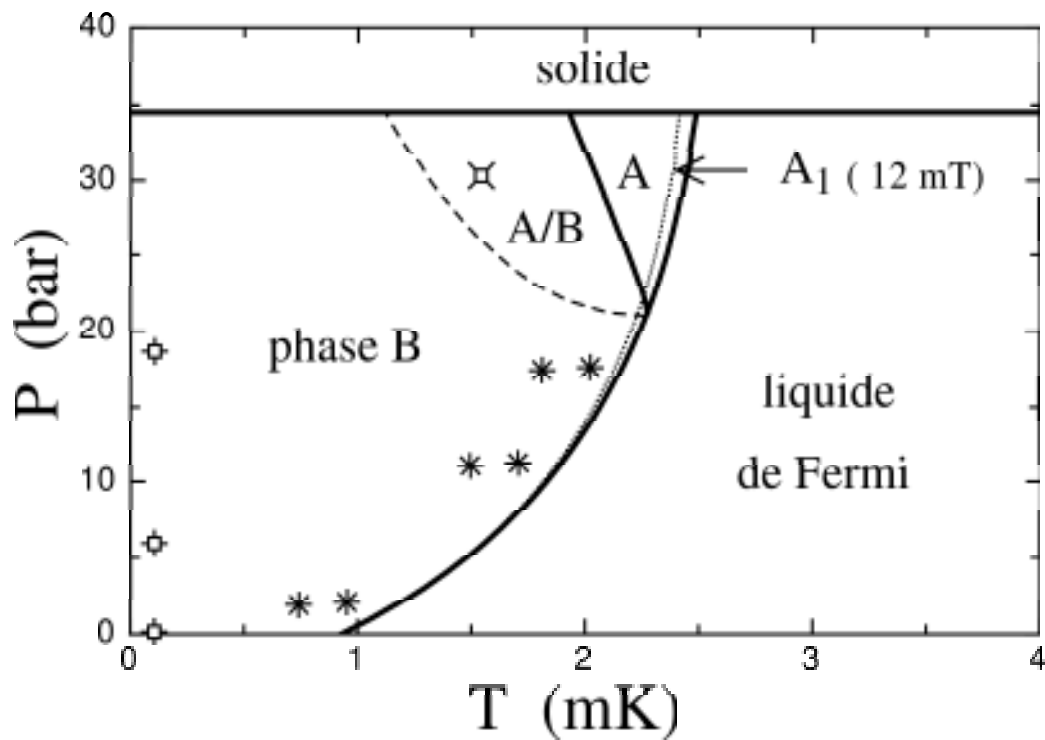


Formation de vortex dans l' ^3He superfluide irradié aux neutrons

HELSINKI

V. Ruutu
Wen Xu
B. Plaçais
G. Volovik
M. Krusius

V. Eltsov
Yu. Makhlin
A. Gill
T. Kibble



vortex dans ${}^3\text{He-B}$

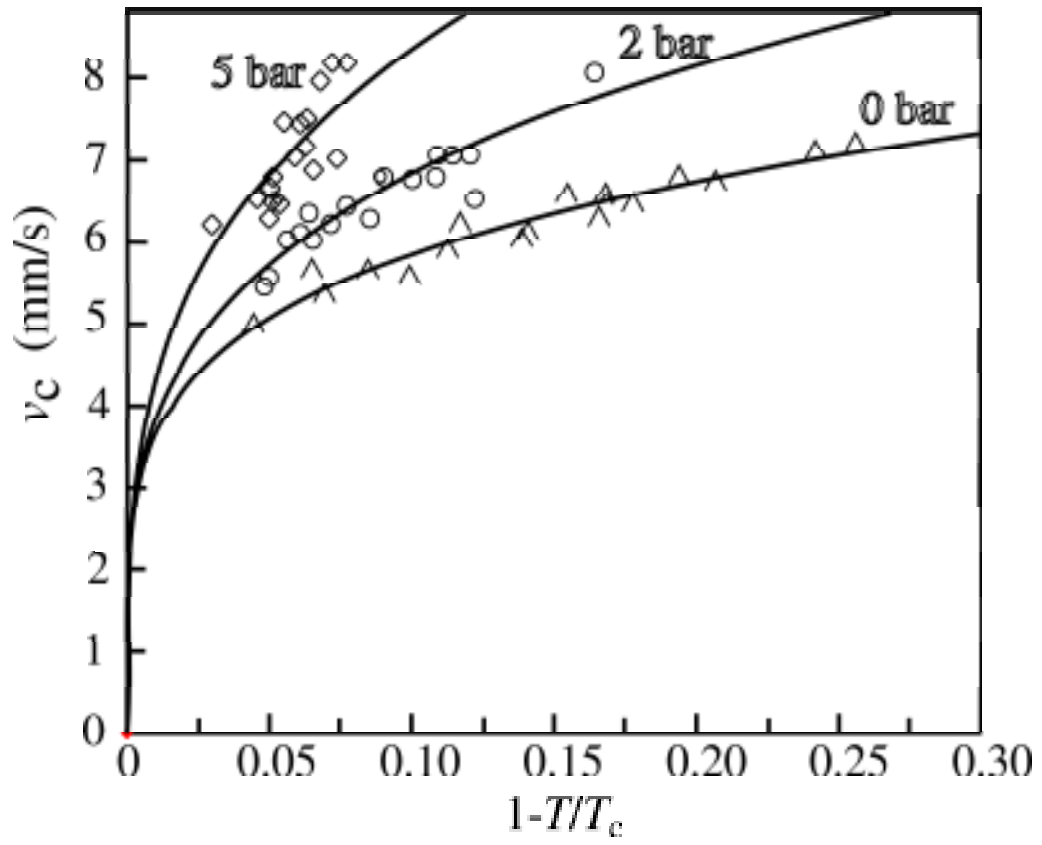
$$v_s = \kappa / 2\pi r \quad ; \quad \kappa = h/2m_3 = 0.067 \text{ mm}^2/\text{s}$$

