# Microscopics of Vortex Pinning in Superconductors

Review

## Vortices in high-performance high-temperature superconductors

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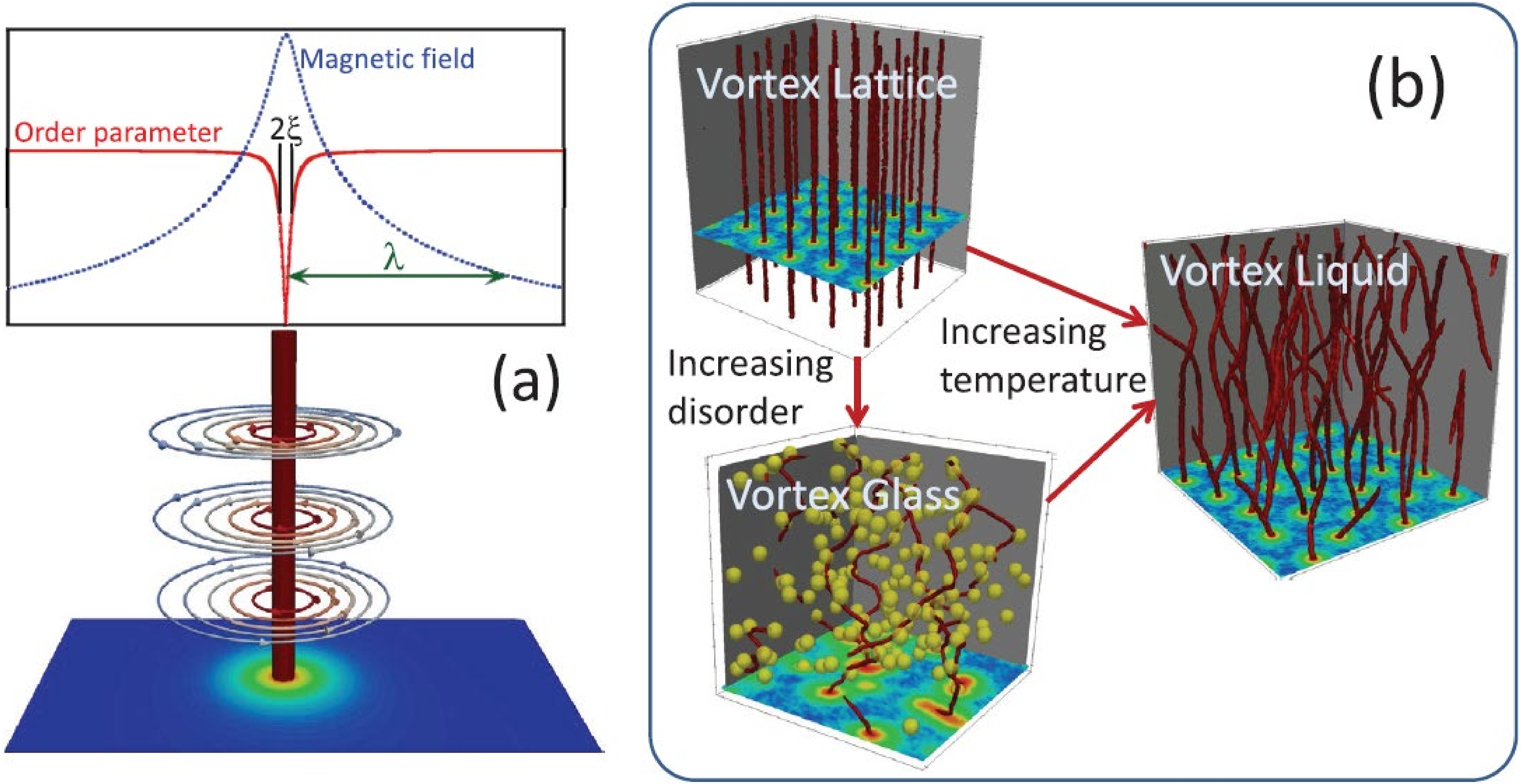


