$\boxed{4.2}$

$\uparrow \downarrow \uparrow$

$\downarrow \uparrow \downarrow$ B

A $\uparrow \downarrow \uparrow$

$$\hat{H} = \sum_{\langle i j \rangle} \bar{S}_i \bar{S}_j + \mu_B B g$$

E ; $|\uparrow\rangle \to E_\uparrow = zJ \langle S \rangle \frac{1}{2}$ $\quad |\downarrow\rangle : E_\downarrow = -zJ\langle S \rangle \frac{1}{2}$

$$\langle S_A \rangle = \frac{1}{2} \frac{e^{-\beta z J \frac{1}{2}\langle S_B \rangle} - e^{\beta J \langle S_B \rangle \frac{1}{2} z}}{e^{-\beta z J \langle S_B \rangle \frac{1}{2}} + e^{\beta z J \langle S_B \rangle \frac{1}{2}}}$$

$$\langle S_B \rangle = \frac{1}{2} \frac{e^{-\beta z J \frac{1}{2}\langle S_A \rangle} - e^{\beta J \langle S_A \rangle \frac{1}{2} z}}{e^{-\beta z J \langle S_A \rangle \frac{1}{2}} + e^{-\beta z J \langle S_B \rangle \frac{1}{2}}}$$

$\langle S_A \rangle$; $\frac{1}{2} \tanh\left(\frac{zJ\langle S_B \rangle}{2k_B T}\right)$ $\qquad$ $\langle S_B \rangle$; $\frac{1}{2} \tanh\left(\frac{zJ\langle S_A \rangle}{2k_B T}\right)$

$2\langle S_A \rangle = x_A$ $\qquad$ $2\langle S_B \rangle = x_B$

$x_A = \tanh(\xi x_B)$ $\qquad$ $x_B = \tanh(-\xi x_A)$

$\underline{x = x_A = -x_B = \tanh(\xi x)}$ $\to$ bez pole

$\xi = \frac{zJ}{4k_B T}$; $\underset{z=4}{T = T_N}$ $\to$ $\xi_N = 1 = \frac{zJ}{4k_B T_N}$

$k_B T_N = J$

$$\underline{\underline{T_N = J/k_B}}$$

$\underline{\to \text{ polem}}$

$\eta = \frac{2 g \mu_B B}{zJ}$ $\qquad$ $x_A = -\tanh(\xi(x_A + \eta))$

$B \parallel z$; $\langle S \rangle \parallel z$

$T > T_N$; $x_A = x_B = -m$

$$\underline{\underline{\chi = \frac{M}{B} \sim \frac{T_N/T}{T_N/T + 1} = \frac{1}{T + T_N}}}$$

$T < T_N$: $x_A = x - m$

$x_B = -x - m$

$x_A = -\tanh(\xi x + \xi(\eta - m)) \doteq -\tanh(\xi x) - \frac{1}{\cos^2(\xi x)} \xi(\eta - m)$

$x_B = \tanh(\xi x) + \frac{1}{\cos^2(\xi x)} \xi(\eta - m)$

$$\eta = \frac{2g\mu_B B}{zJ} \qquad x_A = -\tanh \xi (x_A + \eta)$$
$$x_B = \tanh \xi (x_B + \eta)$$

$B \parallel z$

$T > T_N \quad x_A = x_B = -m$

$$\tanh(\xi(x_A + \eta)) \sim \xi(-m + \eta) = -\xi m + \xi \frac{2g\mu_B B}{zJ}$$

$$-m = x_A \simeq -\xi(-m + \eta)$$
$$-m = x_B \simeq -\xi(-m + \eta)$$

$$m + \xi m = \xi \eta$$

$$m = \frac{\xi \eta}{(\xi + 1)} = \frac{2g\mu_B B \, T_N/T}{zJ(T_N/T + 1)}$$

$$\chi = \frac{m}{B} = \frac{2g\mu_B \, T_N/T}{zJ(T_N/T + 1)}$$

$T < T_N \quad x_A = x - m = -\tanh(\xi x + \xi \eta - \xi m) = -\tanh(\xi x) - \frac{\xi(\eta - m)}{\cos^2(\xi x)}$

$x_B = -x - m = \tanh(\xi x + \xi \eta - \xi m) = \tanh(\xi x) + \frac{\xi(\eta - m)}{\cos^2(\xi x)}$