$$\text{rayon de coeur} \quad \xi = \xi_0 / (1-T/T_c)^{1/2}$$

$$\text{energie de ligne} \quad f_v = \rho_s \kappa^2 / 4\pi \ln(R/\xi)$$

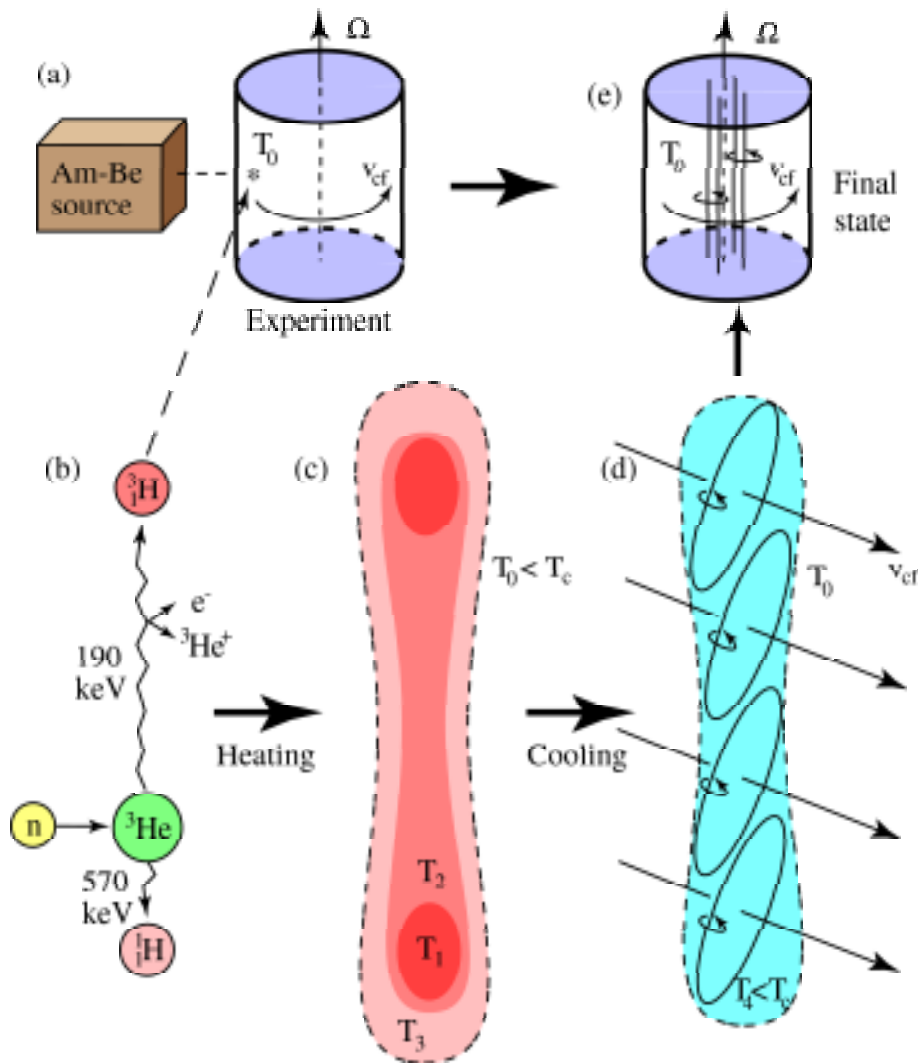
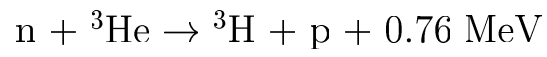
$$\xi_0 = v_F \tau_0 \sim 20\text{--}50 \text{ nm} \quad v_F \simeq 50 \text{ m/s}$$

