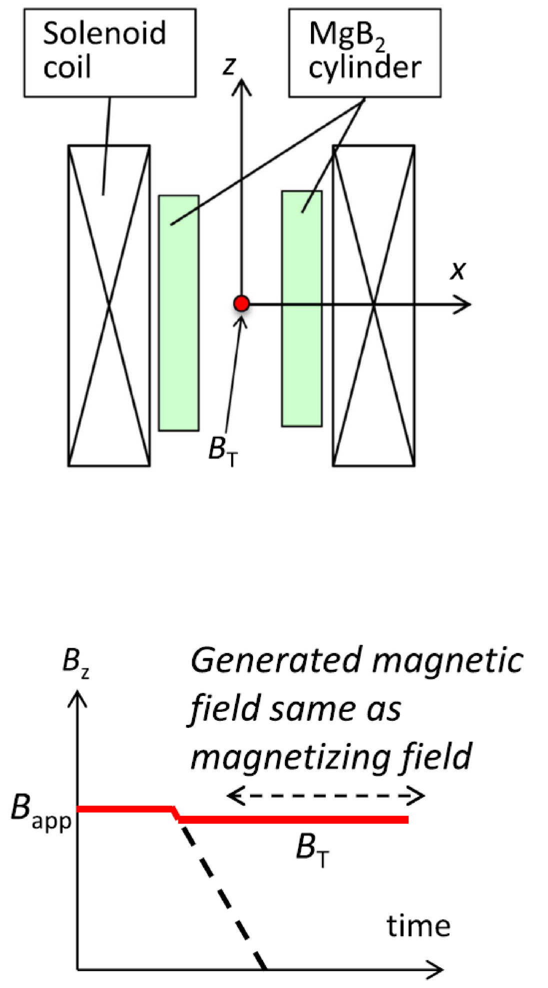
UNIVERSITY OF CAMBRIDGE | BSG | Iwate University 岩手大学

1) Bulk Superconductivity Group, Department of Engineering, University of Cambridge, UK
2) Department of Physical Science and Materials Engineering, Faculty of Science and Engineering, Iwate University, Japan

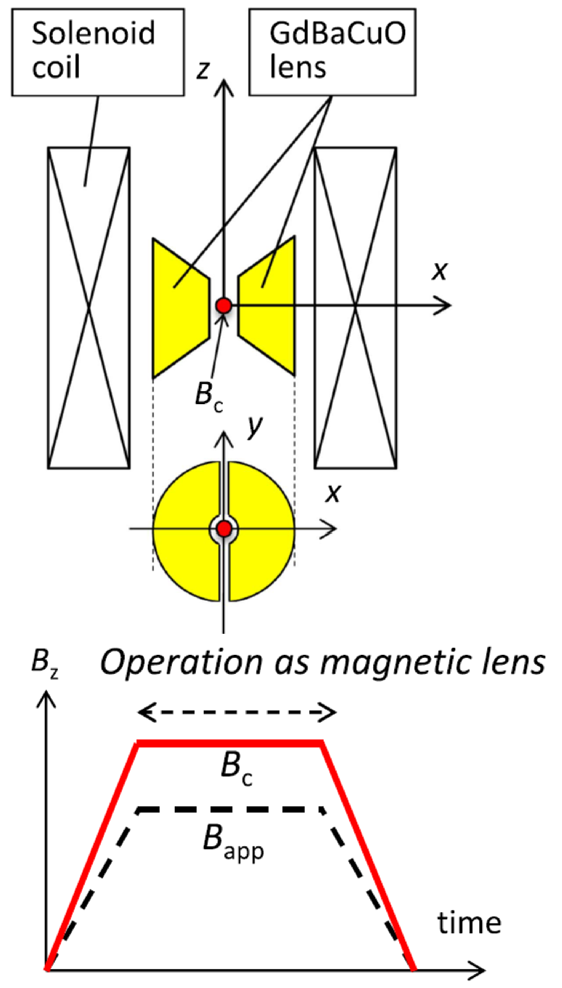
HTFML Concept & Modelling Results

The *Hybrid Trapped Field Magnet Lens* (HTFML) exploits two different characteristics of type-II superconductors:
1) The "*vortex pinning effect*" of an outer superconducting bulk cylinder, which acts as a trapped field magnet (TFM) using field-cooled magnetisation
2) The "*diamagnetic shielding effect*" of an inner bulk magnetic lens, which concentrates an external magnetic field within its bore.

