Resistive States due to the Interplay of Flux Flow and Vortex Dynamics in Artificially Defected Granular Superconductors within the Ginzburg-Landau Theory

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In granular superconductors, grain boundaries act as Josephson junctions, affecting the global critical current density [1]. The application of an external magnetic field and a transport current in type-II superconductors leads to an interaction between vortices and the current via the Lorentz force [2]. When the Lorentz force exceeds the pinning force, a flux flow regime emerges in the sample [3]. Although granular superconductivity is widely studied, the impact of engineered mesoscopic grains with tailored pinning centers on vortex matter remains underexplored. In this work, we simulate a semi-infinite superconducting tape using the generalized time-dependent Ginzburg-Landau (GTDGL) framework [4]. The system consists of intra- and inter-grain regions, where the grain boundaries present a lower T_c than the superconducting matrix. Moreover, the intra-grain regions are artificially defected with 1 (S01), 4 (S04), or 0 (S00) defects. Our results show that although the intra-grain defects are not effective at trapping vortices, they significantly influence the local supercurrent distribution, delay vortex motion, and can guide vortex trajectories. Two distinct flux flow regimes were observed: one confined to the weak link region and, at certain currents, a shared flux flow regime. Additionally, at lower fields, the interaction between vortices and defects in S04 promotes the coalescence of intra-grain vortices with those in the inter-grain region (see Figure 1). These insights may help guide the design and application of granular superconductors in sensors and emerging quantum technologies.

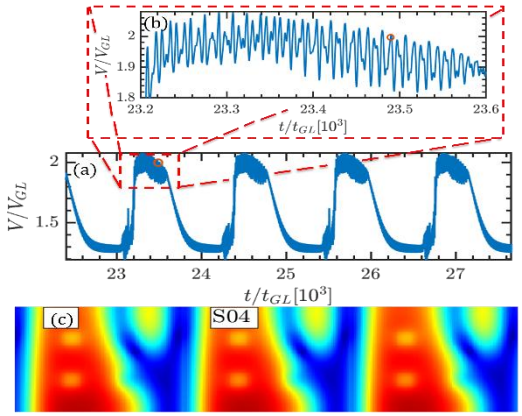

Figure 1: (a) time-voltage curve for $J_{tr} = 0.30750J_{GL}$ at $H = 0.1H_{c2}$, (b) Zoomed-in view, and (c) colormap of |ψ|

Key words: Mesoscopic Grains, Granular Superconductors, Weak Links, Generalized time-dependent Ginzburg-Landau, Vortex Dynamics.

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Note: This abstract will be used for both the presentation and the poster sections.