$$\tau_0 = \hbar/\Delta \sim \hbar/kT_c \sim 0.5\text{--}1.3 \text{ ns}$$

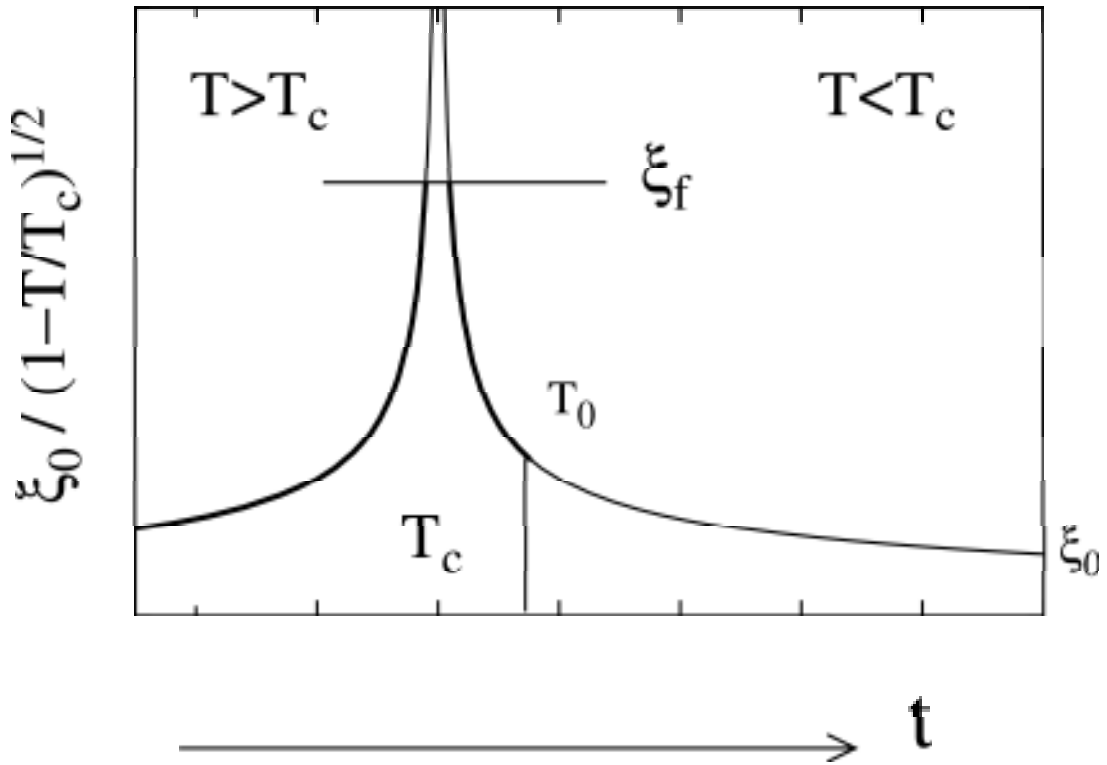


nucleation spontanée

$$V_{cb} = \kappa / (5\pi\xi) \quad (\xi/l)^{1/2} \propto (1 - T/T_c)^{1/4}$$



mécanisme de Kibble Zurek



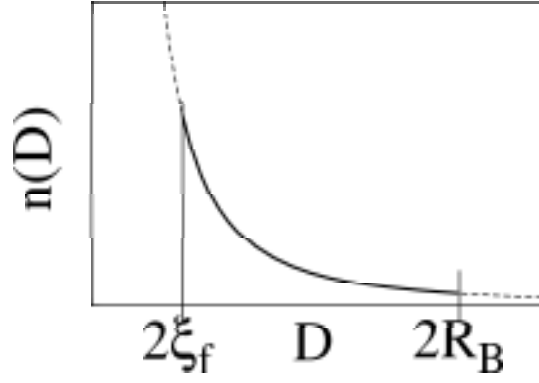
$$\epsilon(t) = 1 - \frac{T}{T_c} = \frac{t}{\tau_Q} \quad \left(\frac{dT}{dt} = -\frac{T_c}{\tau_Q} \right)$$

$$\tau = \frac{\tau_0}{|1 - T/T_c|}$$

Taille des fluctuations gelées

$$\xi_f = \xi_0 \left(\frac{\tau_Q}{\tau_0} \right)^{1/4}$$

$$\rightarrow 1 - \frac{T_f}{T_c} = \sqrt{\frac{\tau_0}{\tau_Q}} \sim 10^{-2}$$



$$\bar{n}(\mathcal{D})d\mathcal{D} = \frac{2C}{\mathcal{D}^4}d\mathcal{D} \quad C \simeq 0.3$$

densité d'anneaux

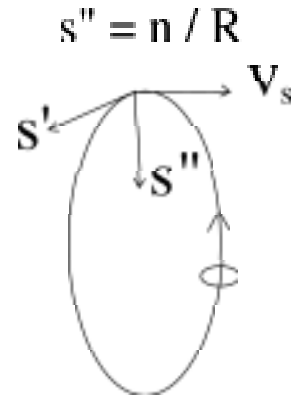
$$\bar{\mathcal{N}} = \frac{4}{3}\pi R_B^3 \int_{2\xi_f}^{2R_B} \bar{n}(\mathcal{D})d\mathcal{D} = \frac{\pi C}{9} \left[\frac{R_B^3}{\xi_f^3} - 1 \right] \simeq \frac{\pi C}{9} \frac{R_B^3}{\xi_f^3}$$

longueur de ligne

$$\mathcal{L} = \frac{4}{3}\pi R_B^3 \int_{2\xi_f}^{2R_B} \pi \mathcal{D} \bar{n}(\mathcal{D})d\mathcal{D} = R_B \frac{\pi^2 C}{3} \left[\frac{R_B^2}{\xi_f^2} - 1 \right]$$

densité de ligne

$$L \simeq \frac{1}{\xi_f^2} \quad (\text{m}/\text{m}^3)$$



$$v_L = v_s + \alpha \mathbf{s}' \times (V_n - v_s)$$

$$v_s = \beta \mathbf{s}' \times \mathbf{s}'' \quad \text{vitesse au coeur} \quad \left(\beta = \frac{\kappa}{4\pi} \ln \frac{R}{\xi(T)} \right)$$

$$\alpha = \frac{B\rho_n}{2\rho} \quad \text{friction mutuelle} \quad (\rho_n \propto \exp -\Delta/kT)$$