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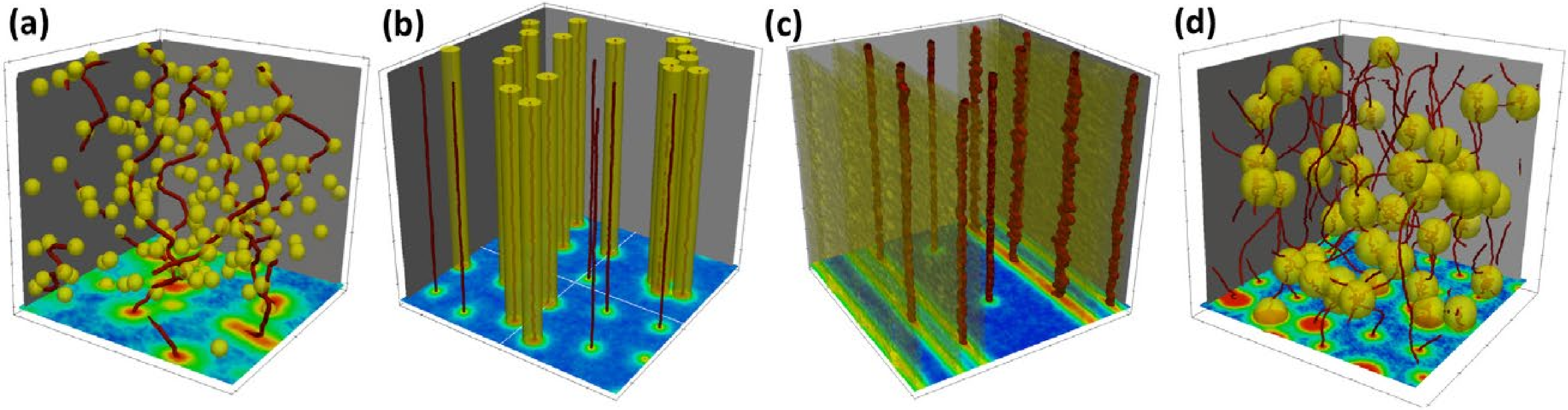


**Figure 5.** 3D Illustration of vortex matter (red) in defect structures (yellow) of different dimensionality. (a) Random atomic / pointlike defects, (b) linear defects (irradiation induced tracks, synthesited self-assembled nanorods, dislocations), (c) planar defects (twin boundaries, stacking faults, layered structure), (d) large random defects (rare earth oxide precipitates, irradiation collision cascades, defect clusters, voids). All figures created using time-dependent Ginzburg–Landau equations, see section 4.2. The bottom plane-cuts show the distribution of the superconducting order parameter amplitude or condensate density (blue: high, red: low).

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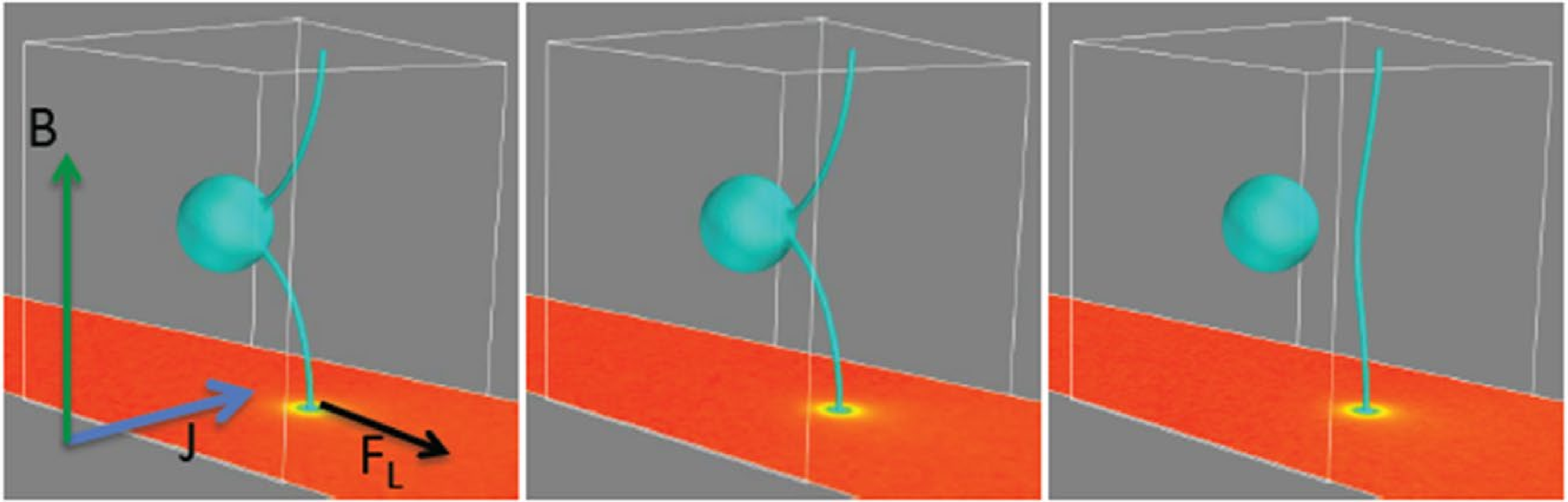


**Figure 6.** Visualization of depinning of a vortex line from a large-size defect obtained from simulations using the time-dependent Ginburg-Landau model. Magnetic field (**B**), applied current (**J**) and resulting Lorentz force ($\mathbf{F}_L$) are indicated.

