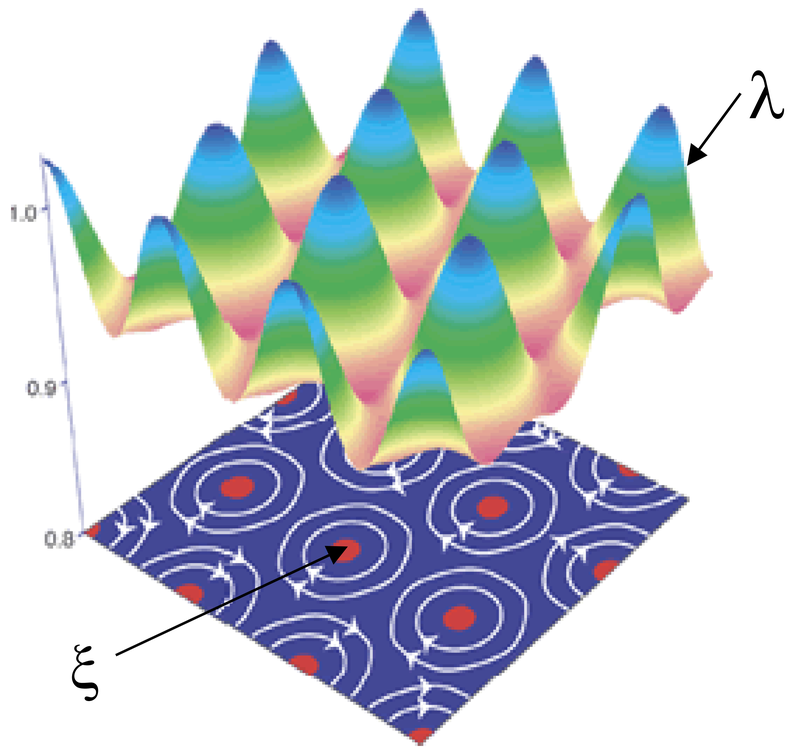
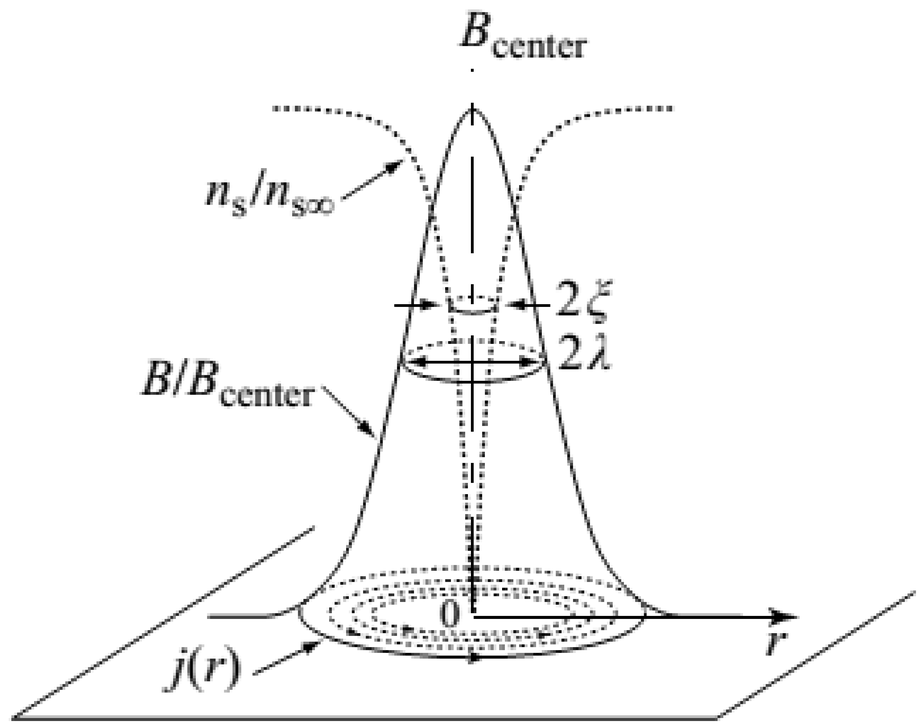
La “materia de vórtices”

