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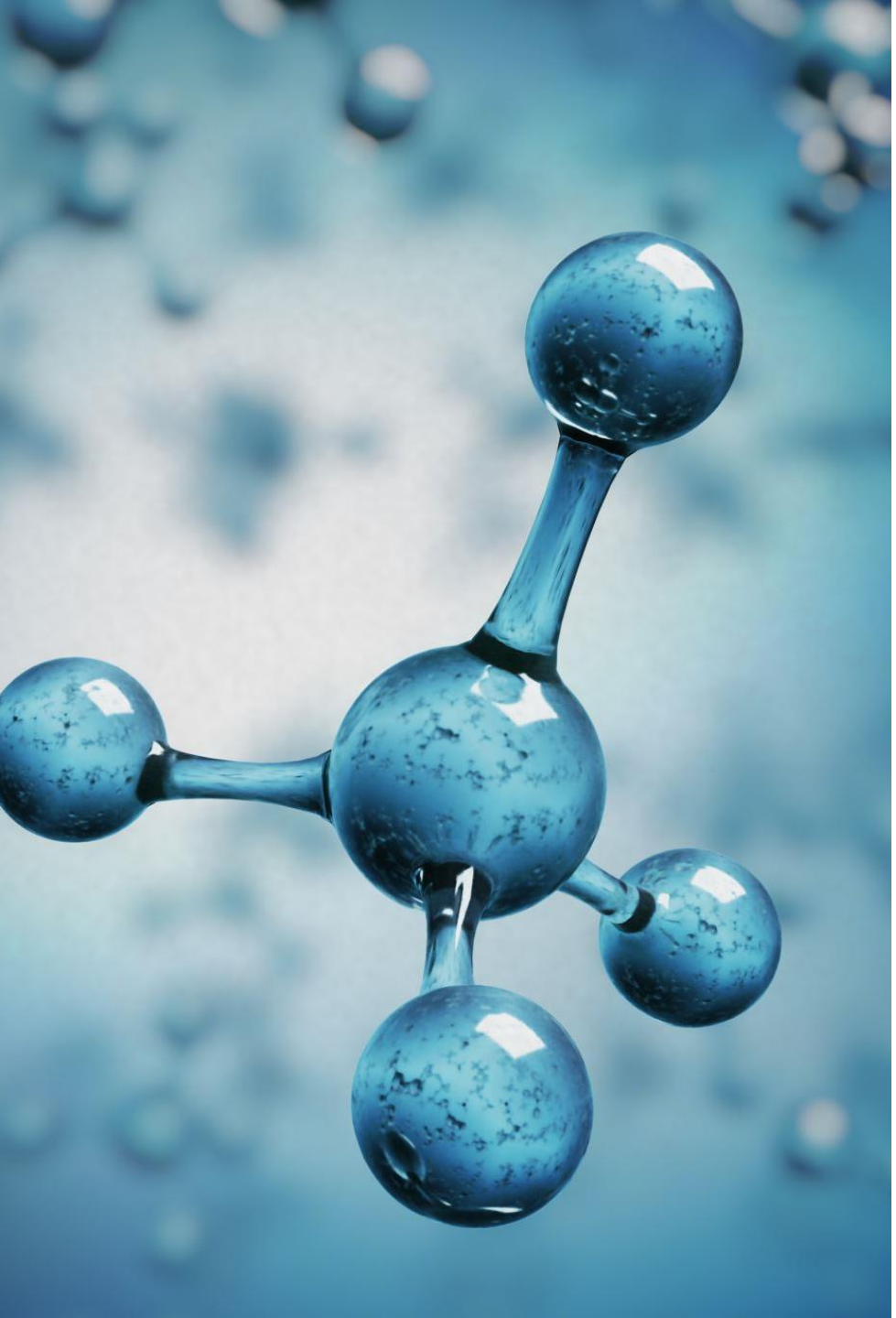
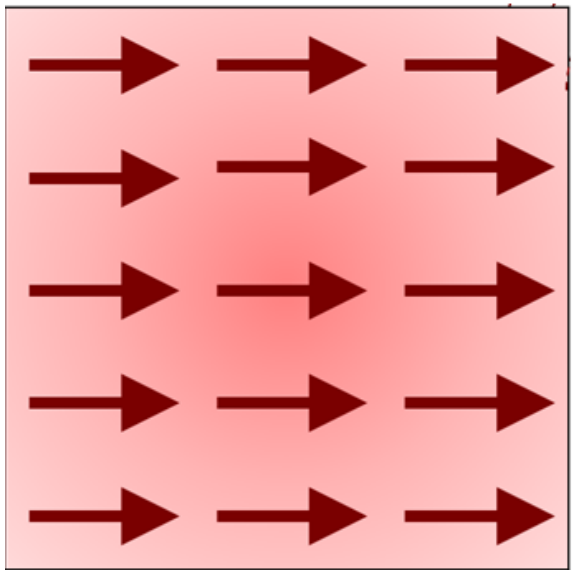
The effect of interfacial morphology on the magnetic and magnetocaloric properties of ferromagnetic nanoparticles with core-shell geometry: A Monte Carlo Study



