The levitation force of CC-tapes stack at different temperatures.

1LP4-12

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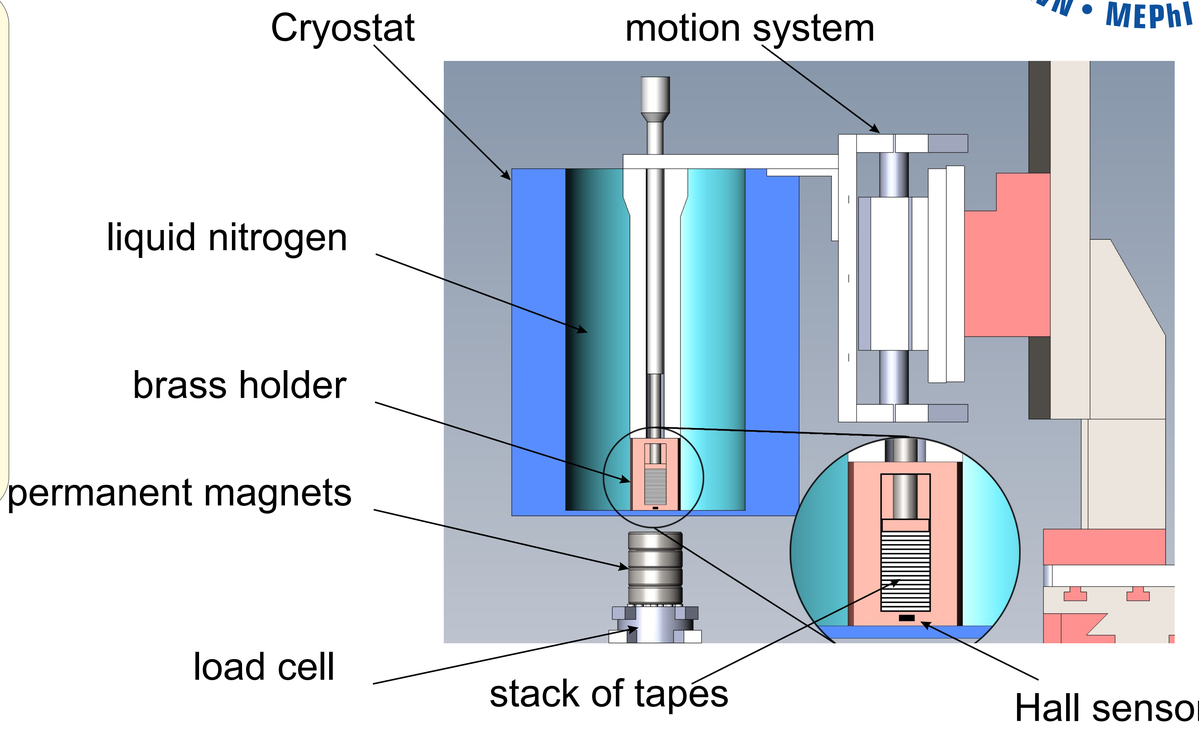
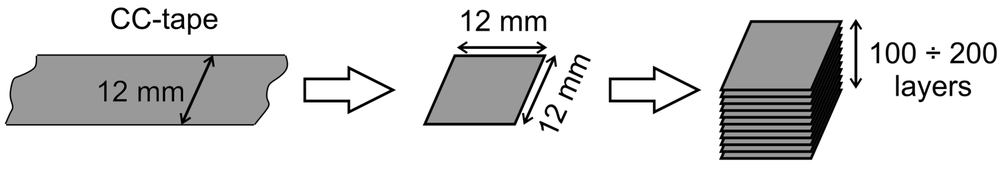
For the development of CC-tapes based bearings and transportation systems it is important to have not only information on the levitation force, but also the data on stability of the system in response to the lateral displacements. This work continues series of studies on the levitation properties of CC-tapes stacks.

In our report, we present new results on investigation of the influence of temperature on the levitation force between the CC-tapes stacks and a permanent magnet. Stability of system in response to lateral displacement was also investigated. The experimental investigations of the influence of lateral displacement on the levitation performance of stack of various thicknesses at various temperatures were processed in this work. In the measurements we used 12 mm wide commercially available CC-tape manufactured by SuperOx. The tape were cut into pieces 12 mm x 12 mm. The number of layers in the stack ranged from 5 to 200. Cooling of the CC-tapes stack was carried out in cryo-free cryostat. Temperature ranges from 14to 77K.