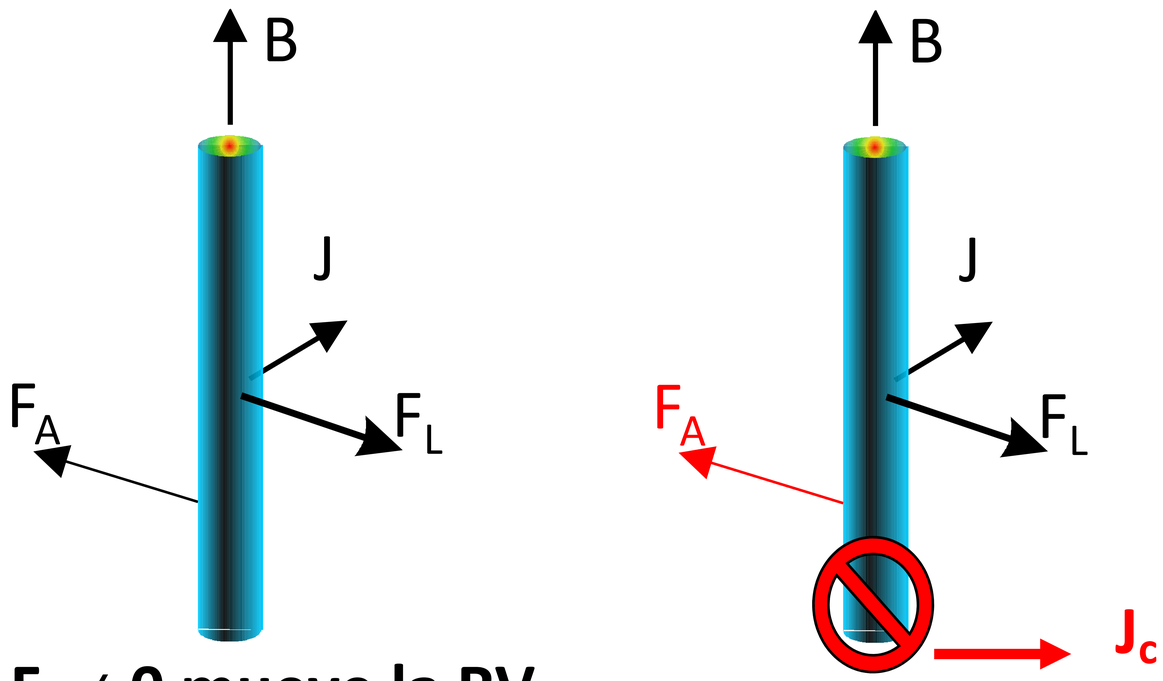
Red de vórtices





En el estado mixto de un superconductor de tipo II, sin defectos, con simetría de traslación, la configuración de mínima energía es un arreglo triangular periódico de vórtices.

El rol de los defectos estructurales

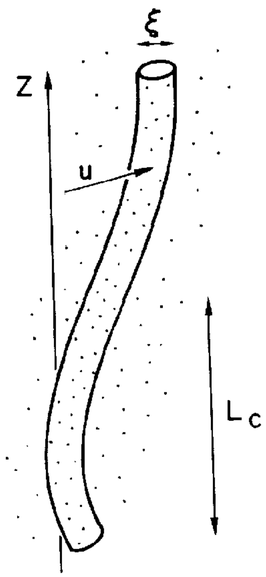


$F_L \neq 0$ mueve la RV

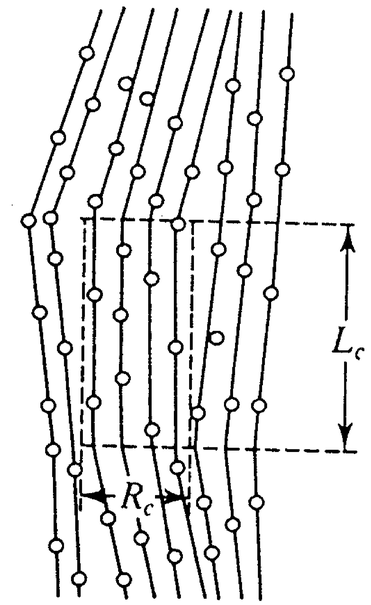
- Aparecen dislocaciones
- No hay orden de largo alcance
- El sistema se desordena

- Los defectos rompen la simetría de traslación!
- Hay sitios energéticamente favorables (centros de anclaje). Si $F_L < F_C$ no se mueven. F_C determina J_C.