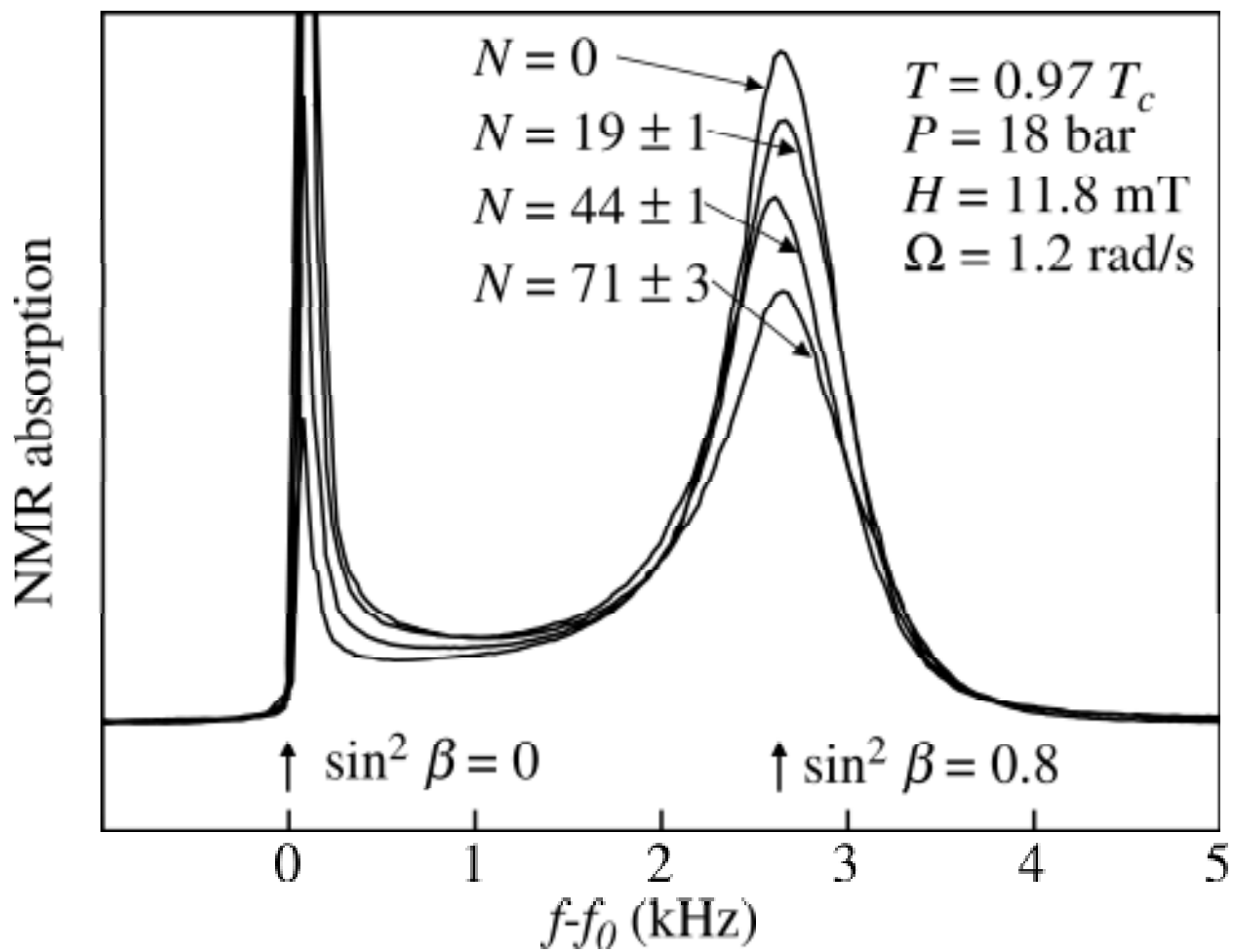
en rotation V_n sélectionne un r_0 tel que

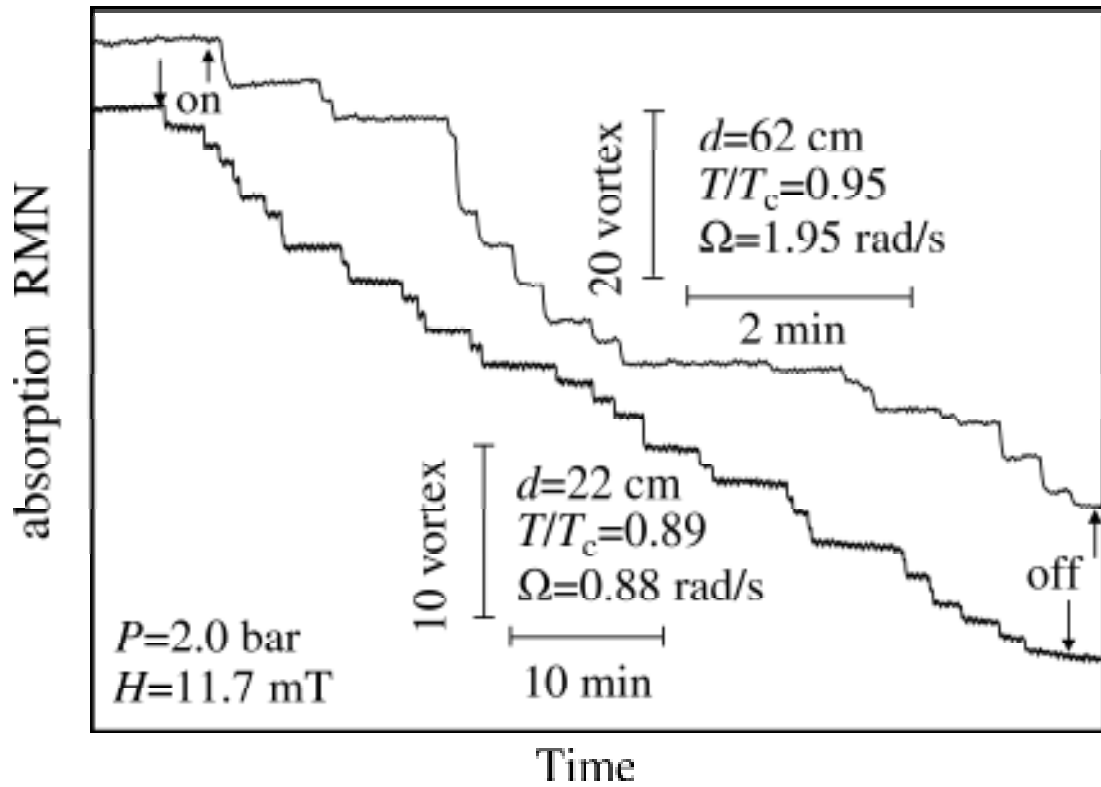
$$R \searrow \text{ pour } R < r_0 \quad \text{et} \quad R \nearrow \text{ pour } R > r_0 = \beta/V_n$$