Results show that temperature has much influence on levitation force. Hysteresis of the restoring force of the stack was observed. The analyses and conclusions of this work are useful for the practical application in magnetic-force-based systems.



Scheme of the measurement setup



SuperOx
SUPERCONDUCTOR TO THE FUTURE

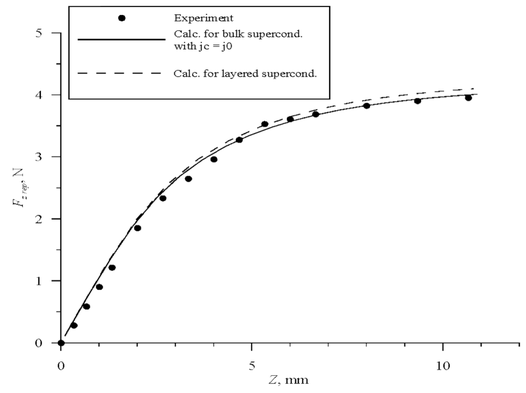
Tapes specifications:

Width — 12 mm

The thickness of the layer of HTS — 1 μm

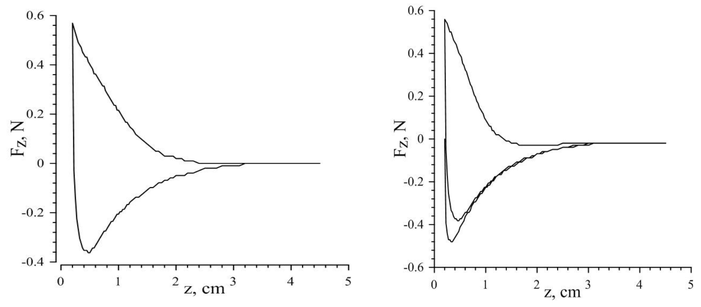
The thickness of the silver layer — 1.5 - 2 μm

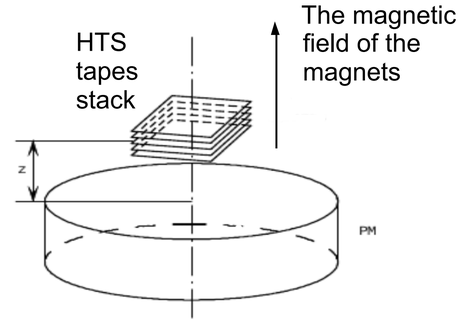
Min. Jc = 300 A (77 K, SF)



The dependence of the maximum of repulsive force on the thickness of the stack of superconductors, ZFC mode

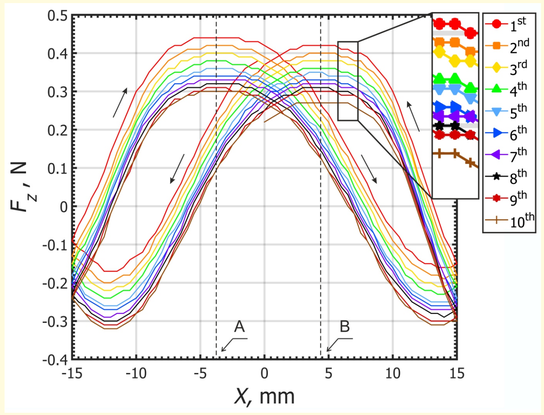
Levitation force for 10 CC tapes stack at T=77.4 K in two modes: (a) ZFC, (b) FC.