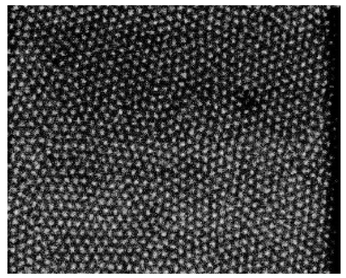
Competencia entre interacciones



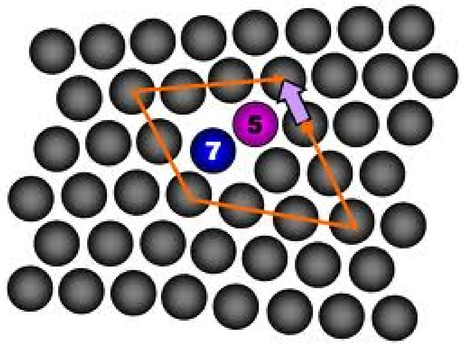
Los vórtices son "objetos" elásticos



La RV pierde correlación de largo alcance

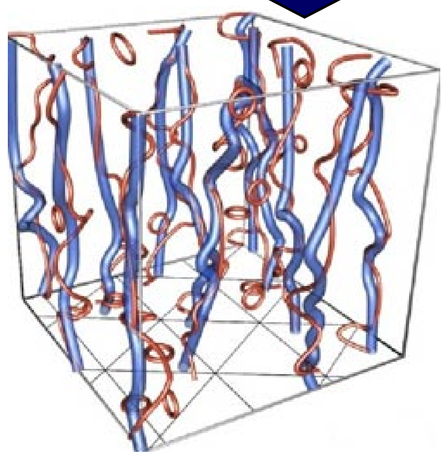


La ineracción entre vórtices compite con el desorden



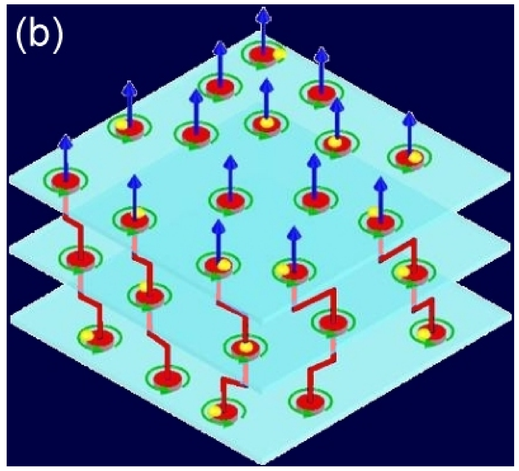
Aparecen dislocaciones

Fluctuaciones térmicas



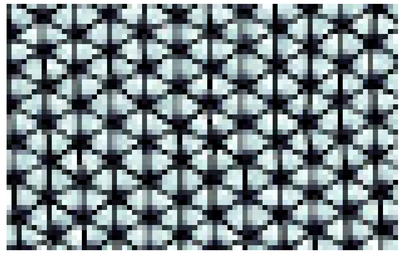
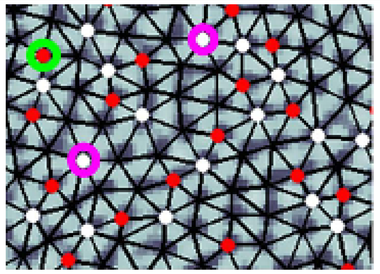
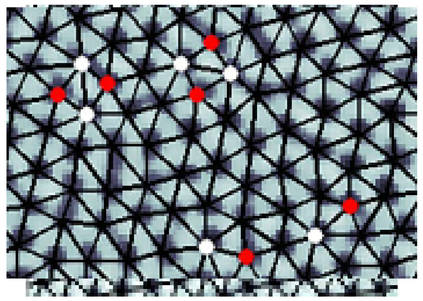
Líquido de vórtices