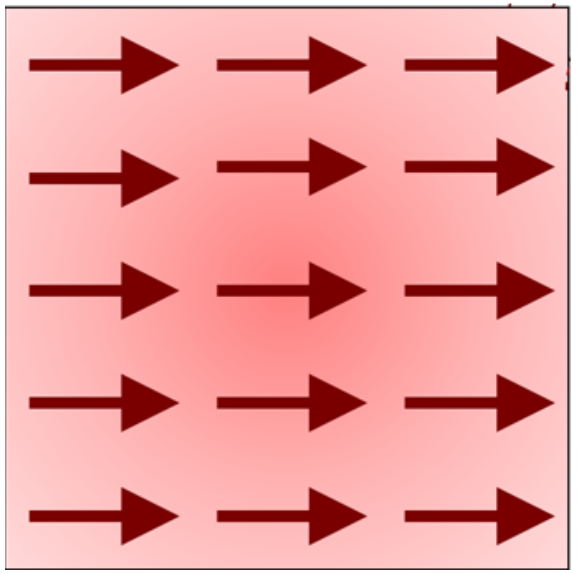
Outline

- Magnetic refrigeration cycle
- Introduction of principle figures of merit for refrigerant materials
- Double-peak magnetocaloric effect: experimental evidence
- A magnetic nanoparticle model
- Presentation of simulation results

