

# **Dynamics of fluxons in field-cooled high-T\_c superconductors**

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Objekttyp: **Article**

Zeitschrift: **Helvetica Physica Acta**

Band (Jahr): **62 (1989)**

Heft 6-7

PDF erstellt am: **26.04.2024**

Persistenter Link: <https://doi.org/10.5169/seals-116103>

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DYNAMICS OF FLUXONS IN FIELD-COOLED HIGH-T<sub>C</sub> SUPERCONDUCTORS

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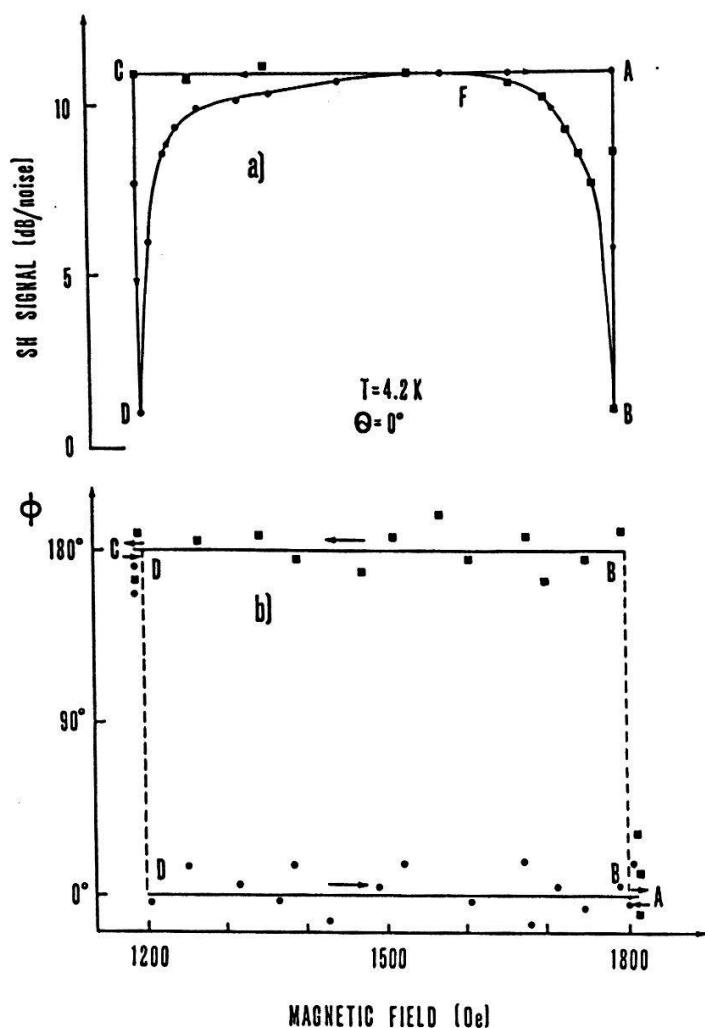
Abstract: Evidence is given that for increasing and decreasing applied fields critical states are developed in field-cooled high-T<sub>C</sub> ceramic superconductors. In samples in the critical state a microwave magnetic field parallel to the applied field induces a magnetization with odd as well as even Fourier components.

The interaction of microwave fields with field-cooled (FC) single-phase ceramic YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> has been studied by investigating the second-harmonic (SH) response to the driving field.

The experiments have been performed by exposing the samples to a dc field H<sub>0</sub> and an ac field H(ω) at an angle Θ with respect to H<sub>0</sub>. The SH signal radiated by the samples has been investigated. It depends on both H<sub>0</sub> and Θ. The signal is phase coherent. The phase as a function of H<sub>0</sub> and Θ has also been investigated.

Fig.1a shows the SH signal intensity as a function of H<sub>0</sub> in the range of fields 1200–1800 Oe. The intensity is independent of H<sub>0</sub> as long as H<sub>0</sub> is increased (or decreased) steadily. Minima are observed when the magnetic field sweep is reversed, independently of the values of H<sub>0</sub> in which the inversions are operated. Fig.1b shows the phase of the SH signal as a function of H<sub>0</sub>. The phase, at a given value of H<sub>0</sub>, may differ by 180° depending on the way H<sub>0</sub> has been attained, at increasing or decreasing fields. On increasing H<sub>0</sub> the phase remains constant as long as H<sub>0</sub> is increased, from D to A. It remains still constant at the same value when H<sub>0</sub> is decreased from A to B, while a 180° variation is observed on crossing B. If the field is further decreased the phase remains constant at the new value until point D is reached.

The results are consistent with the assumption that a critical state



is developed in FC Y-Ba-Cu-O by an increasing (or decreasing) applied field. Supposing valid the Bean's assumption of constant  $J_c$  in superconductors<sup>(1)</sup>, because of the rigidity of the fluxon lattice the response of the sample, in a critical state, to a microwave field is expected to be uneven during a period of the wave: for increasing fields the induction flux is essentially influenced only during the negative semiperiod, so that a magnetization with both odd and even Fourier components results<sup>(2)</sup>.

According to this picture a theory has been developed<sup>(2)</sup>

which accounts quite well for i) SH signal intensity independent of  $H_0$  for constant field sweep; ii) minima at the inversion points of the field sweep; iii) 180° phase variation at those values of  $H_0$  in which the critical state is removed (e.g., points B and D of Fig.1); iiiii) angular dependence of both intensity and phase of the SH signal.

#### References

- (1) C. P. Bean, Rev. Mod. Phys. 36, 31 (1964).
- (2) I. Ciccarello, C. Fazio, M. Guccione and M. Li Vigni, Physica C, submitted.