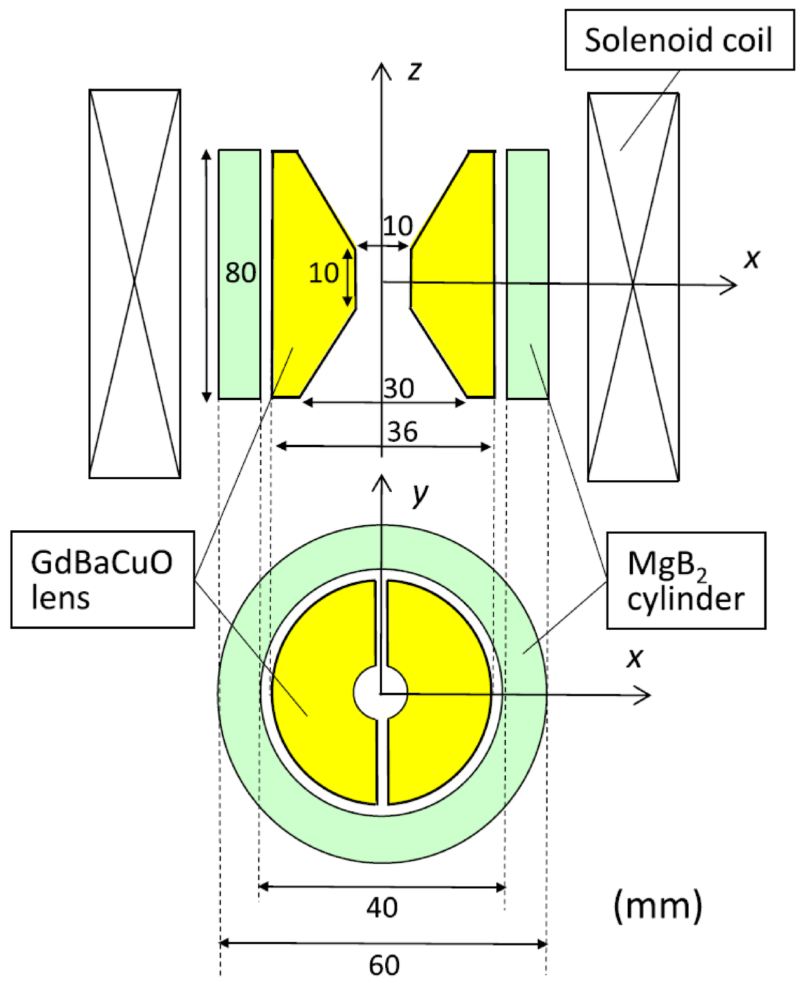
The HTFML can reliably generate a concentrated magnetic field in the centre of the lens that is higher than the trapped field from the cylindrical bulk TFM and the external magnetising field, even after the externally applied field decreases to zero.



