Dislocation dynamics and tearing transitions in crystalline thin films

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A new class of artificial atoms such as synthetic nanocrystals, magnetic colloids or vortices in superconductors, naturally self-assemble into ordered arrays. This property warrants their applicability in the design of novel solids, and devices whose properties often depend on the type of ordering, on the substrate shape, and on the response of these assemblies upon the action of external forces. We present the transport properties of a vortex array in the so-called Corbino disk geometry. In response to an injected current in the superconductor, the global resistance associted to vortex motion exhibits sharp jumps at two threshold current values I_0 and I_1. The first jump corresponds to a tearing transition from rigid rotation to plastic flow due to the reiterative nucleation around the disk center of neutral dislocation pairs that unbind and glide across the entire disk. The threshold current I_0 is shown to closely follow the detailed behavior of the shear modulus of the vortex array. After the second jump at I_1, we observe a smoother plastic phase proceeding from the coherent glide of a larger number of dislocations arranged into radial grain boundaries. We provide an analysis of the topology of the vortex lattice that allows us to unveil the microscopic origin of the observed phenomena.

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