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Reentrant superconductivity in proximity to a topological insulator

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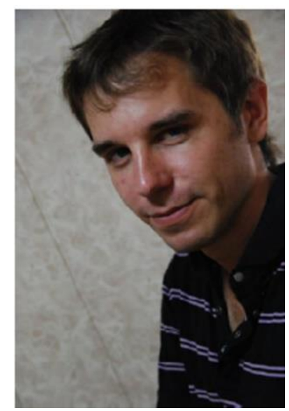
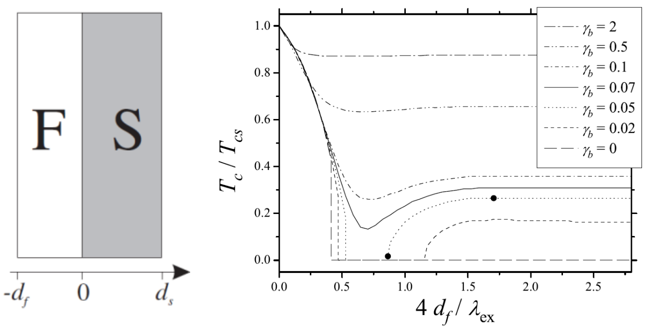
Reentrant superconductivity in proximity to a topological insulator

T. Karabassov,[1] A. A. Golubov,[2,3] V. M. Silkin,[4,5,6] V. S. Stolyarov,[3,7] and A. S. Vasenko[1,8,*]

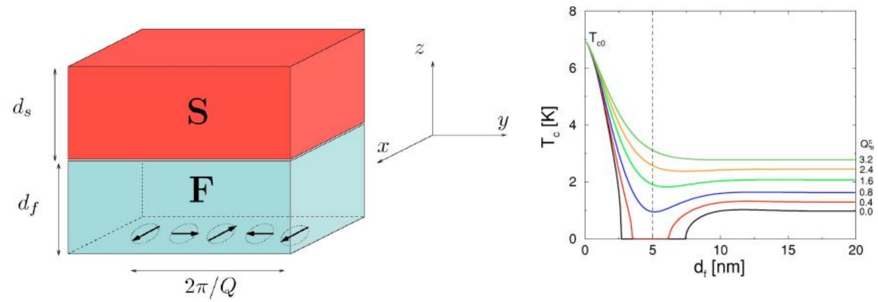


Critical temperature in S/F systems

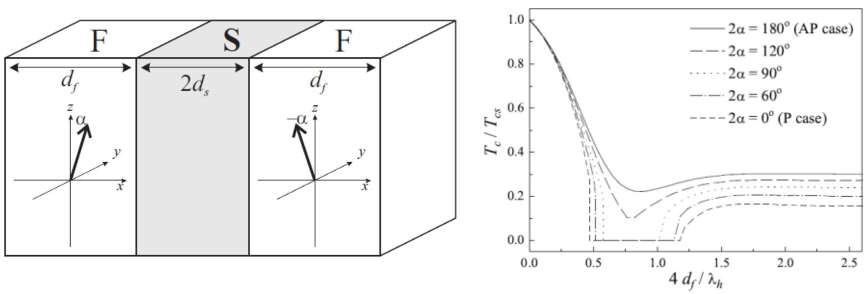


Khusainov, Proshin, PRB 56, 1997

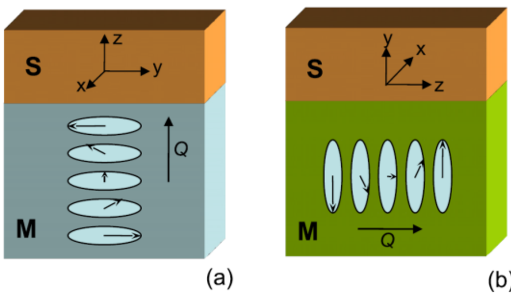
Fominov et al, PRB,2002



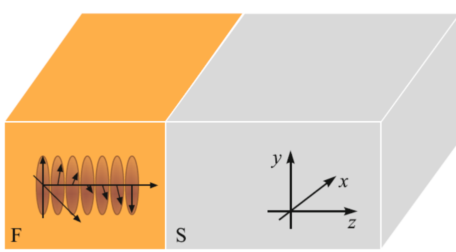
Champel, Eschrig, PRB,2005



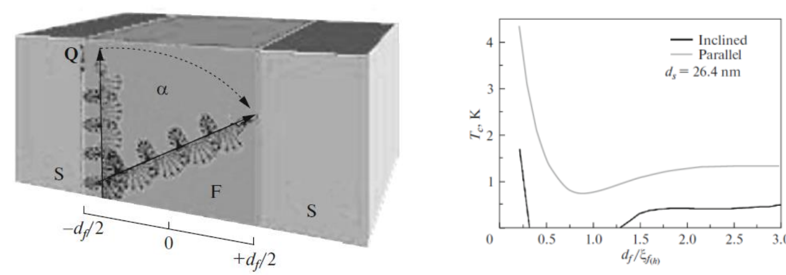