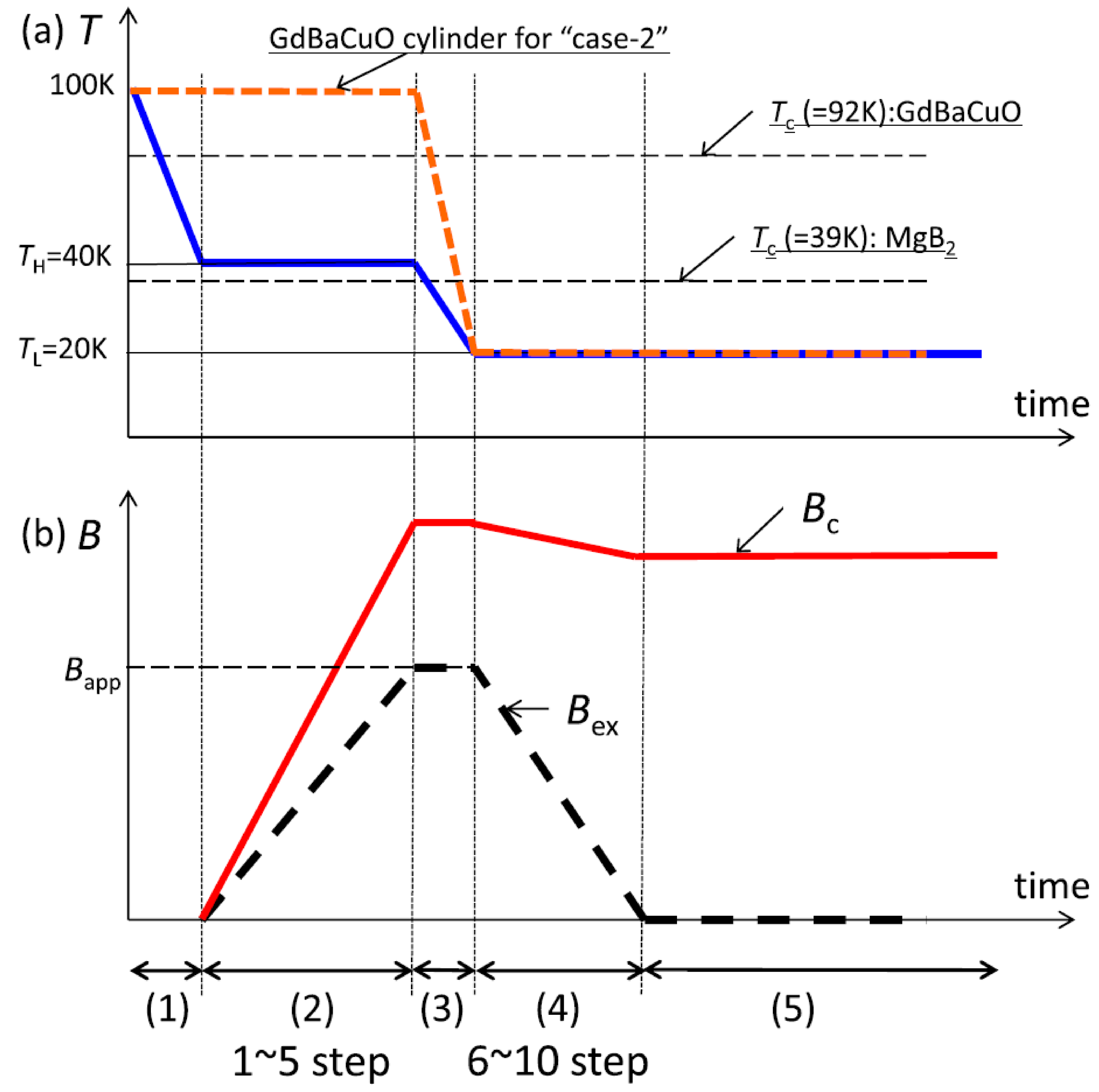
Conventional field-cooled magnetisation process for a superconducting bulk cylinder



Conventional zero-field-cooled magnetisation for a conventional superconducting bulk magnetic lens



Numerical modelling framework & dimensions of the MgB$_2$ cylinder, GdBaCuO magnetic lens & solenoid magnetising coil