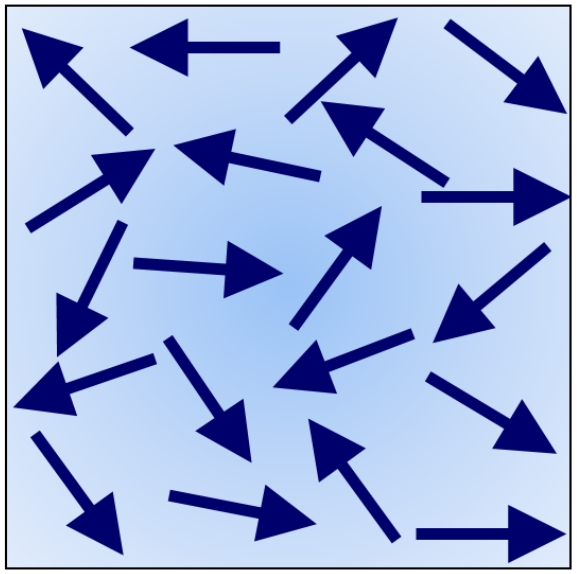
Magnetic refrigeration cycle



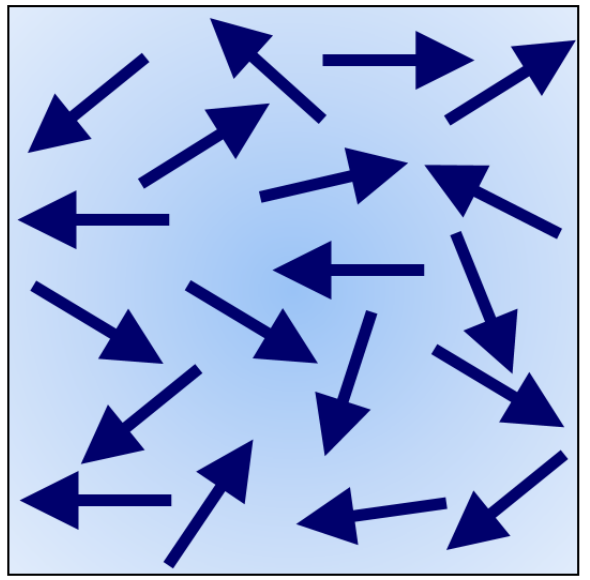
Adiabatic magnetization $(B \neq 0)$



Heat transfer via fluid $(B \neq 0)$

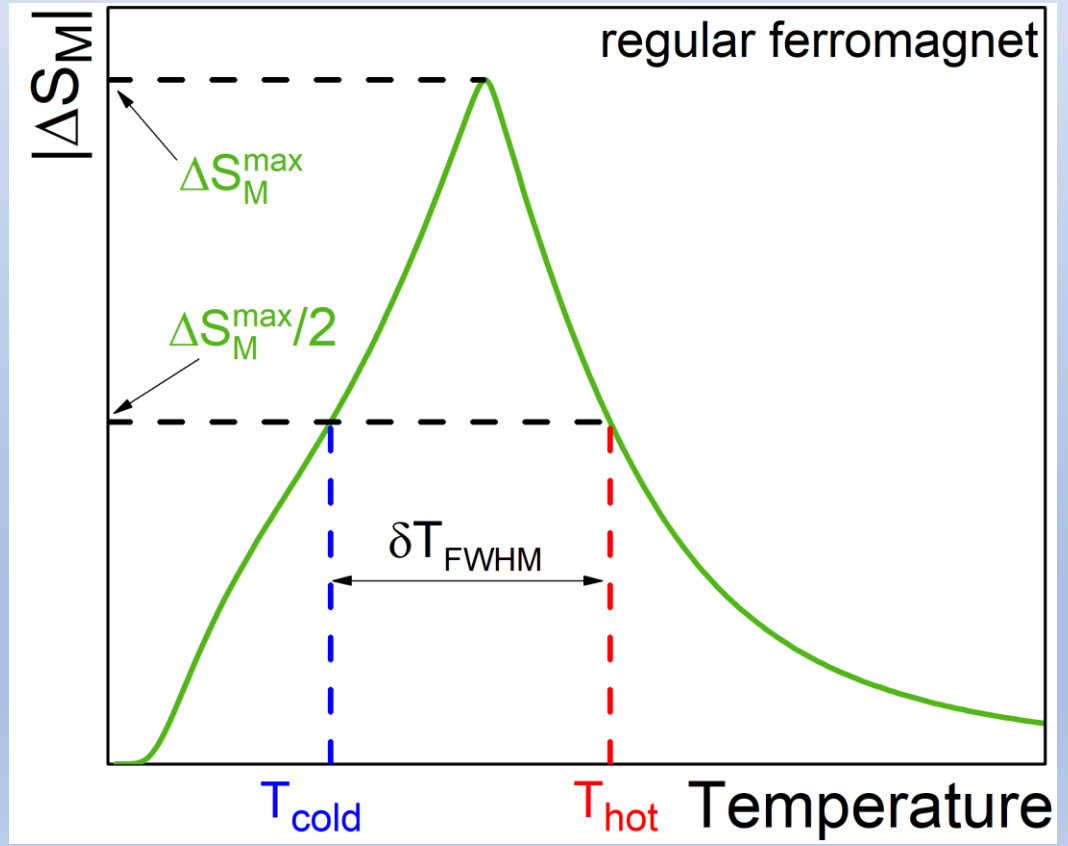