Fominov et al., JETP Lett, 2003



Pugach et al., APL, 2017

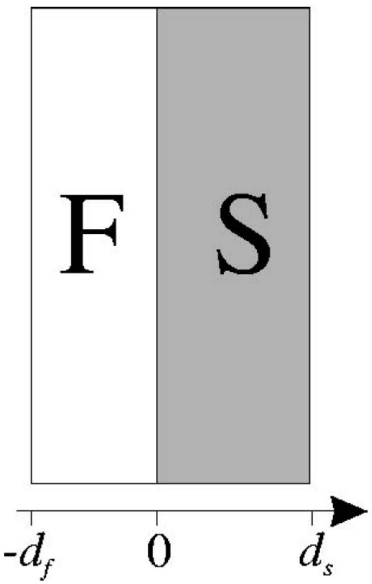


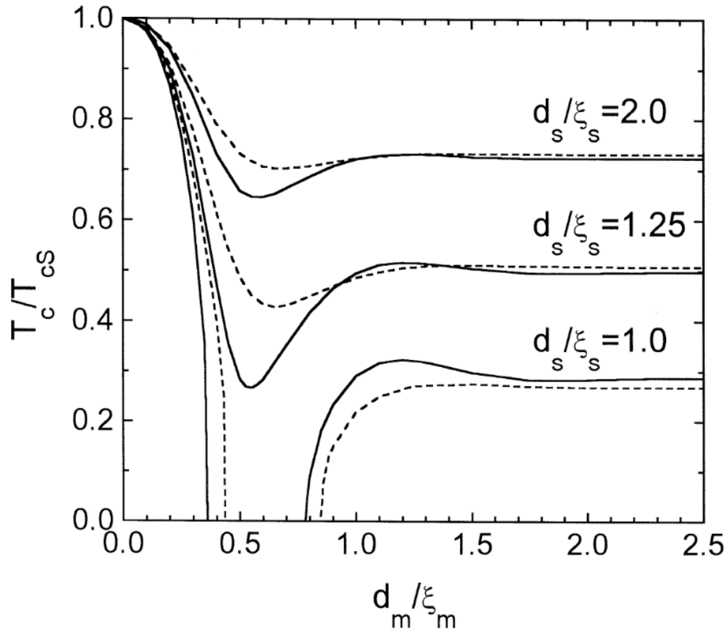
Pugach, Safonchik, JETP Lett, 2018



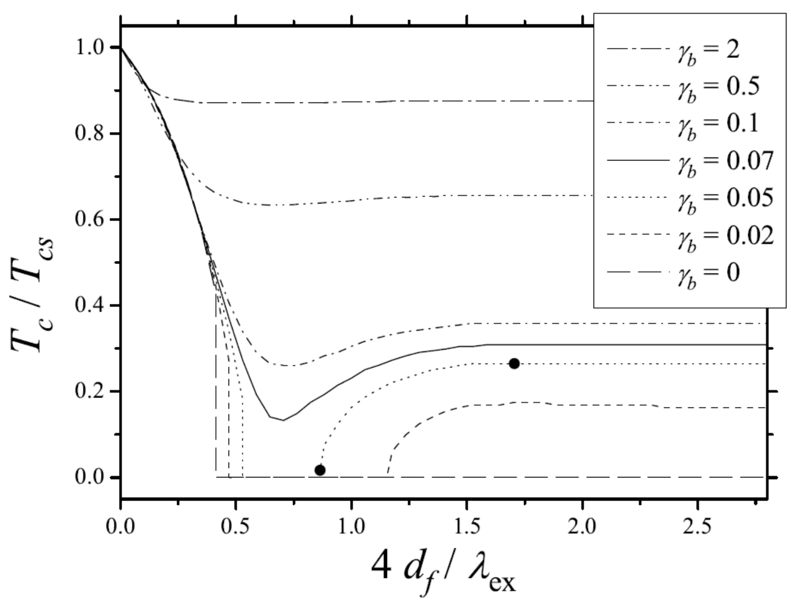
Pugach et al., Phys. Solid State, 2018

Critical temperature in S/F bilayers



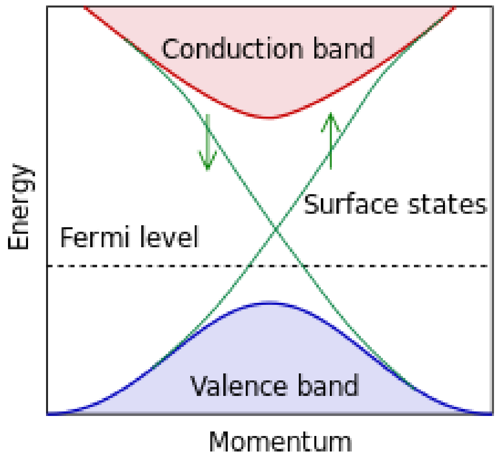


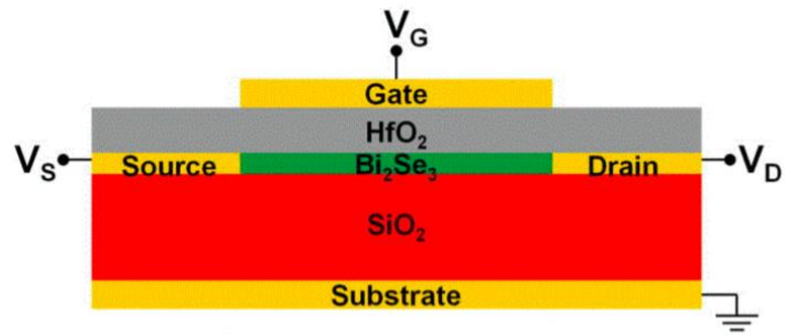
Khusainov, Proshin, PRB **56**, R14283(R) (1997)



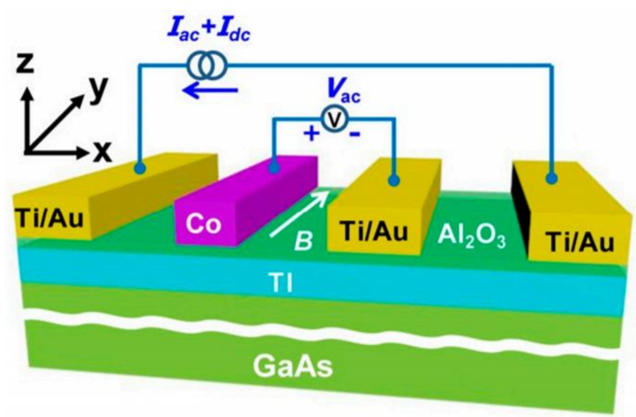
Fominov, Chtchelkatchev, Golubov, PRB **66**, 014507 (2002)

Topological insulators

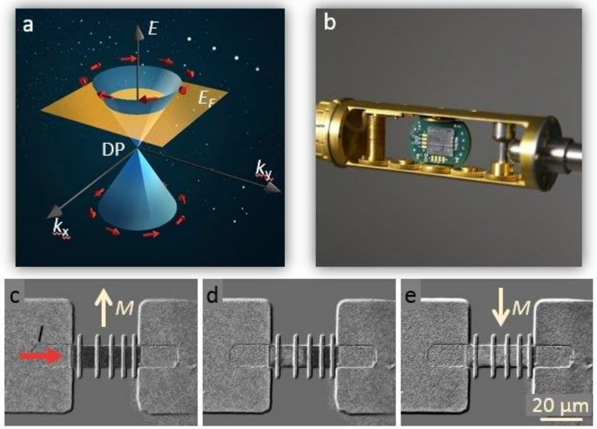




Chang et al. J. Appl. Phys., **112**, 124511 (2012)
Field-effect Transistor



Tang et al. Nano Lett., **14**, 5423 (2014)
Detector of Spin-Polarized Surface States