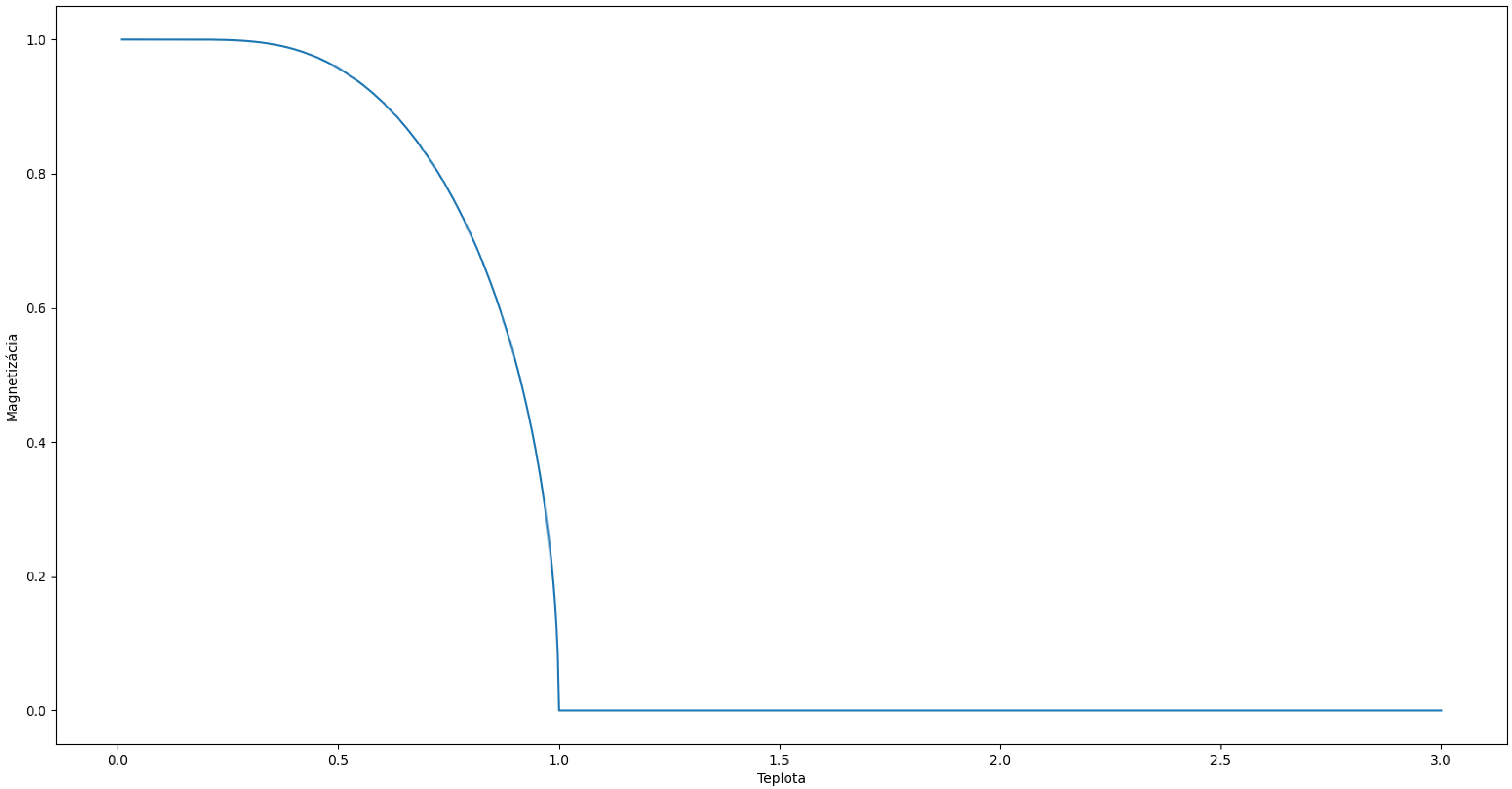
$\tanh x \sim x$

$\cos^2 x \sim 1$

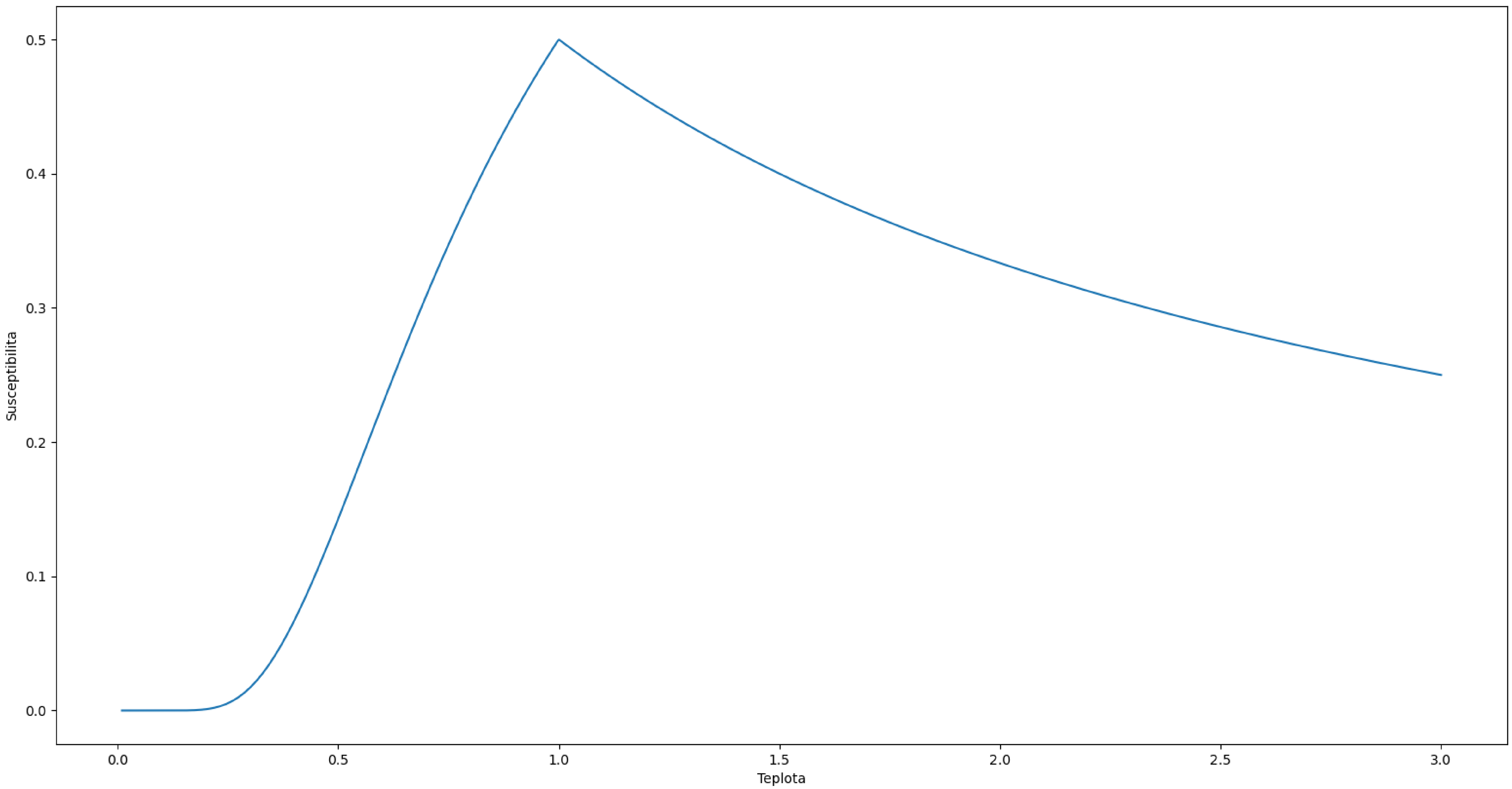
$$\frac{m}{\xi} + m - mx^2 = \eta - \eta x^2$$

$$m = \eta \frac{1 - x^2}{\xi^{-1} + 1 - x^2}$$

$$\chi = \frac{m}{B} = \frac{2\mu_B g}{zJ} \frac{(1 - x^2)}{\frac{T}{T_N} + 1 - x^2}$$



1.0
0.8
0.6
0.4
0.2
0.0
Magnetizácia
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Teplota



Susceptibilita
Teplota
0.0
0.1
0.2
0.3
0.4
0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0