STATISTICS OF THERMOMAGNETIC BREAKDOWN IN Nb SUPERCONDUCTING FILMS

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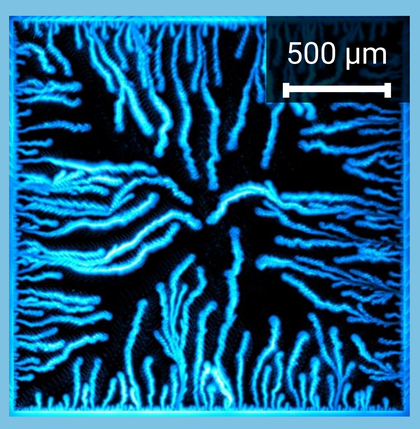


THERMOMAGNETIC BREAKDOWN

In type-II superconductors, as the applied magnetic field H_{applied} is increased, magnetic flux accumulates at the periphery of the sample.

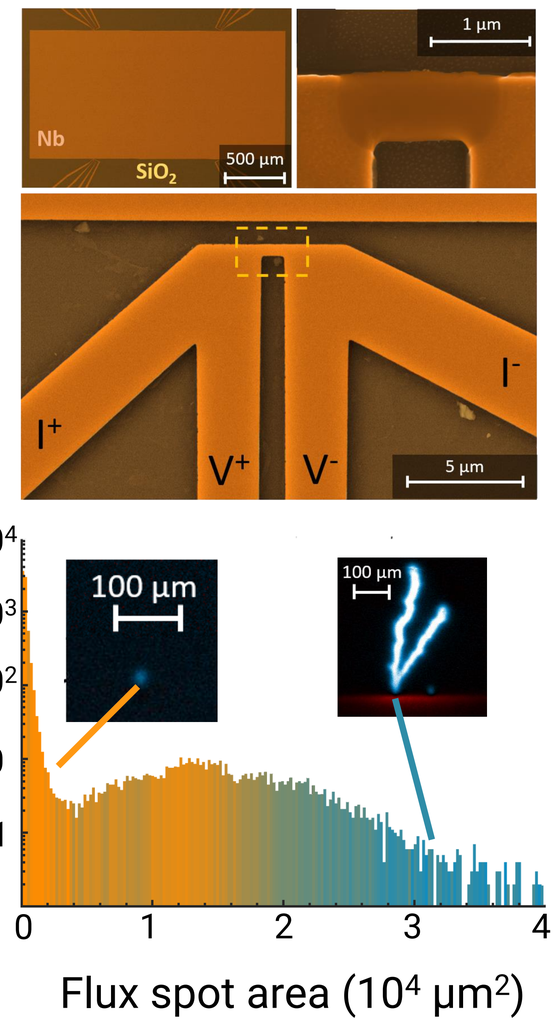
Exceeding the threshold field H_{th} causes a thermomagnetic breakdown (TMB), triggering sudden magnetic flux penetration into the sample.

Like dielectric breakdown or snow avalanches, thermomagnetic breakdown are stochastic phenomena [1].

MOTIVATION

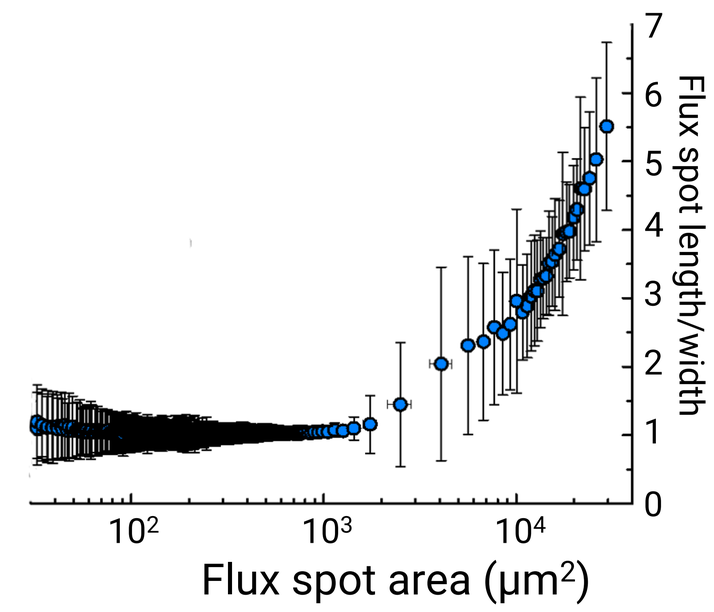
Little information is know about the **statistical distribution** of the thermomagnetic breakdown in superconductors.

Since thousands of experiments can be performed on a single sample by **heating it to reset** their magnetic state, superconductors are unique systems to explore the statistics of stochastic phenomenon.