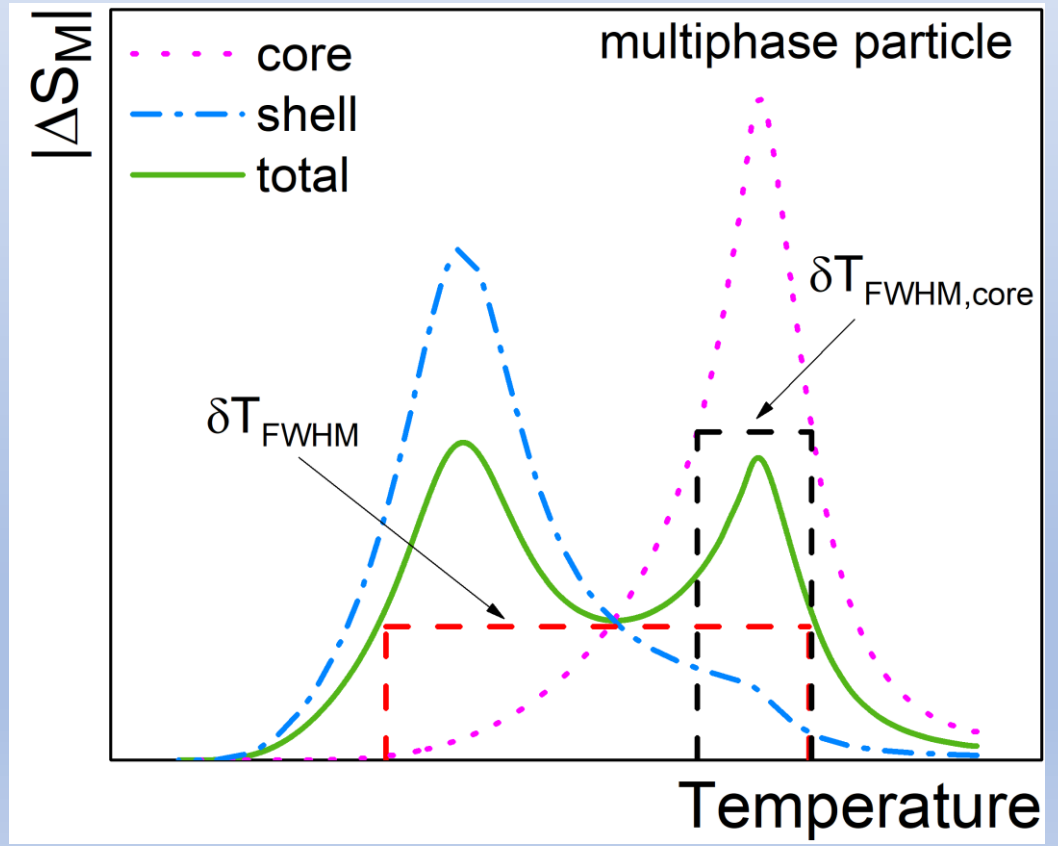
Adiabatic demagnetization $(B = 0)$



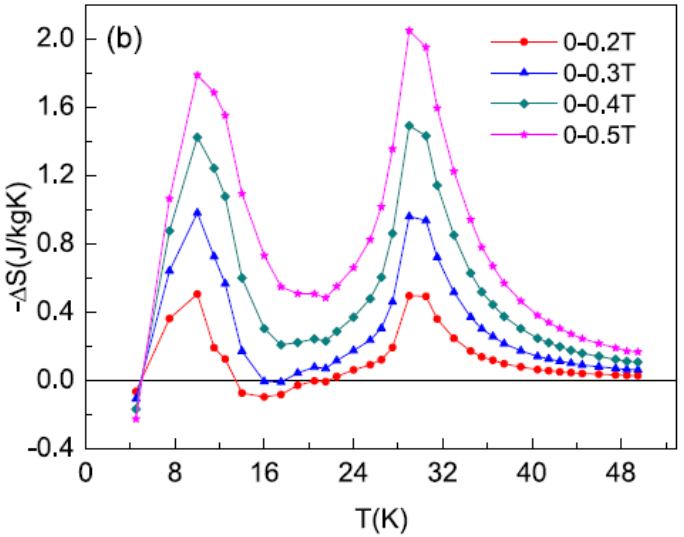
Cooling the refrigerator content

Principle figures of merit for refrigerant materials