$$L \simeq \frac{1}{\xi_f^2} \quad (R \sim L^{-1/2}) \quad dL/dt = \alpha (V_n L^{3/2} - \beta L^2)$$

$$V_n = 0 \quad (\text{déclin libre}) \quad \frac{1}{L} = \frac{1}{L_0} - \alpha\beta t$$

$$\tau_L = (L_0\alpha\beta)^{-1} \sim 10^3 - 10^{-5} \text{ s} \gg \tau_q$$





nombre moyen d'événements / min

$$\overline{\dot{N}_e} = 0 - \dot{N}_n (\leq 20/\text{min})$$

taux de nucléation de vortex

$$\overline{\dot{N}_v}$$

seuil de nucléation

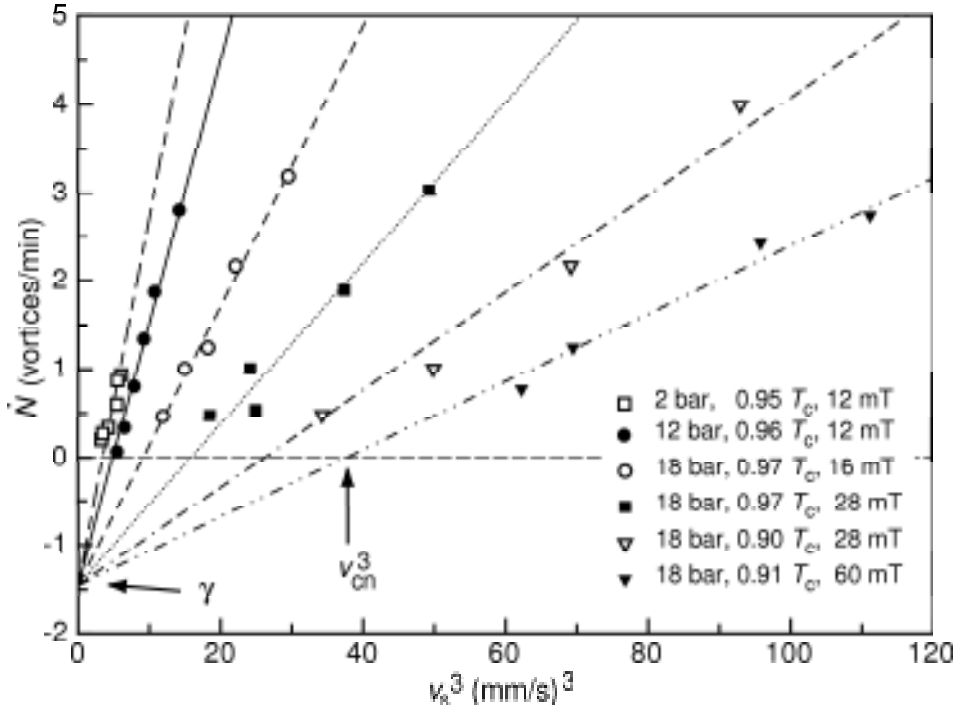
$$V_{cn}(P, T, H)$$

nombre moyen de vortex / événement

$$\overline{\mathcal{N}} = \overline{N_v / N_e}$$

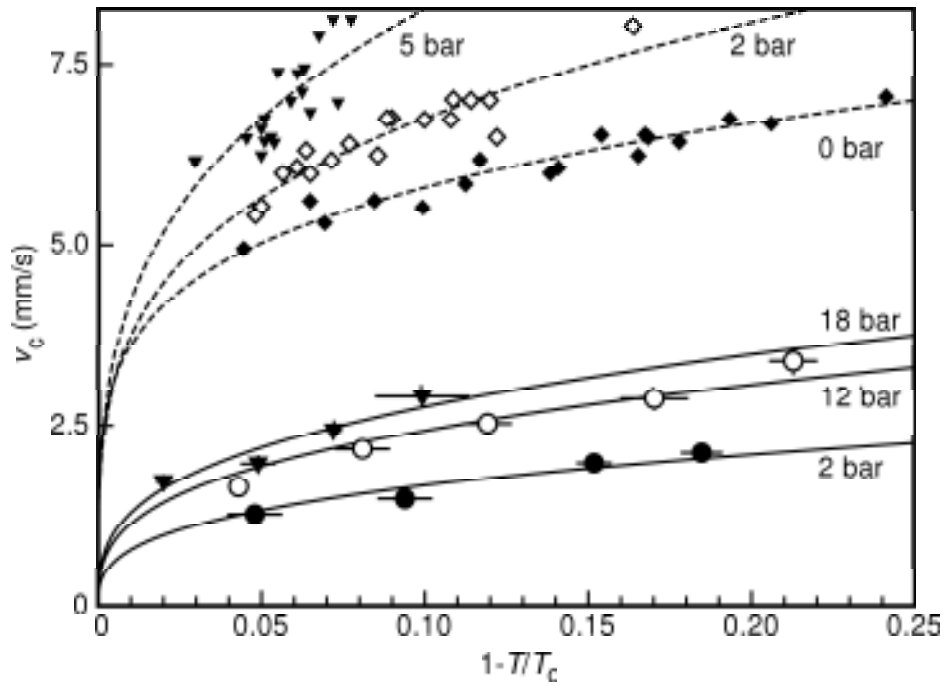
distributions

$$\mathcal{D}(\mathcal{N})$$



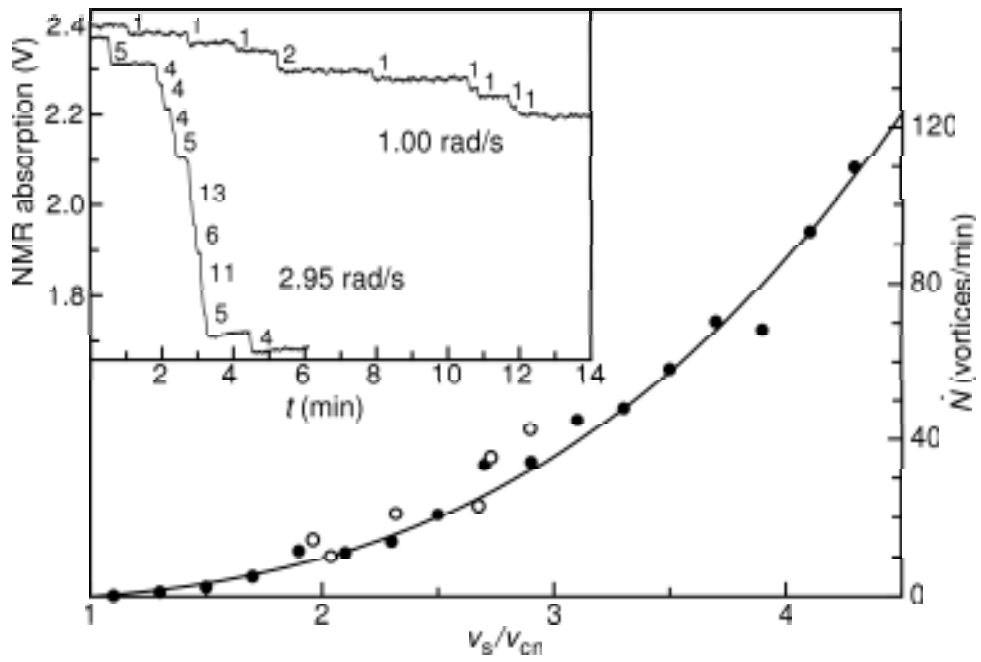
$$\mathcal{N}(V_s) = V_b \int_{2r_o}^{2R_b} d\mathcal{D} n(\mathcal{D}) = \frac{\pi C}{9} \left[\left(\frac{R_b}{r_o} \right)^3 - 1 \right] \quad (n(\mathcal{D}) = 2C/\mathcal{D}^4)$$

$$\dot{N}_v = \gamma \left[\left(\frac{V_s}{V_{cn}} \right)^3 - 1 \right] \quad (\gamma = \dot{N}_n \pi C / 9)$$