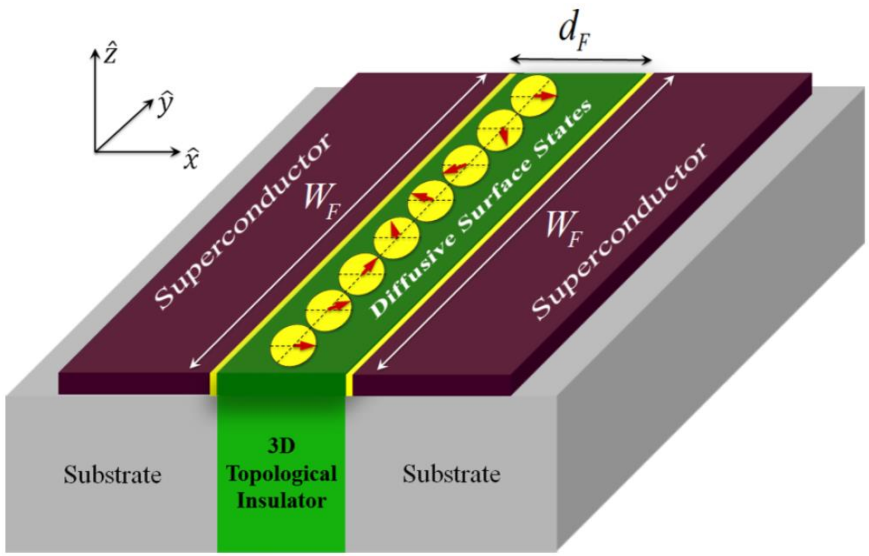


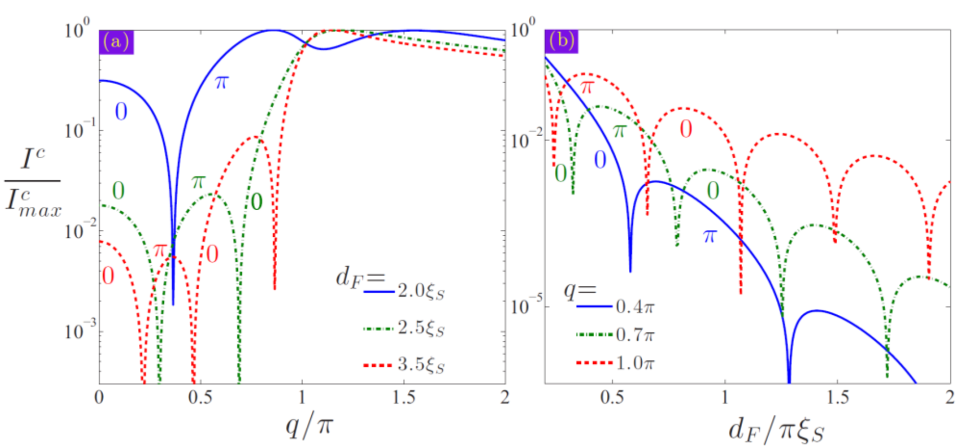
Wang et al., Nat. Commun. **8,** 1364 (2017)
Spin-Orbit Torques for Spintronic applications

PHYSICAL REVIEW B **93**, 214502 (2016)

Josephson junction through a disordered topological insulator with helical magnetization

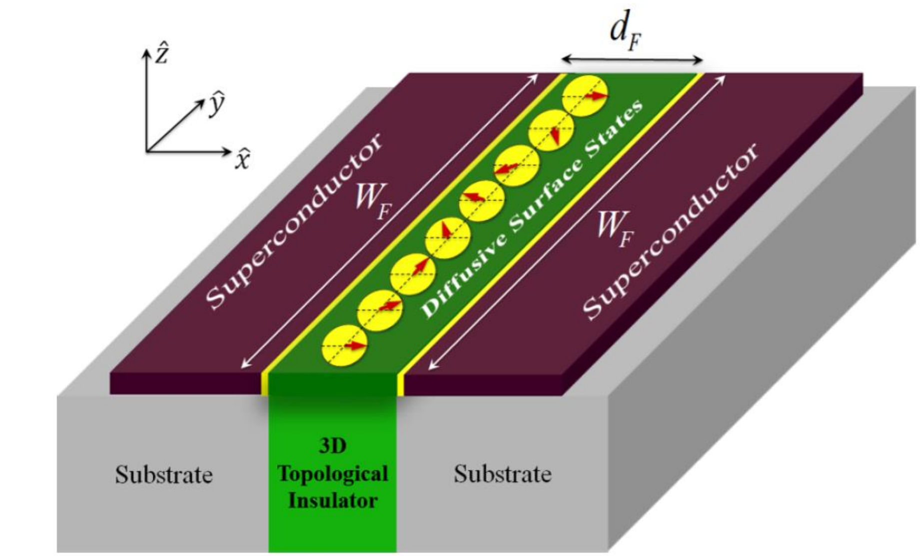
Alexander Zyuzin, Mohammad Alidoust, and Daniel Loss
Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland

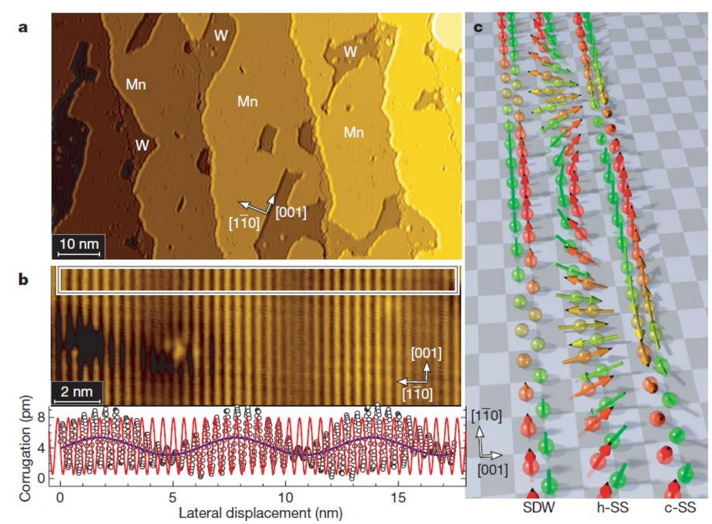


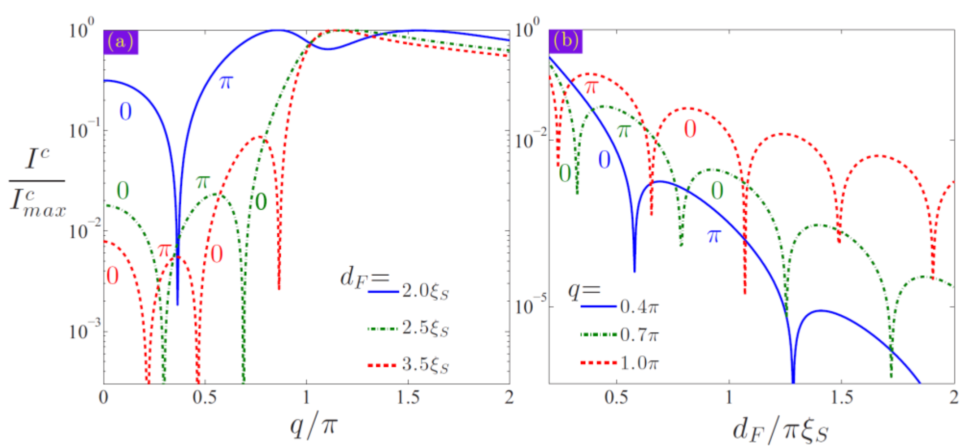


Chiral magnetic order at surfaces driven by inversion asymmetry

M. Bode[1]†, M. Heide[2], K. von Bergmann[1], P. Ferriani[1], S. Heinze[1], G. Bihlmayer[2], A. Kubetzka[1], O. Pietzsch[1], S. Blügel[2] & R. Wiesendanger[1]





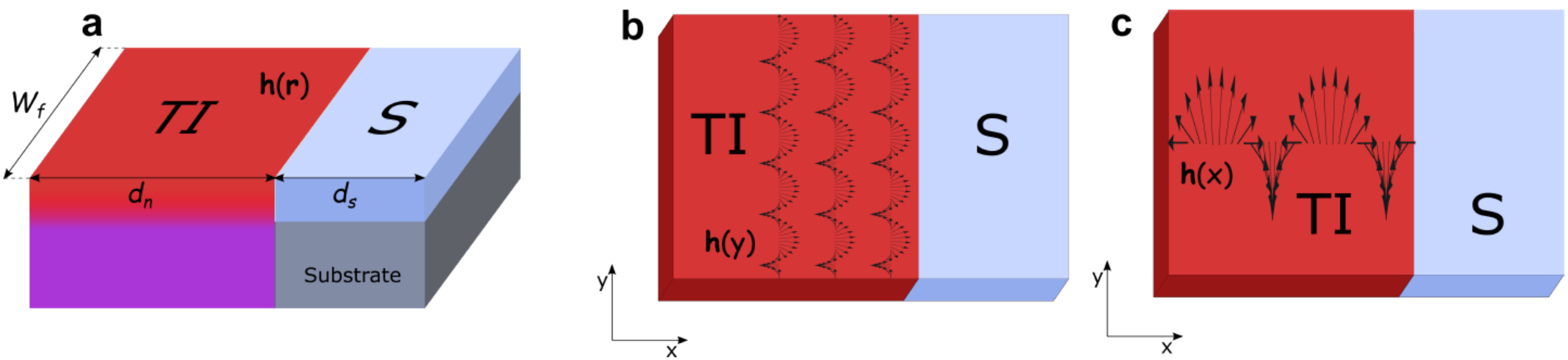


manganese on a tungsten substrate

Bode et al., Nature, **447**, 191 (2007)

Our model

Superconductor/Topological insulator with induced magnetization



Helical magnetization
***h** in x-y plane*

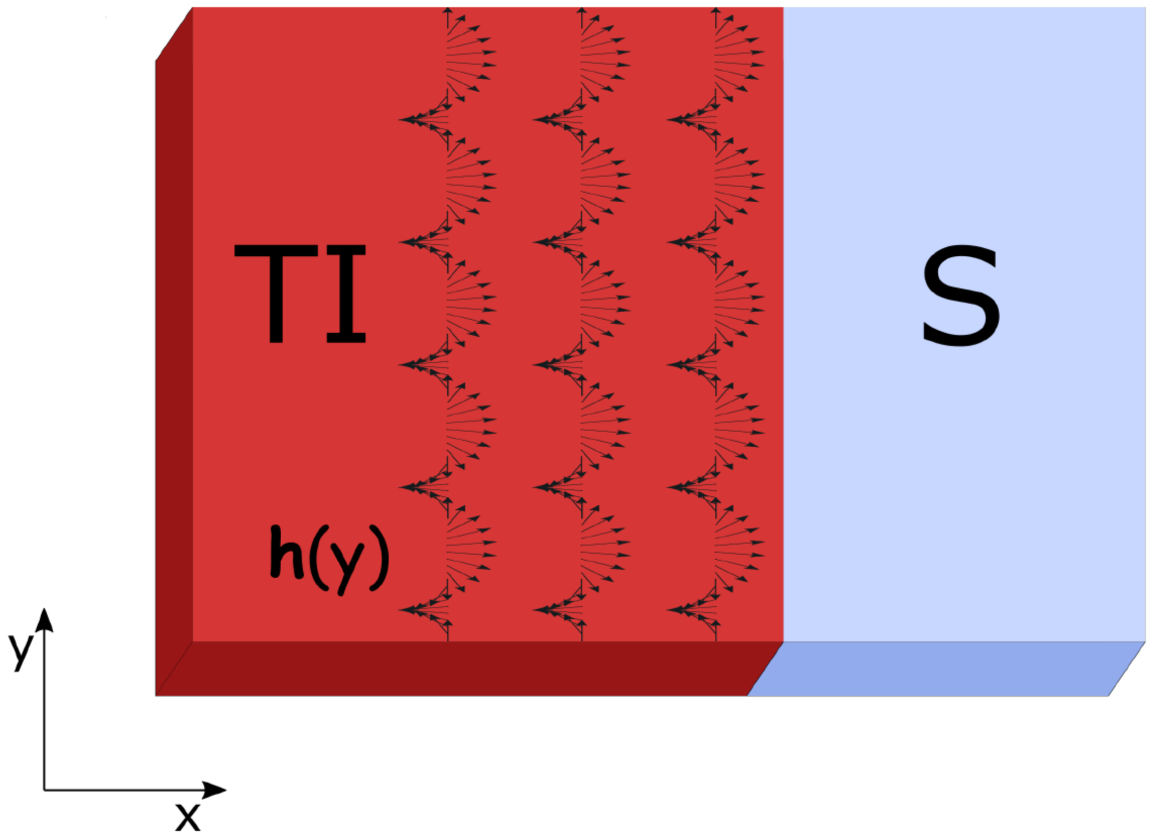
$$\mathbf{h}(y) = h_0(\cos Qy, \sin Qy, 0) \quad (1)$$