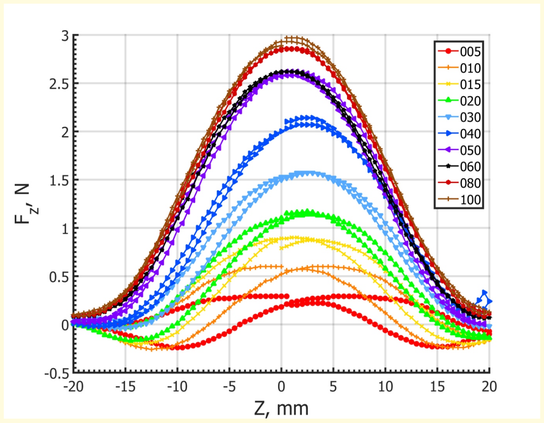


The geometry of the experiment

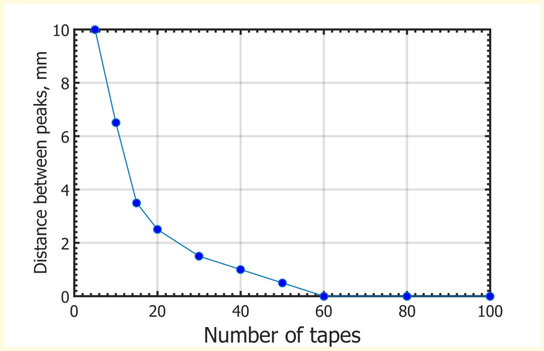
Vertical force



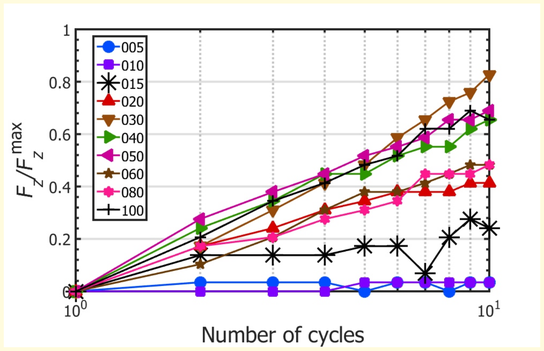
Vertical repulsive force measurements for a stack of 10 layers. 10 lateral movements were performed in a range of ± 15 mm. The distance to the sample is 7 mm, temperature 77 K



First cycle of vertical repulsive force measurements for stacks of various thicknesses. Movements were performed in a range of ± 20 mm. The distance to the sample is 7 mm, temperature 77 K.

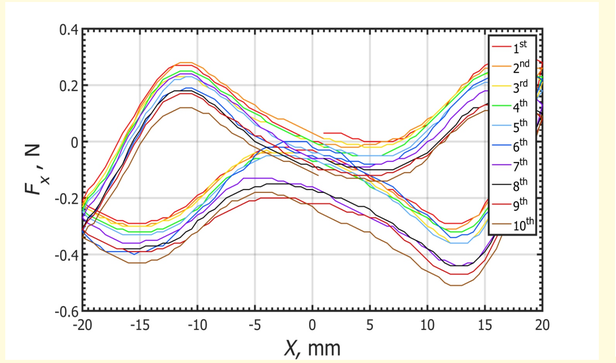


Dependence of the distance between maxima of the repulsive force for movement in the positive and negative directions on the number of layers in the stack. The distance between the peaks becomes insignificant with an increase in the number of layers in the stack.

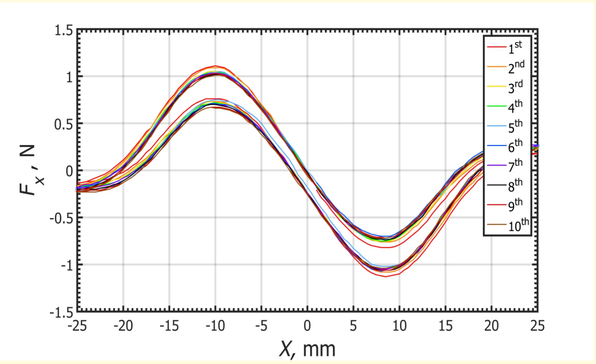


The decrease in levitation force as a function of the number of displacement cycles for stacks of various thicknesses.