anisotropía



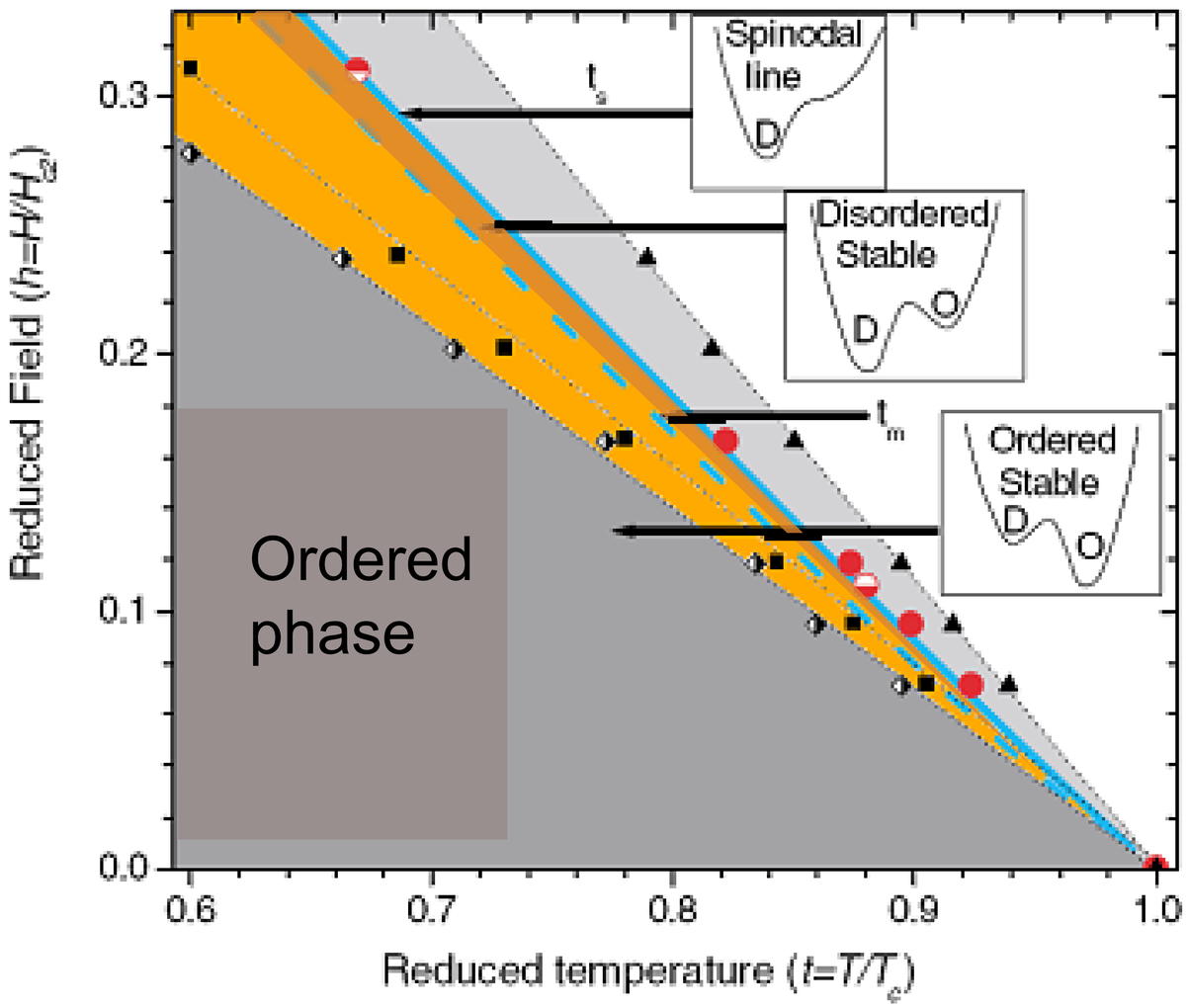
vórtices 2D "panqueques"

La “materia de vórtices” es un sistema complejo con Interacciones competitivas

Interacción dominante	Configuración espacial		Anclaje Efectivo
Vortice-vórtice	Vidrio de Bragg (BG) “sin dislocaciones”.		débil
Vórtice defecto	Vidrio desordenado		fuerte
Compiten	Dislocaciones (desorden intermedio)		intermedio

Imágenes de experimentos de STM, S. Ganbuli et al. Scientific Report 5,10613, 2015