$$\mathbf{h}(x) = h_0(\cos Qx, \sin Qx, 0) \quad (2)$$

$$Q = \frac{2\pi}{\lambda}$$

Helical magnetization h(y)

$$\mathbf{h}(y) = h_0(\cos Qy, \sin Qy, 0)$$



$$Q >> 1$$

Theoretical model

A. Zyuzin, M. Alidoust, and D. Loss, PRB, 2016

$$\xi_s^2 \pi T_{cs}\left(\frac{d^2}{dx^2}+\frac{d^2}{dy^2}\right) f_s - |\omega_n| f_s + \Delta = 0$$

$$\Delta \ln\frac{T_{cs}}{T} = \pi T \sum_{\omega_n}\left(\frac{\Delta}{|\omega_n|} - f_s\right)$$

$$\left(\frac{\partial}{\partial x} - \frac{2i}{\alpha} h_y(y)\right)^2 f_T + \left(\frac{\partial}{\partial y}+\frac{2i}{\alpha}h_x(y)\right)^2 f_T = \frac{|\omega_n|}{\xi_n^2 \pi T_{cs}} f_T$$

$$2\gamma \hat{g}_s \mathbf{n}\cdot\hat{\boldsymbol{\nabla}}\hat{g}_s = [\hat{g}_s, \hat{g}_{\mathrm{SC}}]$$

S | TI

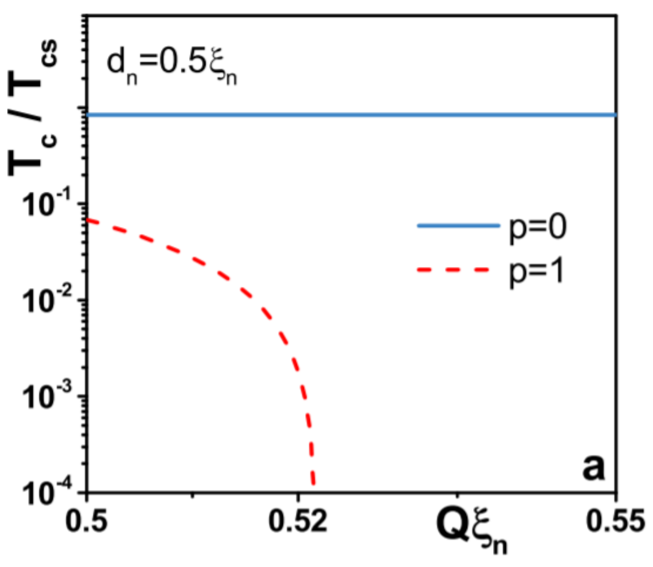
Theoretical model

$$f_T(x,y) = \sum_{p=-\infty}^{+\infty} f_T^{(p)}(x) e^{ipQy}$$

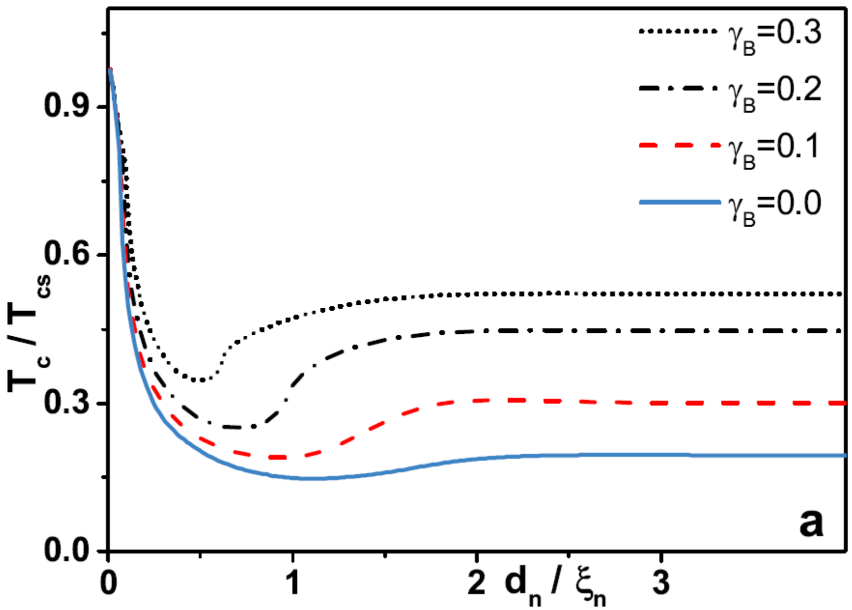
$$f_s(x,y) = \sum_{p=-\infty}^{+\infty} f_s^{(p)}(x) e^{ipQy}$$