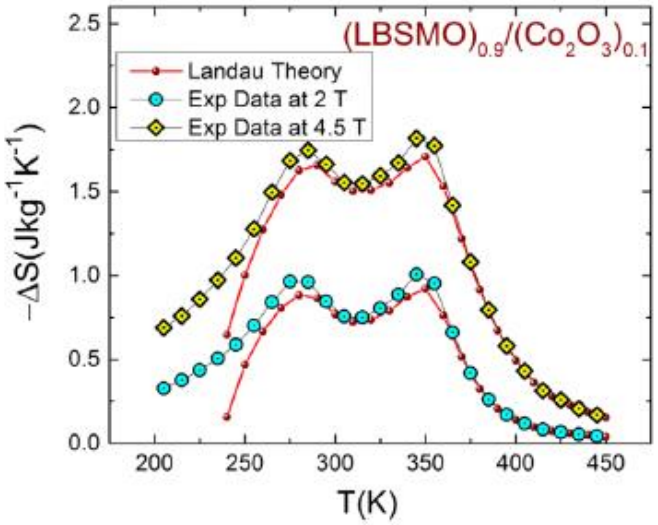




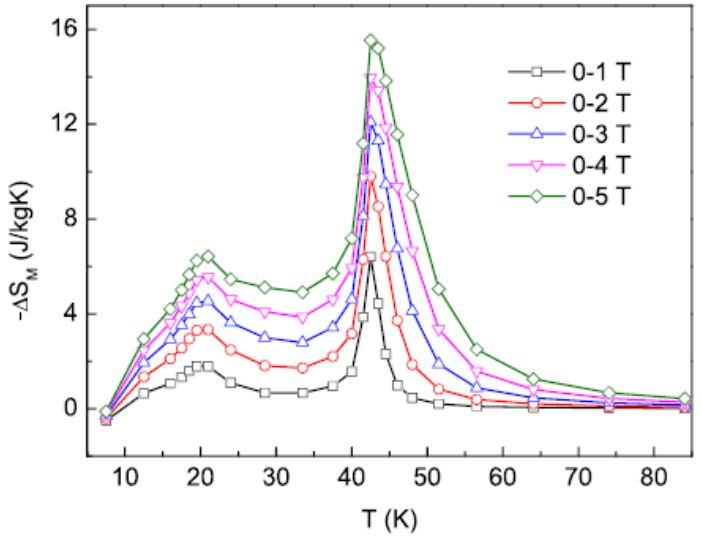
Experimental evidence of double-peak MCE in the literature



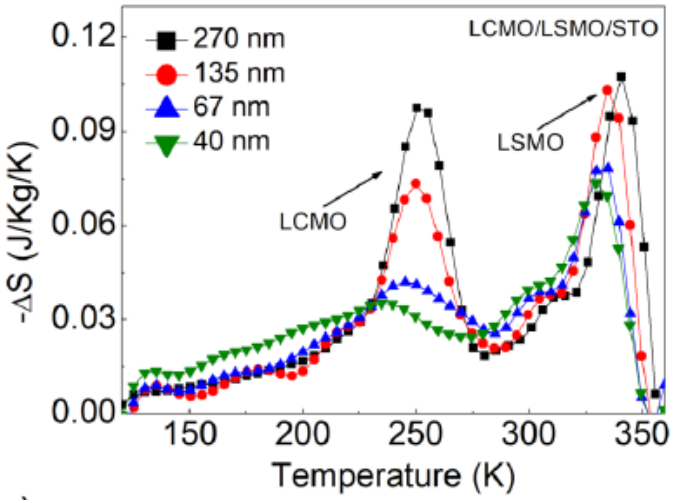
$Ho_{12}Co_7$ compound: Appl. Phys. Lett. 102 (2013) 022421