Fases de vórtices



Monocristales limpios de $NbSe_2$

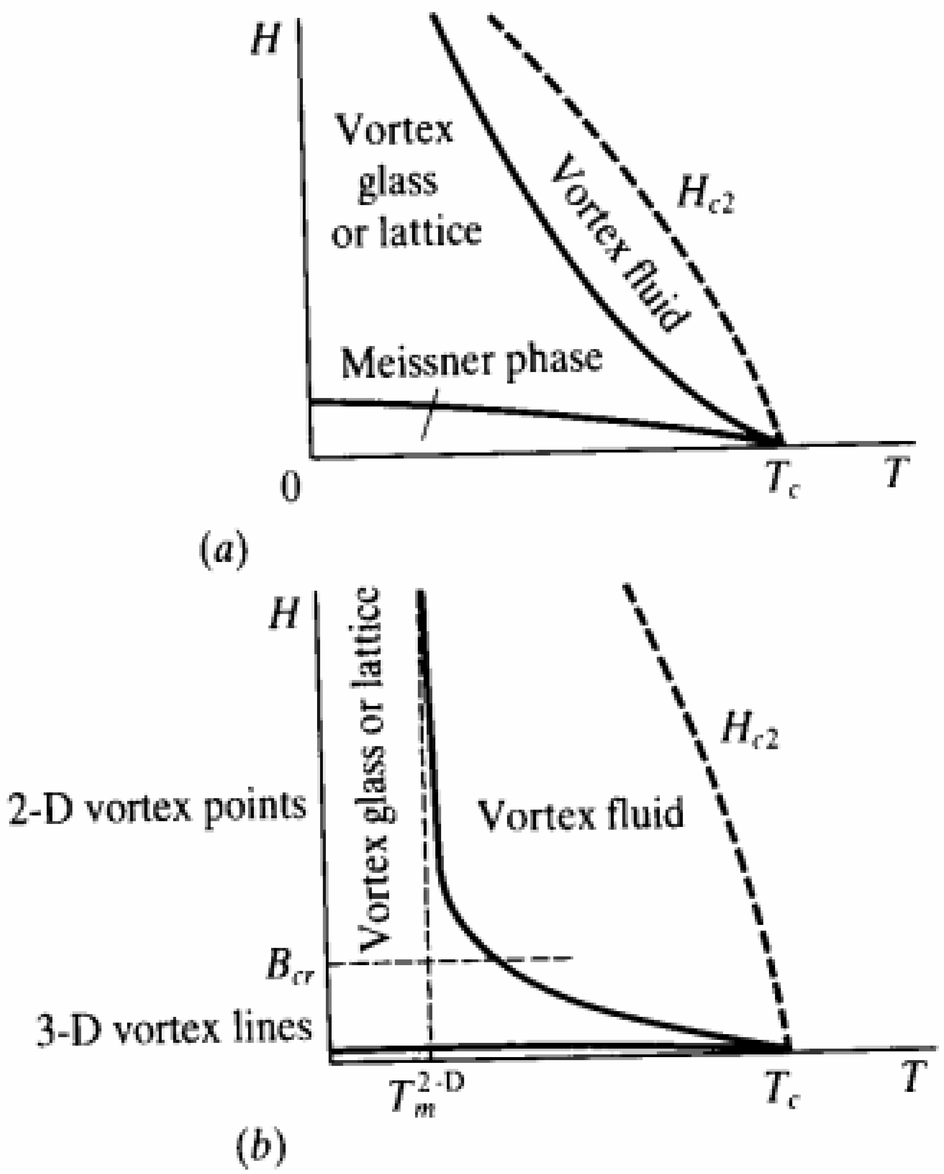
Z. Xiao et al; PRL. **85**,3265 (2004)

En los superconductores muy limpios, la mayor parte del estado mixto está ocupado por la fase ordenada de Vidrio de Bragg

Las J_c son muy bajas.

Muy cerca de H_{c2} (T) los vórtices se desordenan

Fases de vórtices en SATs



La anisotropía y las fluctuaciones térmicas son muy relevantes.

FIGURE 9.8
Schematic phase diagrams for melting of the flux-line solid for (*a*) 3-D material (e.g., YBCO) and (*b*) highly layered material (e.g., BSCCO). The latter shows the crossover from 3-D to 2-D melting at the crossover flux density B_{cr}, which is at inaccessibly high fields for the 3-D material in (*a*).