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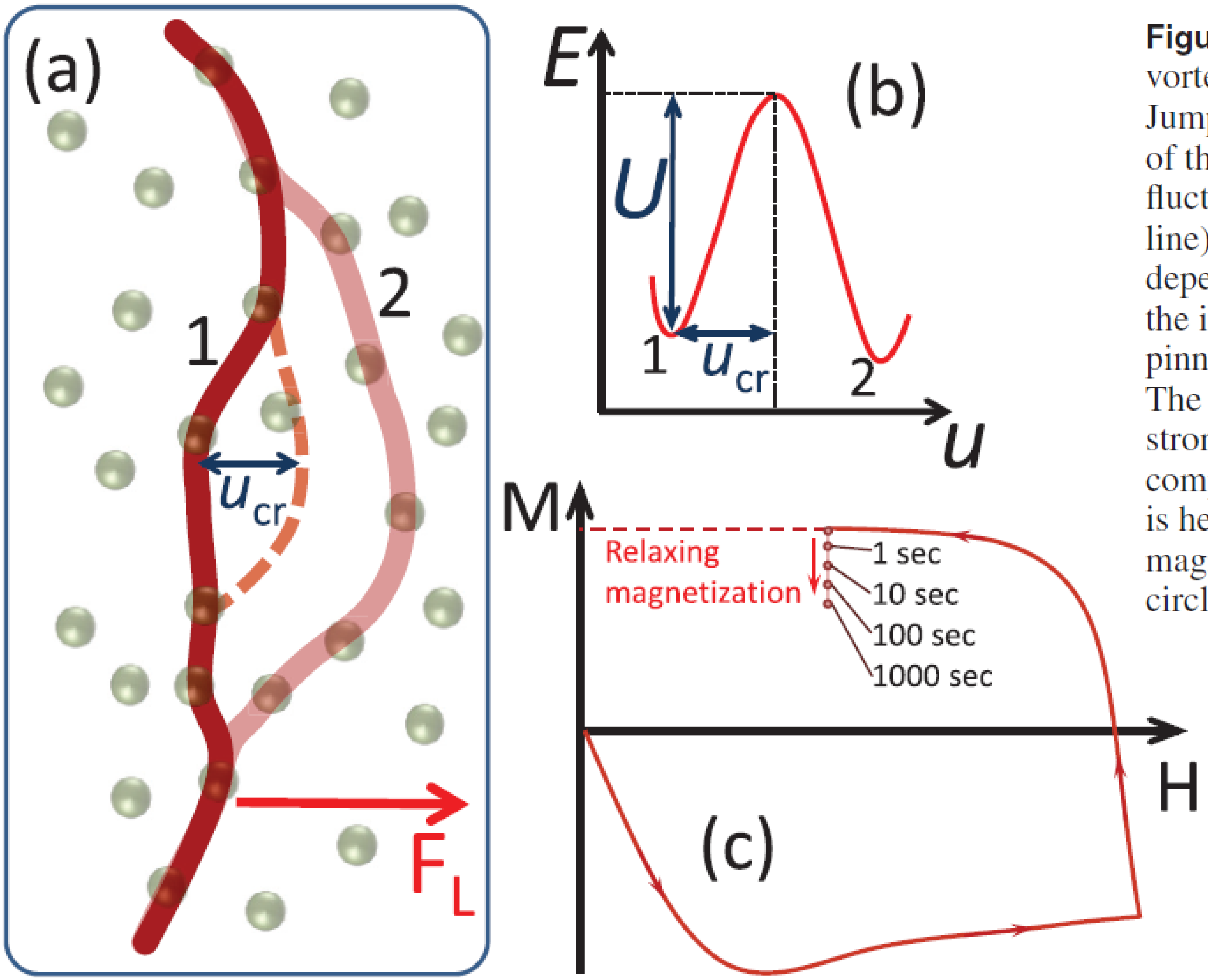


**Figure 10.** (a) Illustration of two metastable states of a pinned vortex (marked by 1 and 2) separated by the potential barrier $U$. Jump from the initial state 1 into the next state 2 may occur because of thermal noise. Such a jump is only possible after a rare strong fluctuation in the form of a critical nucleus is generated (dashed line). Slow creep motion of vortices is due to such jumps. (b) The dependence of the energy $E$ on the vortex displacement $u$ from the initial state. (c) Schematic magnetization loop for a strong-pinning superconductor showing pronounced hysteresic behavior. The arrows mark the magnetic-field sweep direction. In the case of strong pinning the equilibrium magnetization is usually small as compared to the hysteretic magnetization. When the applied field is held constant, the magnetization relaxes towards the equilibrium magnetization (vertical red arrow) via vortex creep. The small circles track time evolution of the relaxed magnetization.

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