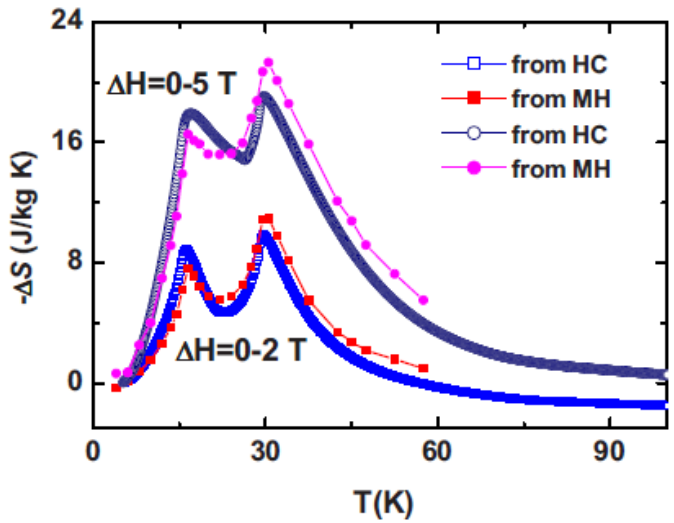
$(LBSMO)_{1-x}/(Co_2O_3)$ composite: Ceramics International 42 (2016) 7447



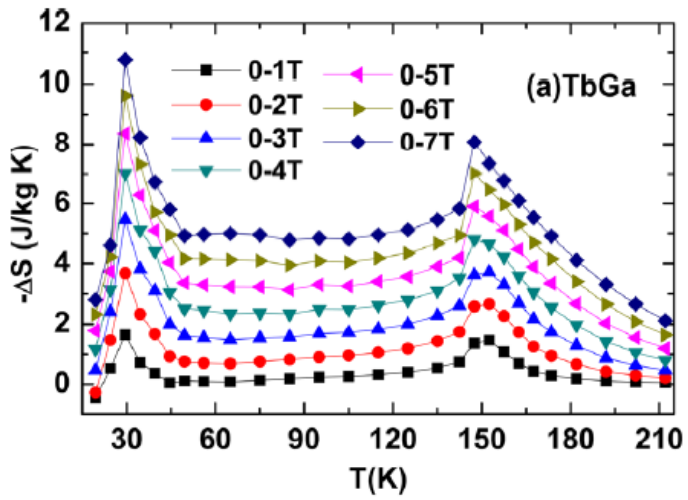
(NdGa compound: AIP ADVANCES 8 (2018) 056425