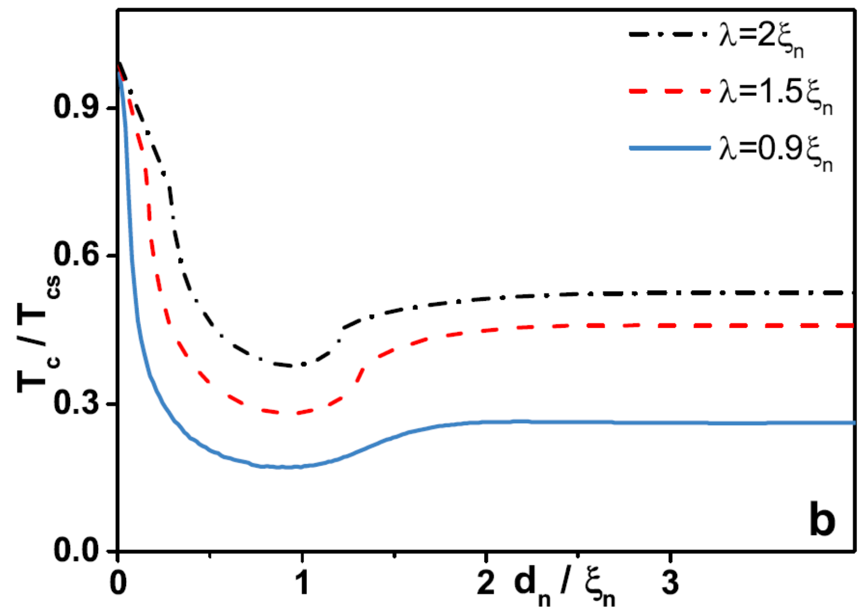
$$\Delta(x,y) = \sum_{p=-\infty}^{+\infty} \Delta^{(p)}(x) e^{ipQy}$$

$$Q >> 1$$



Helical magnetization h(y)

