# Temporal evolution of topological domain-wall defects in ferromagnetic superconductors

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The coexistence of seemingly contradictory phenomena, such as superconductivity and ferromagnetism in $EuFe_2(As_{1-x}P_x)_2$, gives rise to a variety of effects not observed in materials that exhibit either ferromagnetism or superconductivity alone [1]. The interplay between two competing order parameters, characterizing the magnetic and superconducting subsystems, leads to the emergence of complex magnetization patterns, contributing to a highly diverse phase diagram [1,2]. In this unique system, ferromagnetic bulk domain walls are stabilized, and can coexist with vortices and anti-vortices of the superconducting condensate [2]. In our study, we show that the formation of ferromagnetic domain walls in the Meissner state of such a material is accompanied by the temporal evolution of topological Y-shaped defects of the domain wall structure. Through experimental observation of the magnetization pattern on the surface of the bulk sample, we identified the slow motion of the defects along the domain walls. The experimental findings align with the theoretical analysis of emerging patterns, utilizing a model that combines the Ginzburg-Landau theory for the superconducting condensate and the Landau-Lifshitz-Gilbert equations for magnetization.

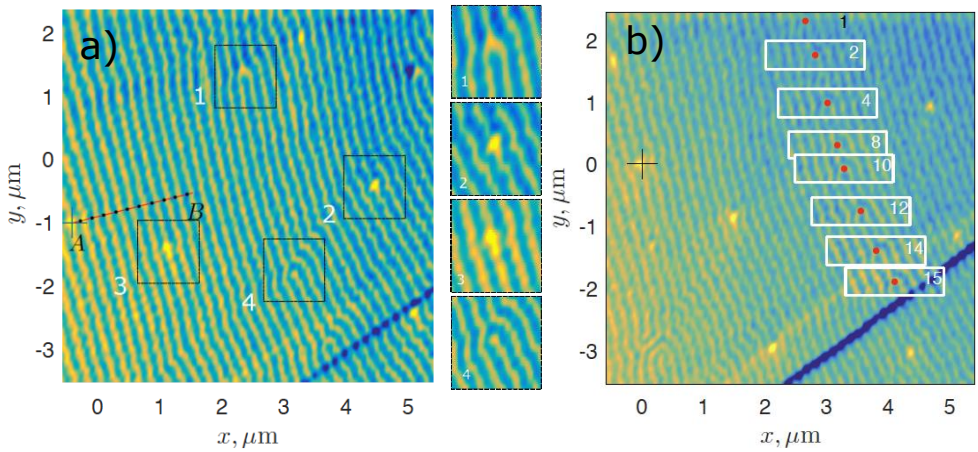


**Fig. 1:** *a) Domain walls in $EuFe_2(As_{1-x}P_x)_2$ at T=18K; defects in boxes 1-4 are enlarged in the corresponding panels; 2 and 3 are vortex defects, 1 and 4 are topological Y-shaped defects. b) A defect (red spot) moves downwards along the domain wall (time-frame insets are numbered as 1-15).*

## References

1. V.A. Stolyarov et al., Sci. Adv. **4**, eaat1061 (2018).
2. A. Vagov, et al., Comm. Physics **6**, 284 (2023).