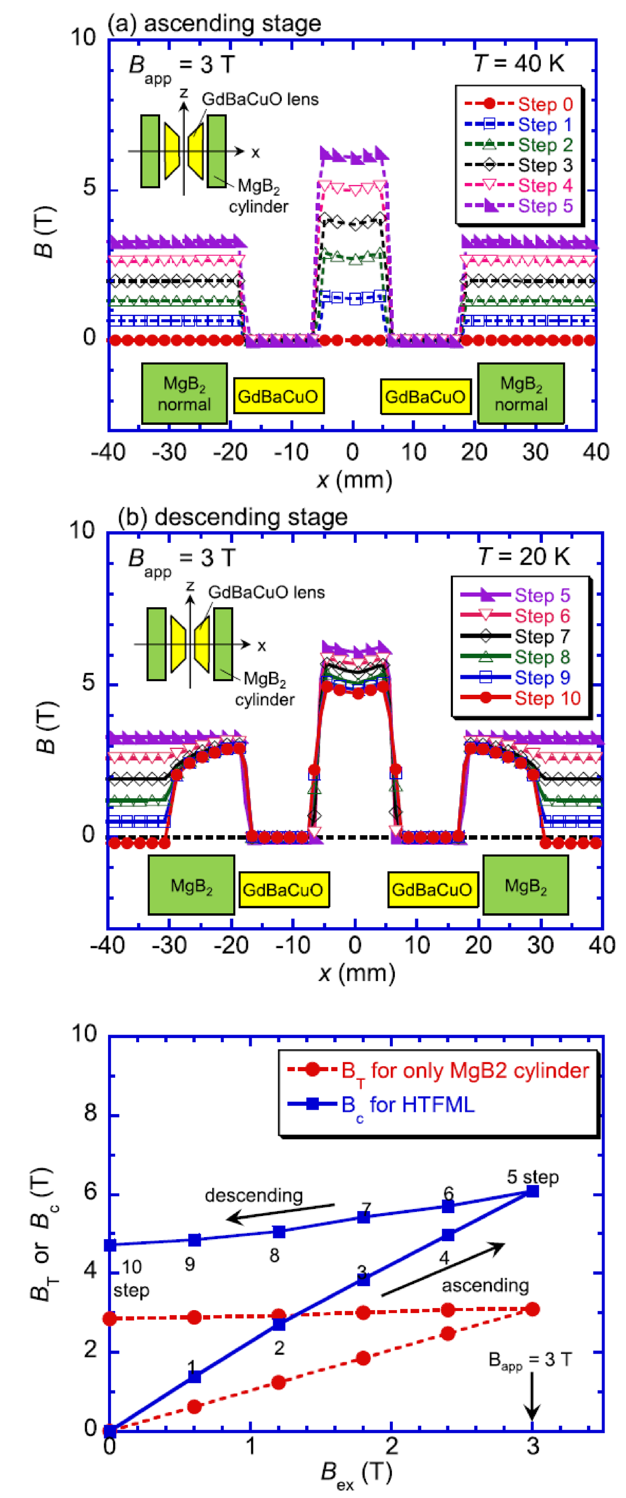


Time step sequence of (a) temperature & (b) external field, B_{ex}, and concentrated magnetic field, B_c, at the centre of the lens for both cases

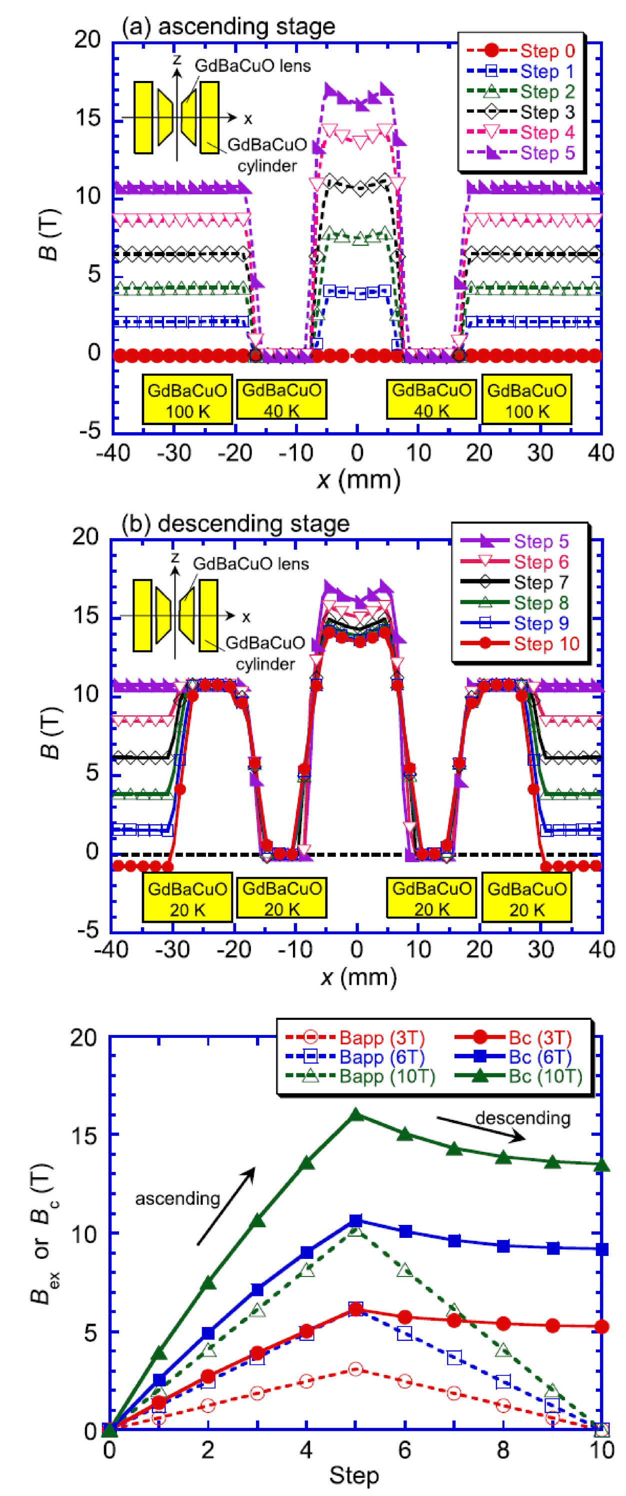
Case 1: Exploit difference in T_c of two bulk materials, e.g., MgB$_2$ (T_c = 39 K), GdBaCuO (T_c = 92 K)