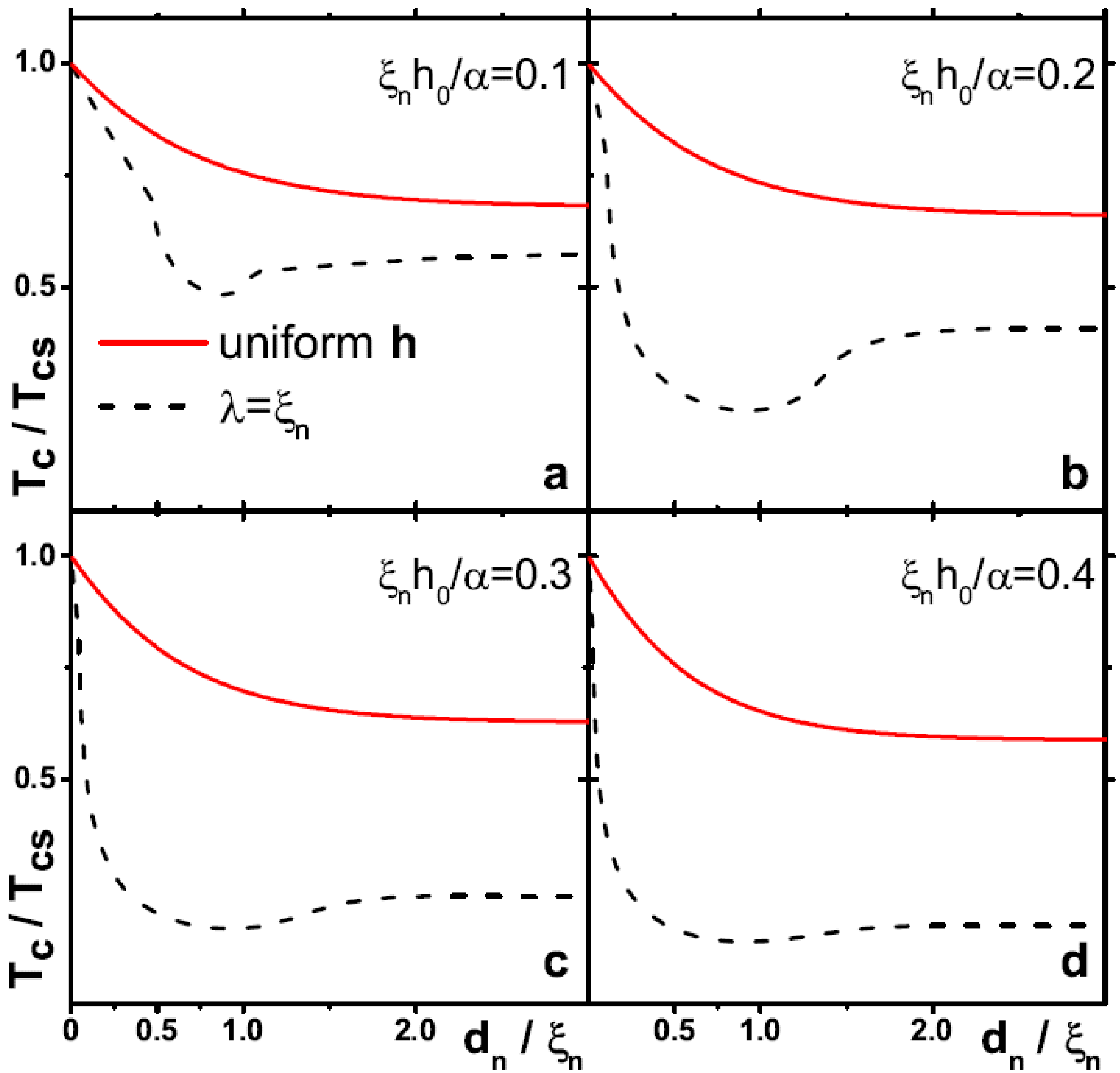




$$\gamma_B = R_b \sigma_n / \xi_n$$

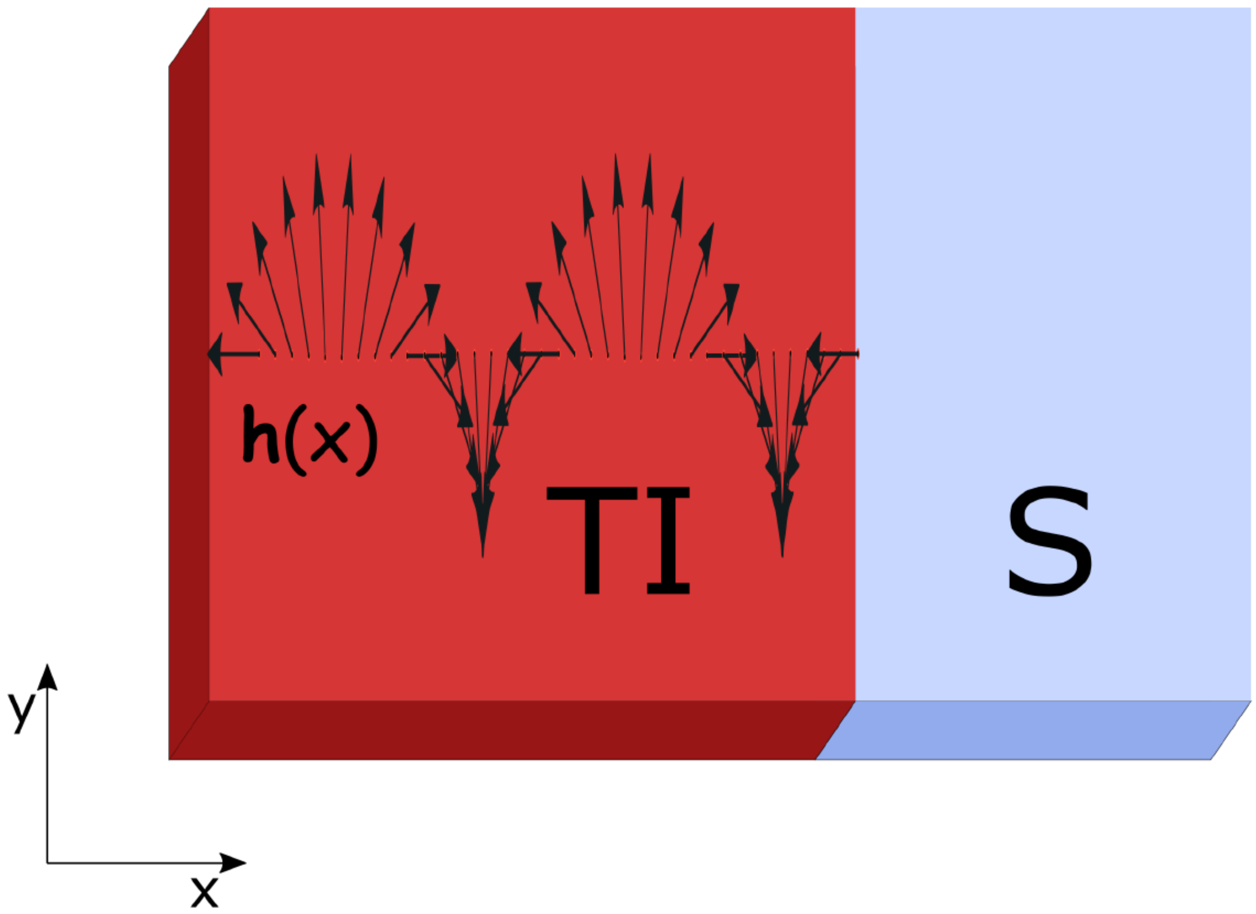
$$Q = \frac{2\pi}{\lambda}$$

Comparison with uniform exchange field



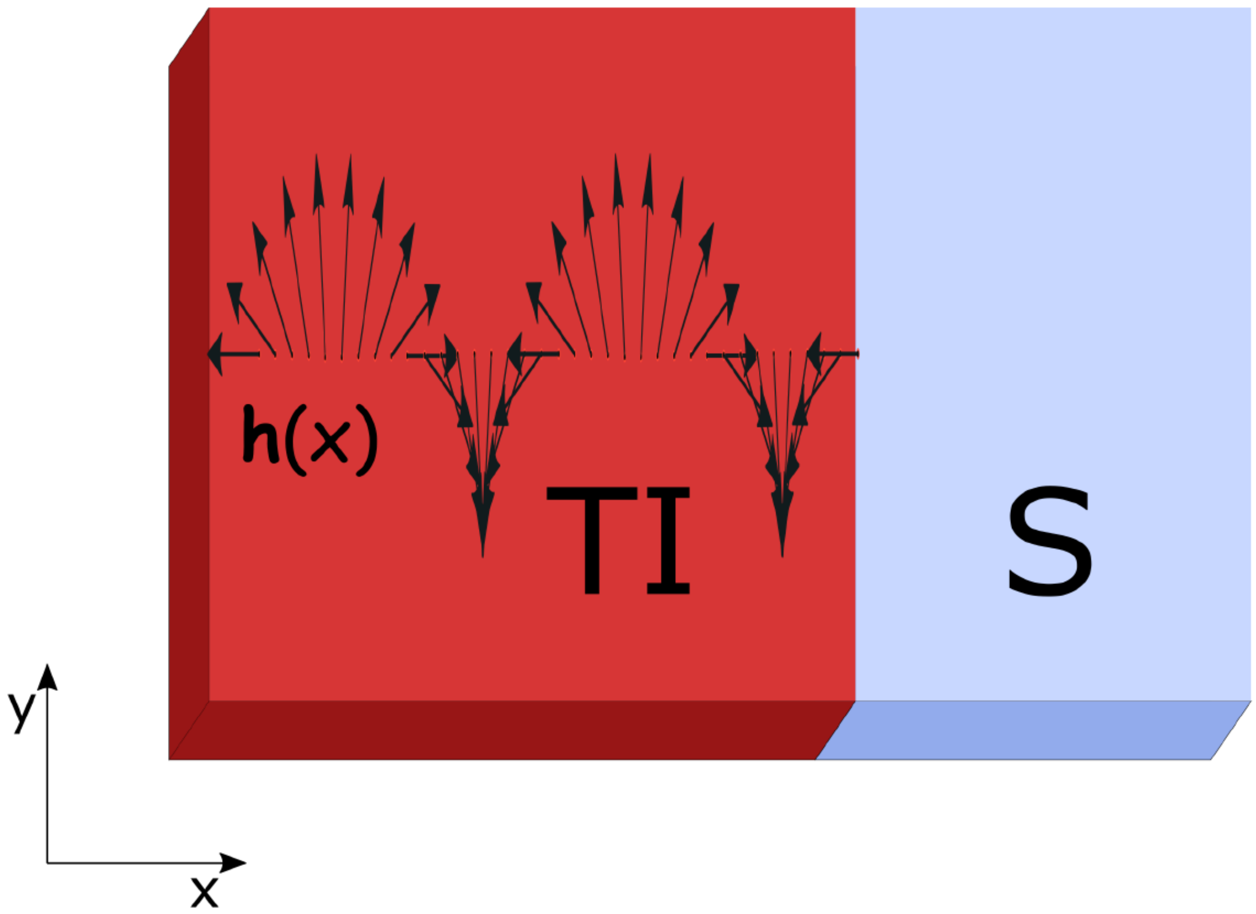
Helical magnetization h(x)