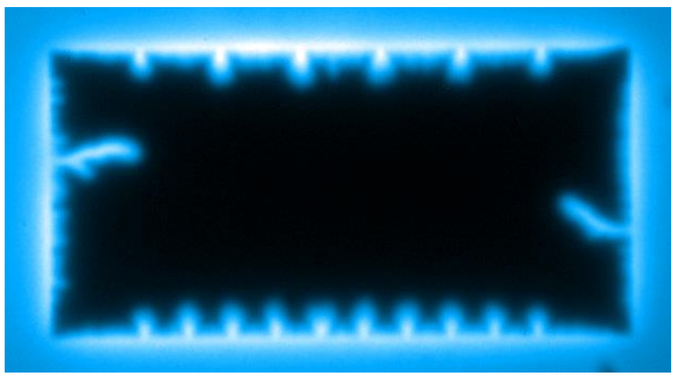


In our experiement [2], the sample layout consist of a 100 nm thick Nb film. Four symetrically place Nb heaters allow to quickly reset the magnetic state of the film.

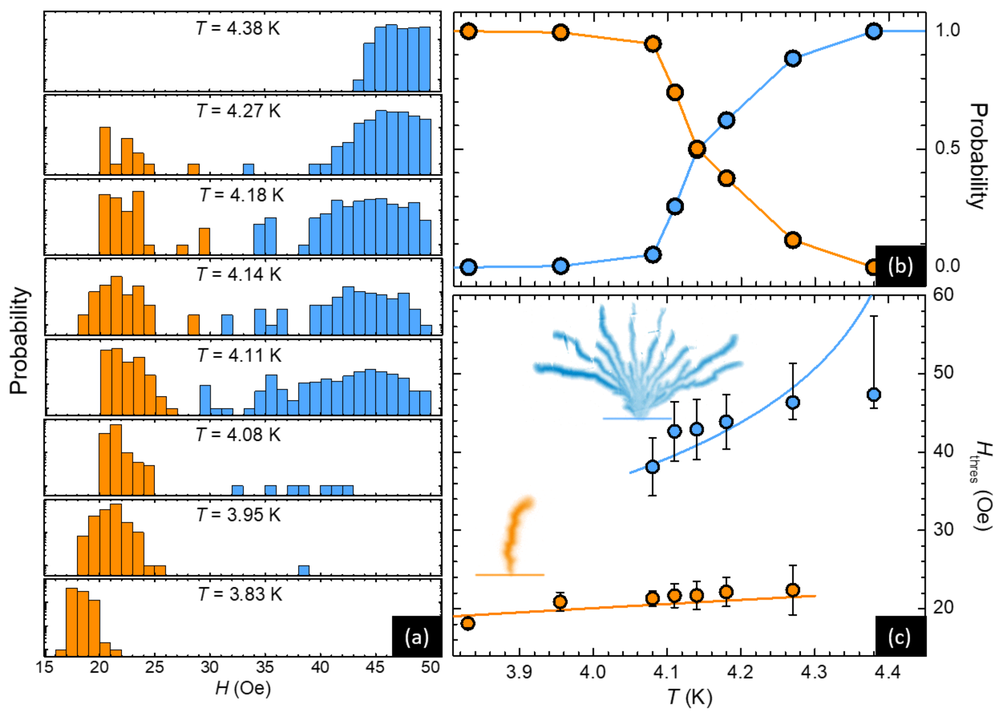
Flux penetration is analysed using magneto-optical imaging [3].



The flux spots **size** and **shape** distributions allow to define a criterion to distinguish dynamical from thermomagnetic breakdown.



As already hinted [4], the location of the two type of breakdown are anti-correlated, highlithing the role of defects in flux penetration



We find a **bimodal distribution** for the H_{th} of TMB, strongly dependent on T.

The two modes are associated to **finger-like breakdown** (in orange) and **branching breakdown** (in blue).

Even though the two type of instabilities seem described by different models [5], there is a **smooth transition** between the two.

CONCLUSIONS

Introducing a shape criteria allowed for discrimination between dynamic and thermomagnetic breakdown in magneto optical imaging experiments.

We unveiled the temperature dependency of the threshold field of the thermomagnetic breakdown and the details of the transition from finger-like magnetic burst to dendritic branching morphology.

Article + poster

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REFERENCES

[1] P. Bak et al. *Phys. Rev. Lett* **59**, 381 (1987).
[2] S. Blanco Alvarez et al. *Sci. Rep.* **9**, 3659 (2019).
[3] G. Shaw et al. *Rev. Sci. Instrum.* **89**, 023705 (2018).
[4] J. Brisbois et al. *Phys Rev. B* **93**, 054521 (2016).
[5] J. Vestgården et al. *Phys. Rev. B* **93**, 174511, (2016)