Numerical simulation of high-temperature superconducting stacked-tape magnetic lens via H-ϕ model

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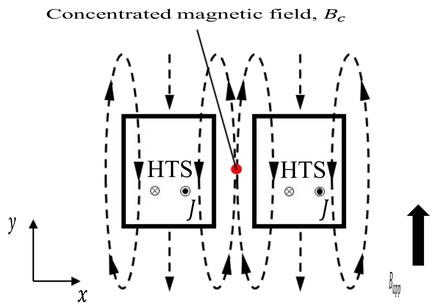
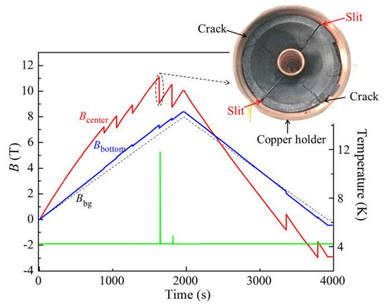
Introduction

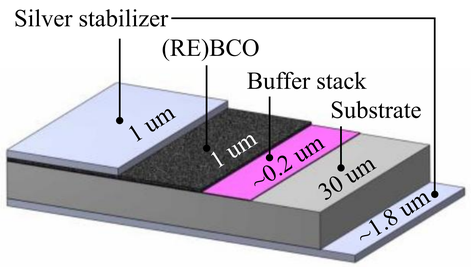
The high-temperature superconducting (HTS) magnetic lens can concentrate the magnetic flux density in the required local area. The HTS tape has good mechanical strength and thermal stability, so it is expected to achieve magnetic flux concentration under a strong magnetic field.



Working principle of HTS magnetic lens



Fragmentation and flux jump of HTS bulks[1]



Superconducting tape used in simulation[2]

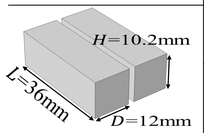
Numerical Model

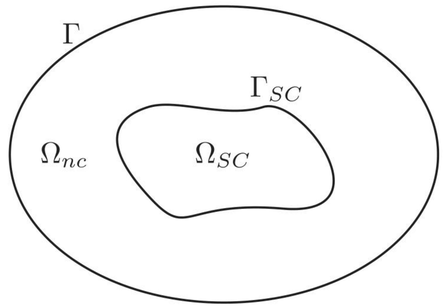
Research method: H-ϕ formulation[3]

Governing formulation (SC): $\nabla \times \rho \nabla \times \mathbf{H} = -\mu_0 \frac{\partial \mathbf{H}}{\partial t}$

Governing formulation (NC): $\nabla \cdot \nabla \phi = 0$

Comparison between the two methods

A simple model	Formulation	DOF
	H-formulation	150416
	H-ϕ formulation	85559

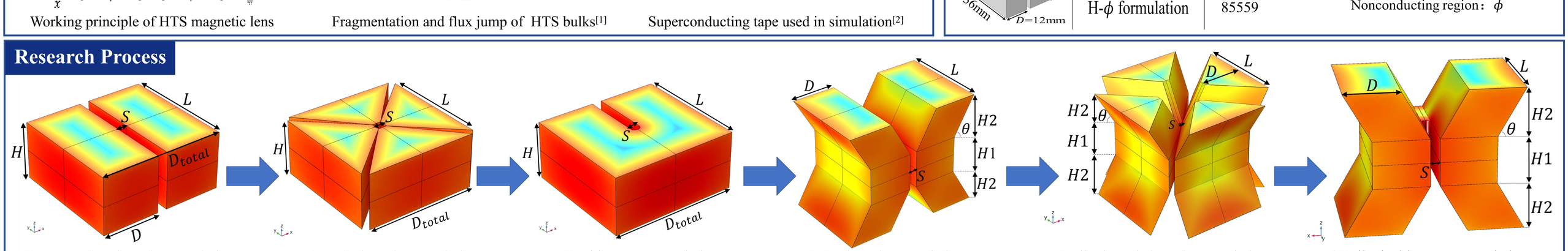


Independent variable

Superconducting region: **H**

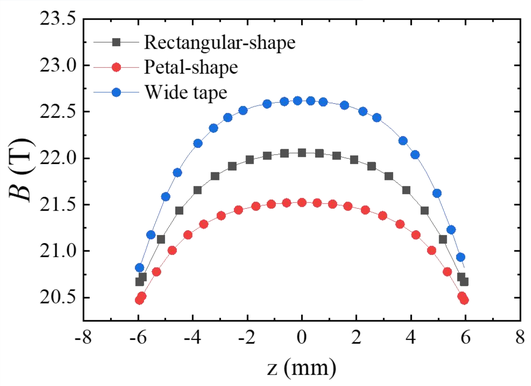
Nonconducting region: ϕ

Research Process

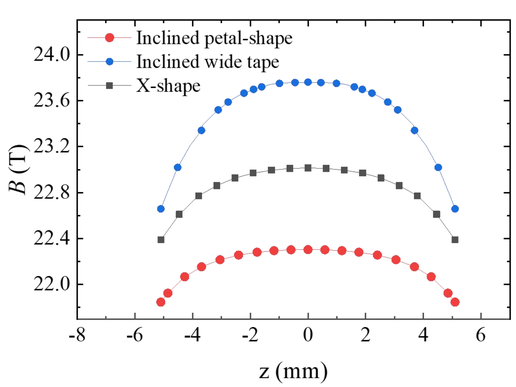


3D rectangular-shaped magnetic lens | 3D petal-shaped magnetic lens | 3D wide tape magnetic lens | 3D X-shaped magnetic lens | 3D tilted petal-shaped magnetic lens | 3D tilted wide tape magnetic lens

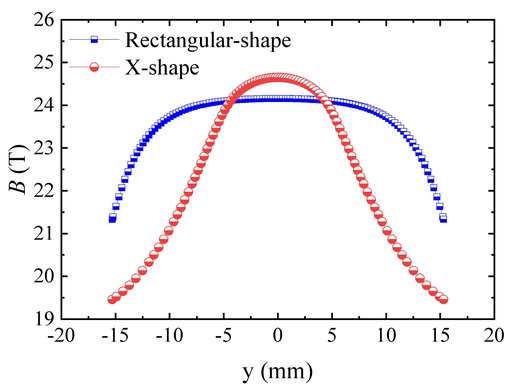
Results and Discussion



Longitudinal magnetic flux density distribution of 3D rectangular-shaped, petal-shaped, and wide tape magnetic lens



Longitudinal magnetic flux density distribution of 3D X-shaped, tilted petal-shaped, and wide tape magnetic lens



Longitudinal magnetic flux density distribution of 2D X-shaped and rectangular-shaped magnetic lens

Conclusions

1.The results show that when B_{app}=20 T, the rectangular-shaped and X-shaped magnetic lenses can reach the B_c of 22.69 T and 25.62T, respectively.

2. The wide tape magnetic lens has stronger magnetic shielding ability, so the magnetic flux concentration effect is better.

3. The X-shaped magnetic lens can change the current distribution, B_c is larger than the rectangular-shaped magnetic lens of the same size.

References

[1] Zhang, Z. Y., et al. Superconductor Science and Technology 25.11 (2012): 115012.

[2] Patel, A., et al. Sci. Technol 31.9 (2018).

[3] Arsenault ., et al. IEEE Transactions on Applied Superconductivity 31.2 (2020): 1-11.

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