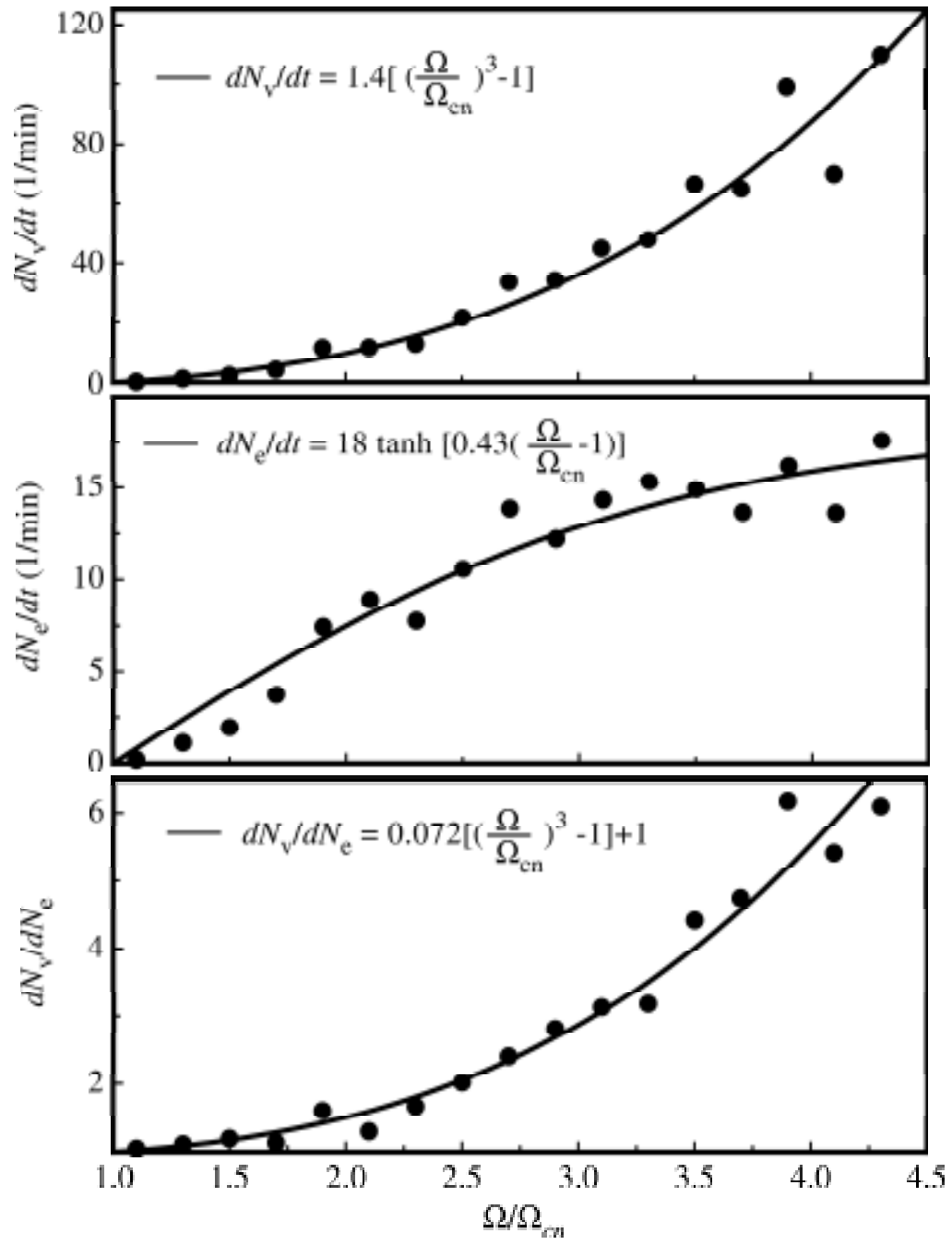


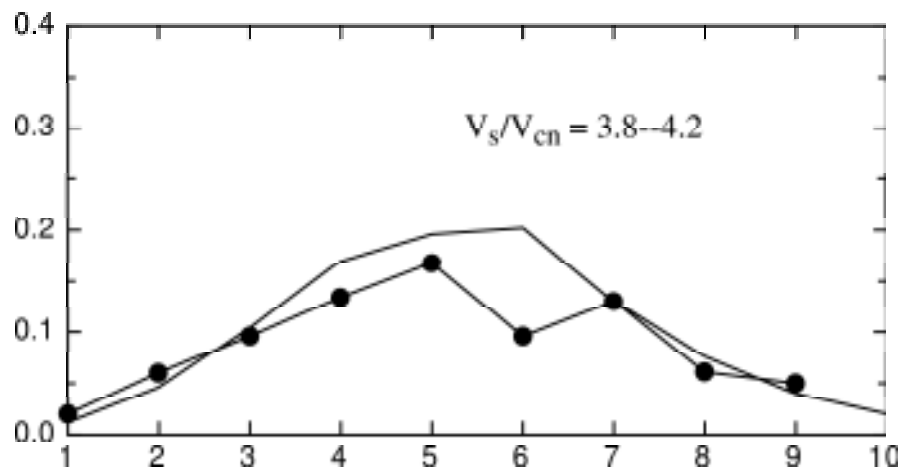
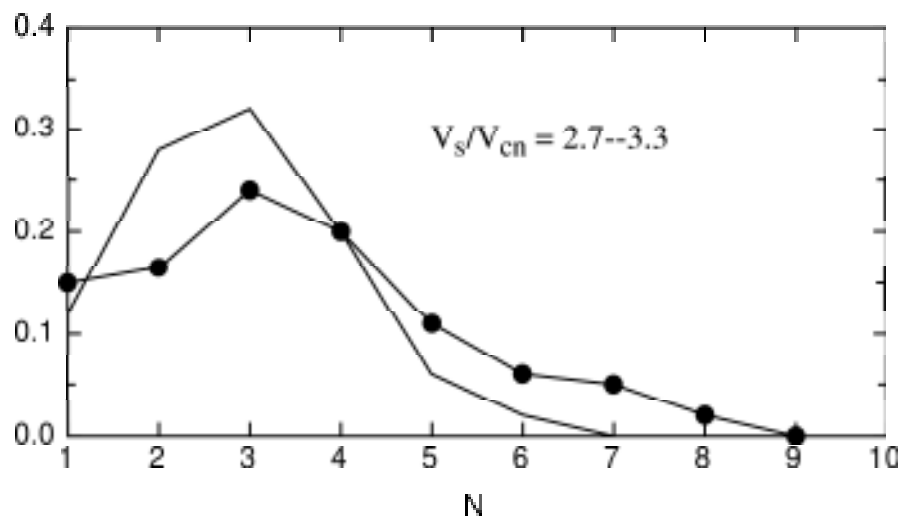