Fases de vórtices en SATs

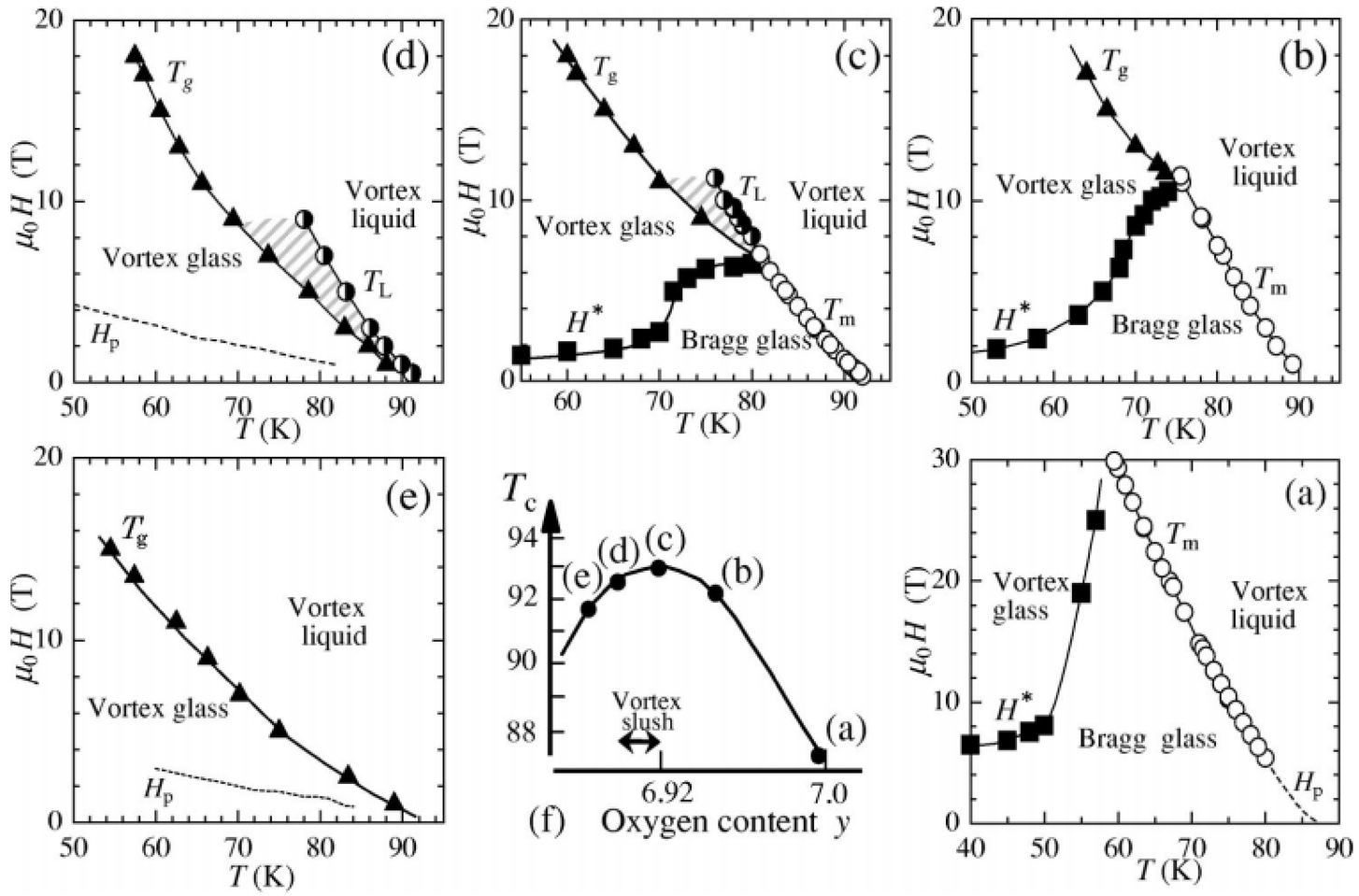


FIG. 6. Vortex phase diagram for untwinned YBCO with various oxygen contents y above and below the optimal condition. (a) Heavily overdoped YBCO ($y \sim 7.0$) (Ref. 16). (b) Slightly overdoped YBCO ($y \simeq 6.95$) (Refs. 9 and 10). (c) Optimally doped YBCO ($y \simeq 6.92$, studied in this paper). (d) Slightly underdoped YBCO ($y \simeq 6.90$) (Ref. 16). (e) Underdoped YBCO ($y \simeq 6.88$). (f) Schematic diagram of T_c vs y. The electron irradiation effect (Ref. 10) has been examined for slightly overdoped YBCO in (b). The shaded portions in (c) and (d) correspond to the vortex slush regime.

Monocristales demaclados de $YBa_2Cu_3O_y$

Shibata et al; PRB. **66**, 214518 (2002)

Pequeños cambios en el dopaje alteran dramaticamete las fases de vórtices