Case 2: Using same material for whole HTFML, e.g., GdBaCuO, but utilising separate cooling mechanism for cylinder & lens

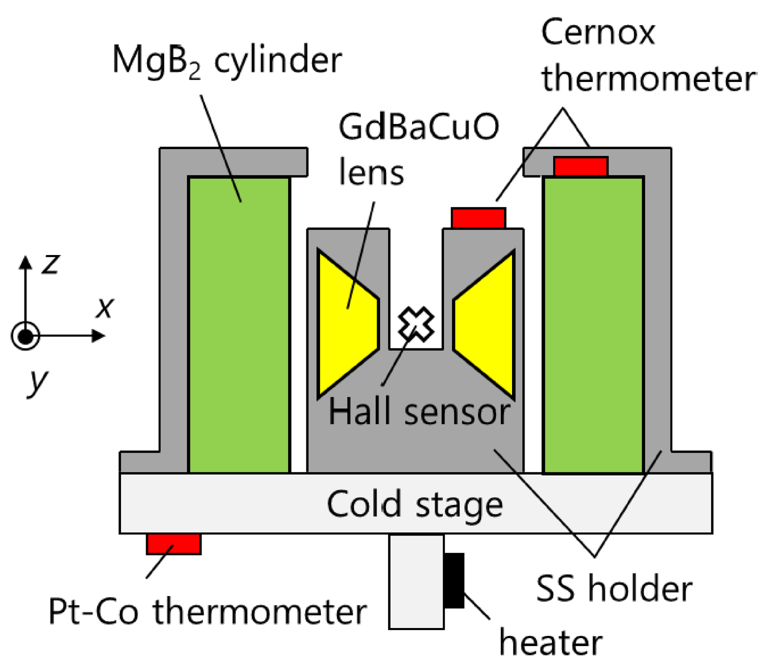
Numerical results: Case 1

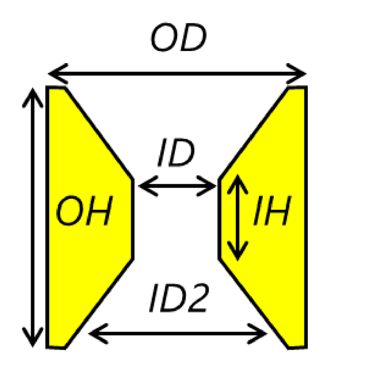


Numerical results: Case 2

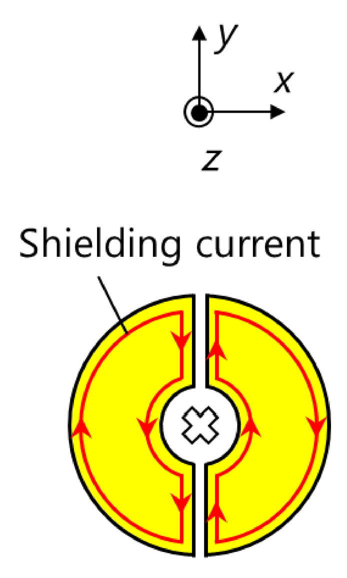


HTFML Experimental Results



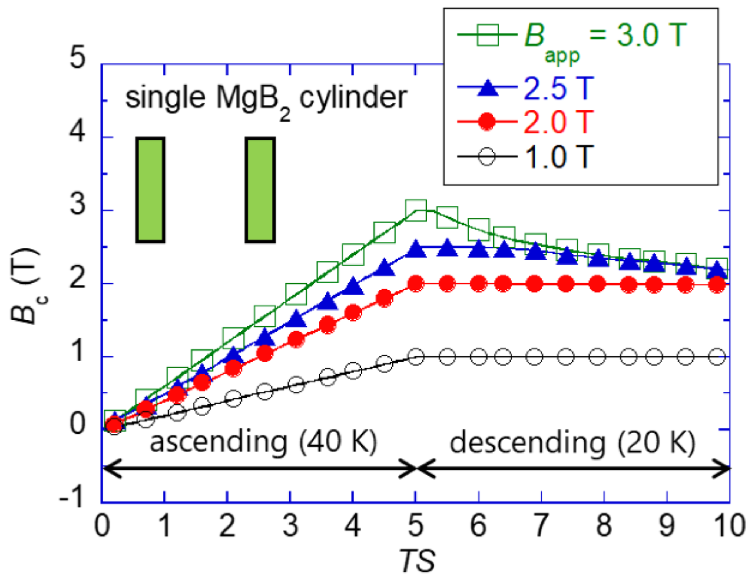


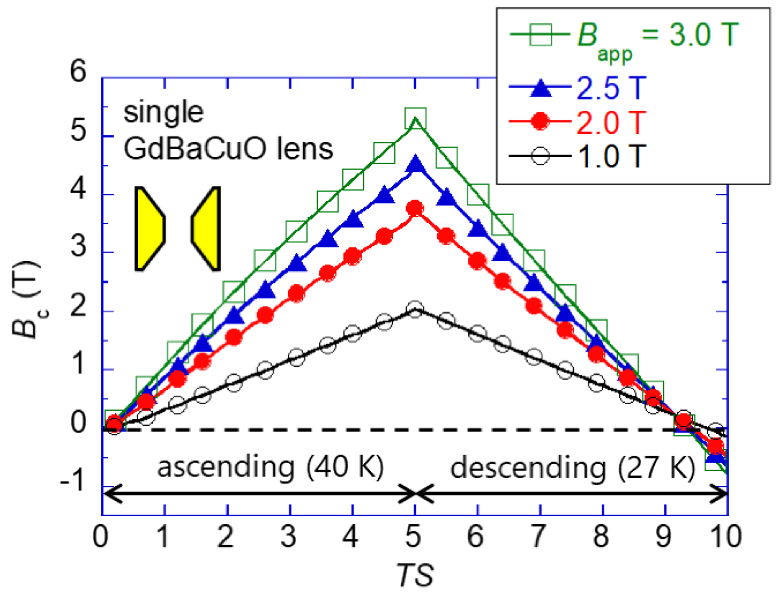
Cross-sectional view



Top view

- MgB$_2$ cylinder: ID = 40 mm, OD = 60 mm, H = 60 mm; Experiments Projects Constructions S.R.I., Italy