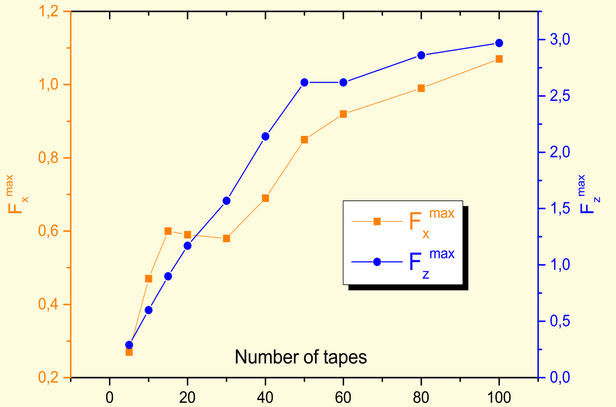
Lateral force



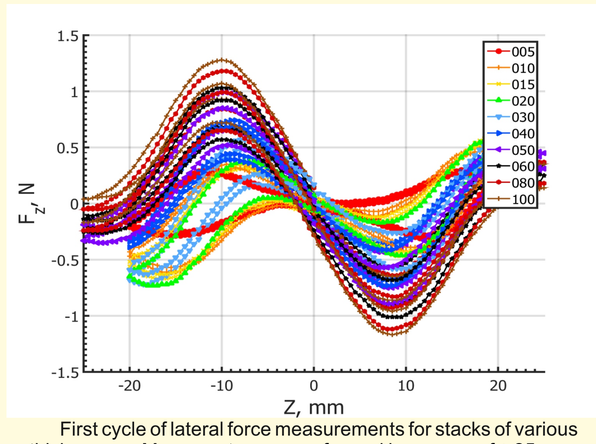
Vertical repulsive force measurements for a stack of 5 layers. 10 lateral movements were performed in a range of ± 20 mm. The distance to the sample is 7 mm, temperature 77 K, ZFC



Vertical repulsive force measurements for a stack of 100 layers. 10 lateral movements were performed in a range of ± 25 mm. The distance to the sample is 7 mm, temperature 77 K, ZFC

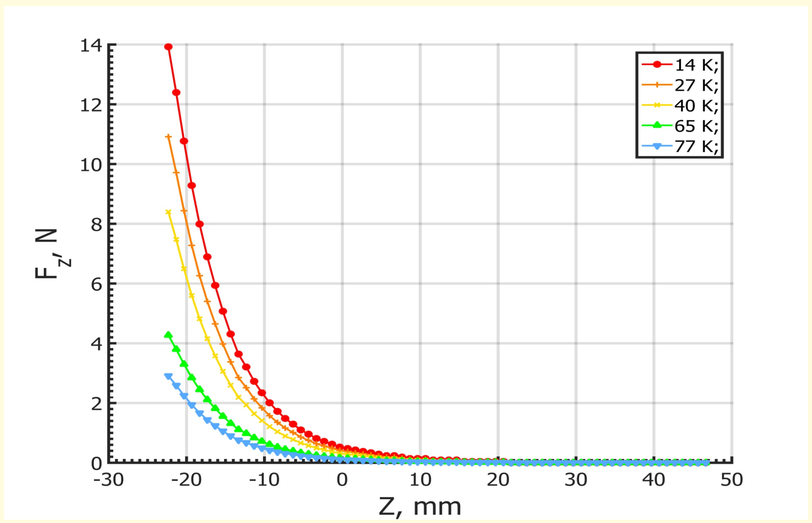


The dependence of the maximum repulsive force and maximum lateral force on number of elements in the stack



First cycle of lateral force measurements for stacks of various thicknesses. Movements were performed in a range of ± 25 mm. The distance to the sample is 7 mm, temperature 77 K, ZFC

Temperature dependence



The dependence of the repulsive force on the distance between the stack and permanent magnet for various temperatures of the stack

Conclusion

Summarizing obtained data we have come to the following conclusions:

1) It was found that the functions of dependency of maximum of the repulsive force (ZFC mode) and attractive force (FC mode) on the thickness of the tapes stack have nonlinear character that allows us to make the optimal choice of geometrical parameters of the stack while keeping the necessary values of the levitation force
2) The spatial dependence of the levitation force during lateral movement in one cycle has a clearly visible hysteresis for stacks of less than 60 layers. The hysteresis manifests in the presence of two maxima in the repulsive force, one for movement to the right and one for movement to the left.
3) The distance between maxima in the repulsive force decreases with an increase in the number of layers in the stack and becomes insignificant for stacks of more than 60 layers.
4) The lateral force depends on the number of movement cycles and decays with each cycle, but decay is visible only for small stacks (5 tapes in the stack).
5) The dependences of the maximum repulsive force and maximum lateral force on number of elements in the stack are in good agreement.