LSMO/LCMO bilayers: J. Appl. Phys. 127 (2020) 154102

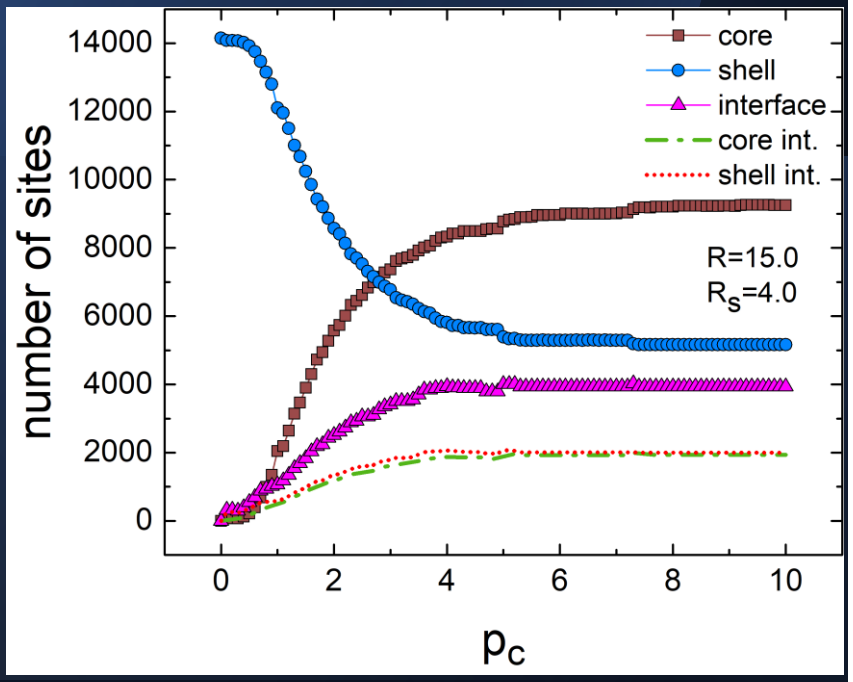


ErGa compound: Applied Phys. Lett. 95 (2009) 132504



RGa (R=Tb,Dy) compound: J. Appli. Phys. 111 (2012) 07A917

Model and Simulation Details



a nanoparticle of core/shell morphology

$$H = -J_c \sum_{<i,j>} S_i S_j - J_{sh} \sum_{<k,l>} S_k S_l - J_{int} \sum_{<i,k>} S_i S_k - h \sum_n S_n$$

core exchange **shell exchange** **interface exchange**

J_c=1.0 $J_s = 0.5 * J_c$ J_{int}: variable

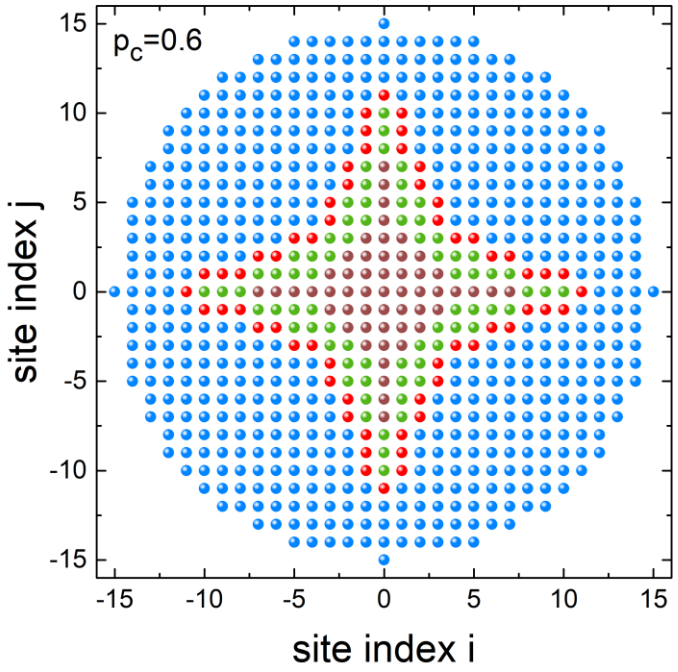
- Distance between two points A: (x_1, y_1, z_1) and B: (x_2, y_2, z_2)

$$D_p(A,B) = (|x_1 - x_2|^p + |y_1 - y_2|^p + |z_1 - z_2|^p)^{1/p}$$

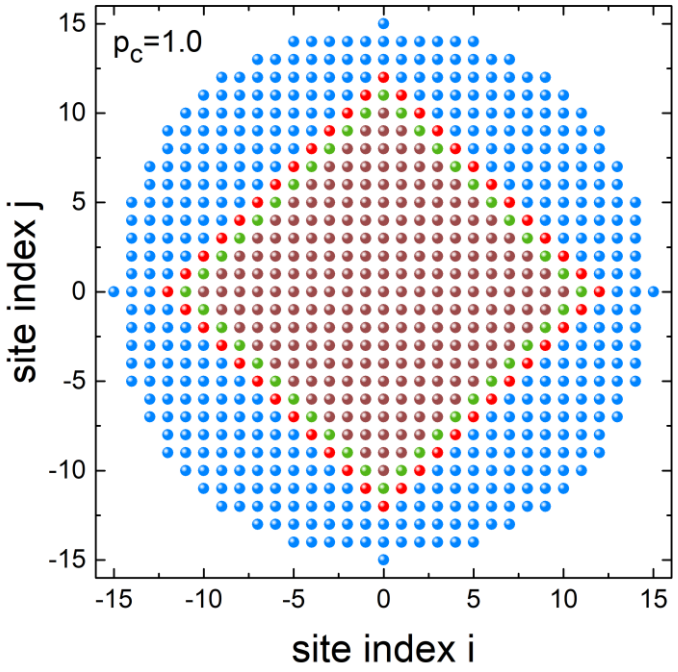
(minkowski distance [1,2])