- GdBaCuO lens: ID = 10 mm, OD = 36 mm, H = 30 mm; Nippon Steel Corporation, Japan; machined into a cone-shape ID = 10 mm, OD = 30 mm, ID2 = 26 mm, OH = 30 mm, IH = 8 mm
- Thin slits (200 µm) made in lens to disrupt circumferential shielding current flow
- Embedded in stainless steel holder for mechanical support





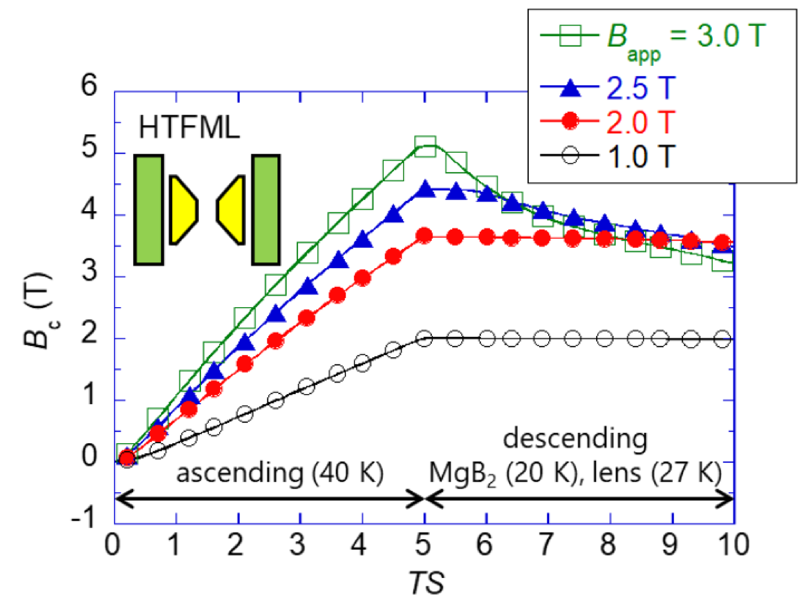


Table I. Concentrated magnetic field, B_c, at TS = 5 and 10 at the center of the HTFML, and calculated magnetic field concentration ratio, B_c/B_{app} for various applied magnetic fields, B_{app}.

B_{app} (T)	B_c (T) at TS = 5	B_c (T) at TS = 10	B_c/B_{app} at TS = 10
1.0	2.00	1.99	1.99
2.0	3.65	3.55	1.76
2.5	4.45	3.46	1.38
3.0	5.19	3.22	1.07