Highlights

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A precursor mechanism triggering the second magnetization peak phenomenon in superconducting materials

M. Polichetti[1,2], A. Galluzzi[1,2], K. Buchkov[3,4], V. Tomov[3], E. Nazarova[3], A. Leo[1,2], G. Grimaldi[2], S. Pace[1,2]

[1]Department of Physics "E.R. Caianiello", University of Salerno, Via Giovanni Paolo II, 132, 84084 Fisciano, Salerno, Italy.
[2]CNR-SPIN, UOS Salerno c/o Università di Salerno - Via Giovanni Paolo II 132, 84084 Fisciano (SA), Italy
[3]Institute of Solid State Physics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee, 1784 Sofia, Bulgaria.
[4]Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Acad. G. Bonchev Str. Bl. 109, 1113 Sofia, Bulgaria.

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The correlation in type-II superconductors between the creep rate S and the Second Magnetization Peak (SMP) phenomenon which produces an increase in J_c, as a function of the field (H), has been investigated at different temperatures by starting from the minimum in $S(H)$ and the onset of the SMP phenomenon detected on a $FeSe_{0.5}Te_{0.5}$ sample. Then the analysis has been extended by considering the entire $S(H)$ curves and comparing our results with those of many other superconducting materials reported in literature. In this way, we find evidence that the flux dynamic mechanisms behind the appearance of the SMP phenomenon in $J_c(H)$ are activated at fields well below those where the critical current starts effectively to increase. Moreover, the found universal relation between the minimum in the $S(H)$ and the SMP phenomenon in $J_c(H)$ shows that both can be attributed to a sequential crossover between a less effective pinning (losing its effectiveness at low fields) to a more effective pinning (still acting at high fields), regardless of the type-II superconductor taken into consideration.

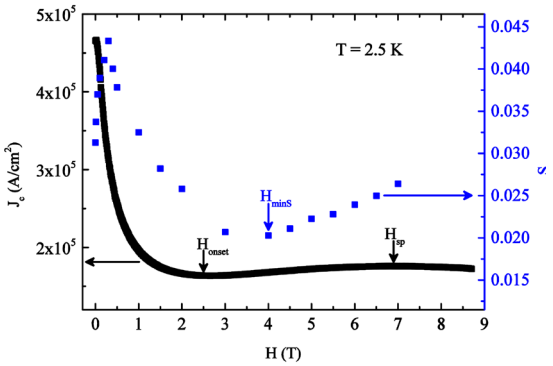

Fig. 1: The field dependence of relaxation rate S (blue closed squares, right scale) shown together with the $J_c(H)$ curve (black closed squares, left scale) measured at the same temperature $T = 2.5$ K.

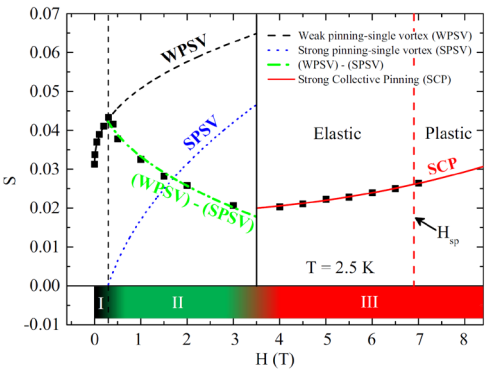

Fig. 2: S as a function of H at $T = 2.5$ K. The black dashed line is the fit of the first $S(H)$ increase. The blue dotted line is the strong pinning single vortex behavior speculated for the vortices that enter in the twin boundaries. The green dashed-dotted line is the fit of the decreasing $S(H)$ data by the subtraction of the black and blue line. The red solid line is the fit of the second $S(H)$ increase. In the bottom of the figure, the field intervals relative to the three $S(H)$ portions are identified with different colours. Finally, the black vertical solid line separates the single vortex state from the collective pinning state while the red vertical dashed line, individuated by the H_{sp} value, separates the elastic regime from the plastic regime in the framework of the collective pinning theory.