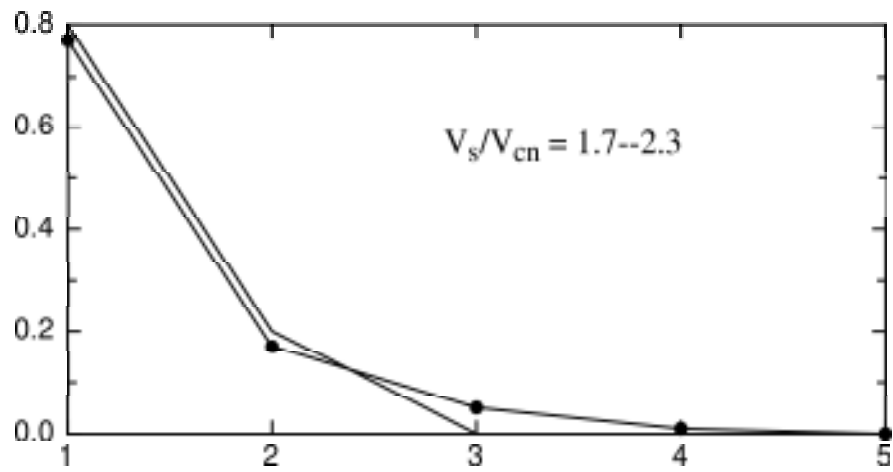
sous irradiation $V_{cn} \approx \kappa / (4\pi R_b) \ln(R_b/\xi) \propto (1 - T/T_c)^{1/3}$