$$\mathbf{h}(x) = h_0(\cos Qx, \sin Qx, 0)$$



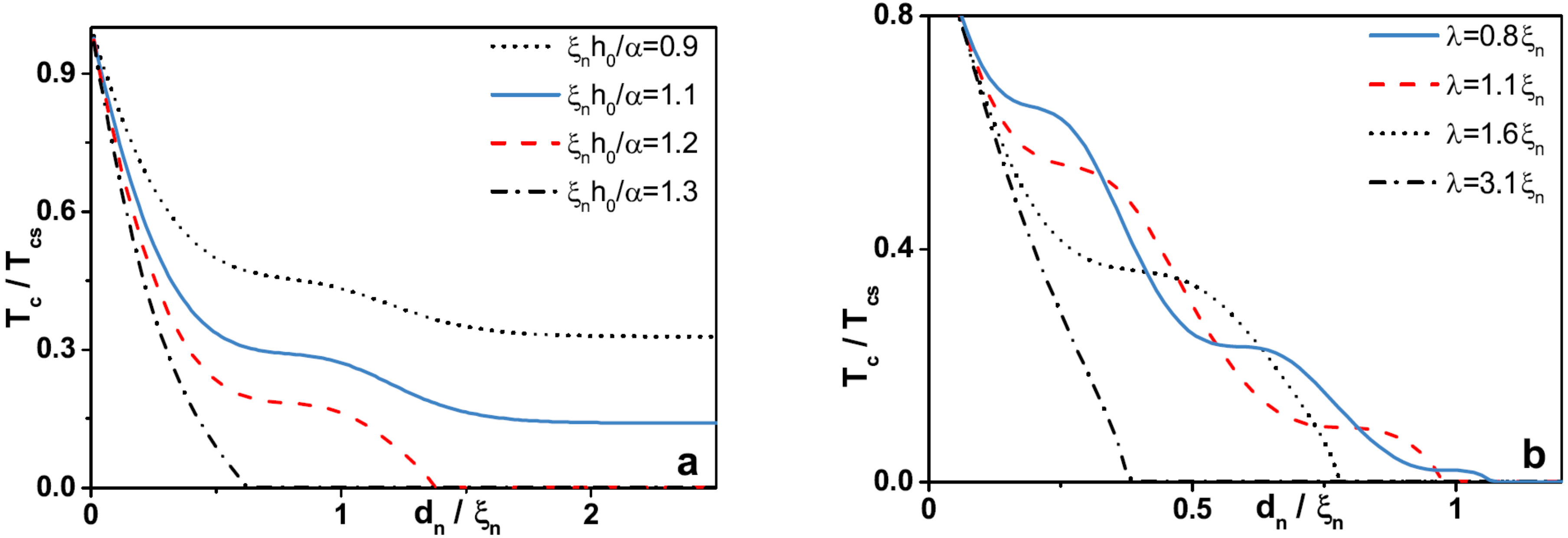
Helical magnetization h(x)

$$\mathbf{h}(x) = h_0(\cos(Qx + \phi_0), \sin(Qx + \phi_0), 0)$$



Helical magnetization h(x)

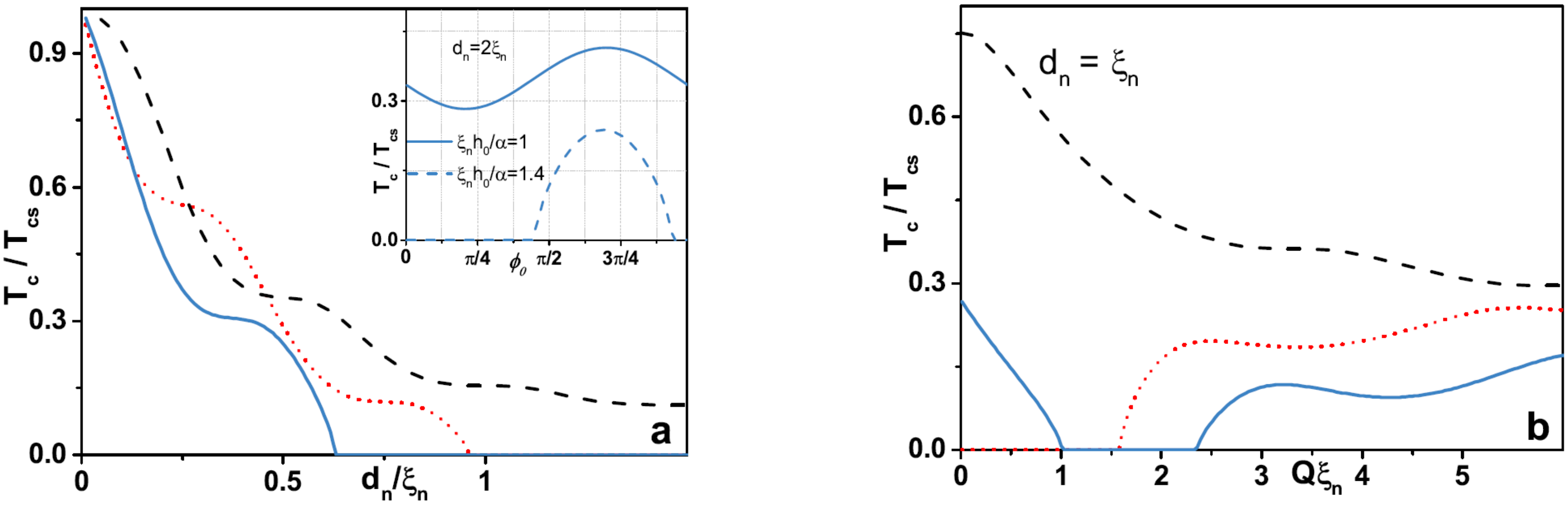
$$\mathbf{h}(x) = h_0(\cos(Qx + \phi_0), \sin(Qx + \phi_0), 0)$$



$\phi_0=0$

Helical magnetization h(x)

$$\mathbf{h}(x) = h_0(\cos(Qx + \phi_0), \sin(Qx + \phi_0), 0)$$



$\phi_0=0$, $\phi_0=\pi/4$, $\phi_0=\pi/2$

Summary

- A model for calculating the critical temperature in the S / TI hybrid structure has been developed;
- We found monotonic dependence of T_c for uniformly magnetized TI;
- Non-monotonic behavior of T_c for helical magnetization pattern was revealed.

Thank you!