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Interaction between magnetohydrodynamic and temperature instabilities during S-N switching of thin II-type superconductor films

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Recently attention was drawn to complex calculations between the interaction of mechanic and hydrodynamic instabilities [1]. There is no doubt that soon there will appear calculations of the interaction between temperature and magnetohydrodynamic or plasma instabilities. However, the creation of mathematical models in these complex cases requires a clear understanding of the occurring physical processes. Here it will be described interaction between magneto-hydrodynamic and temperature instabilities induced by ns overcritical current pulses during switching between superconducting (S) and normal (N) states of the thin films.

Earlier It was described the S-N switching of the high quality films with hallmark as the cumulative effect [2]. The cumulative effect appears due to bending of the S-N border. The border width is characterized by Pearl length λ_{eff} of about 1 μm wide. Its specific longitudinal properties are more obvious the better are the superconducting properties of the films, i.e. both current ***I*** and expelled magnetic field ***B*** are better concentrated at the film edge.

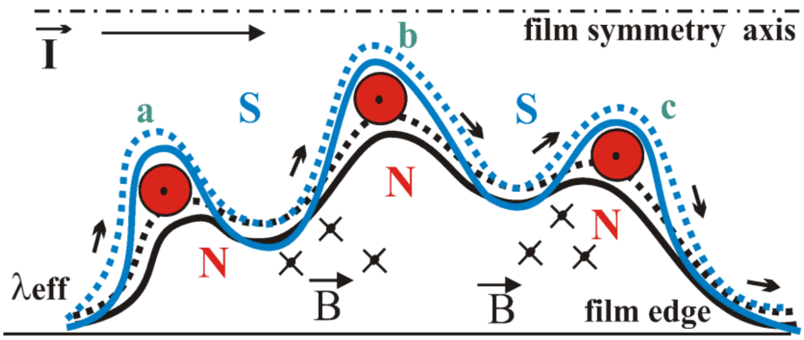

Fig.1 Interaction of unstable S-N border of width λ_{eff} with areas of temperature growth (a,b,c). View from above.

In mechanics, it is known Euler instability, half wave bending of a rod under applying force, and Ishlinsky-Lavrent'ev instability, bending of the rod by vibration modes of different frequencies under the pulsed applying force. In our magnetohydrodynamic case the S-N border near film edge is bent under the current pulse as the superposition of half wave with one of the modes (see Fig.1). Current concentration at the marked points (a,b,c) induces temperature instability followed by local S-N switching and inside penetration of the N state.

Scanning electron microscope images of damaged samples show that the interaction depending on the film quality and the current amplitude suggests different scenarios for the movement of N zone. It can be the soft one, without damage of the film and up to the explosive one, when strong cumulative effect breaks the S-N border, and a melting of the film occurs.

REFERENCES

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[2] O. Kiprijanovič, S. Ašmontas, *Theses of LNP conference* (2015) p. 315.