rayon de la boule normale $R_b \simeq 0.4 \left(\frac{E_0}{C_V T_c} \right)^{1/3} (1 - T_0/T_c)^{-1/3}$

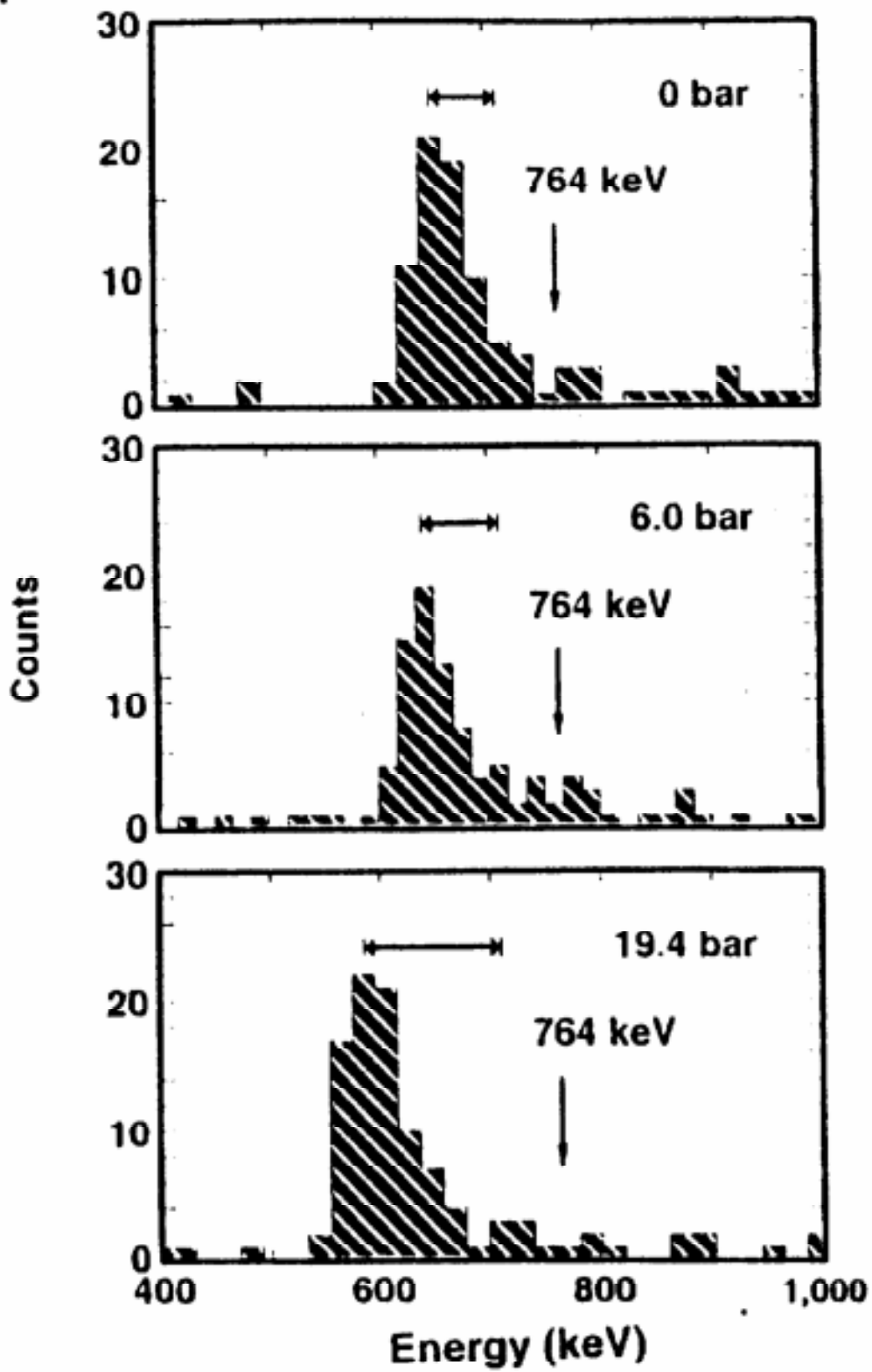


$$\dot{N}_v = \gamma \left[\left(\frac{V_s}{V_{cn}} \right)^3 - 1 \right] \quad (\gamma = \dot{N}_n \pi C / 9)$$





Distribution du nombre de vortex par événement



$$S = S_0 \exp -BdL$$

$$1/L = Bd / \ln(S_0/S) = 1/L_0 - \alpha\beta t$$

$$10^{13} < L_0 < \infty \text{ (m/m}^3\text{)}$$

GRENOBLE-LANCASTER

C. Bauerle

S. Fisher

G. Pickett

Yu. Bunkov

H. Godfrin

Hyvää Joulua