- p_c: metric order of the particle **core**
- p_s: metric order of the particle **shell**
- R: radius of the particle
- R_s: thickness of the shell layer

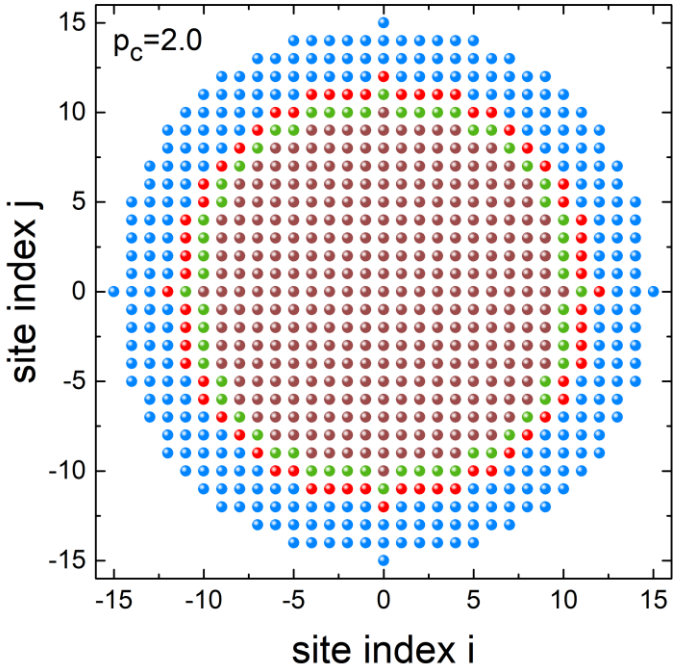
[1] Vasilakaki et. al, Nanoscale, 2015, 7753 (magnetic hyperthermia)
[2] Suarez et. al, Journal of Magnetism and Magnetic Materials 482 (2019) 120 (Exchange bias effect)



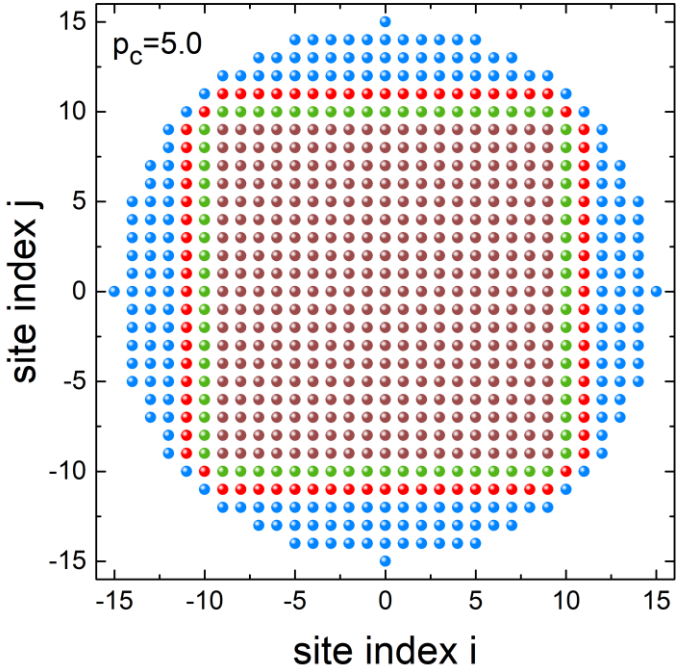
asteroid



octahedral

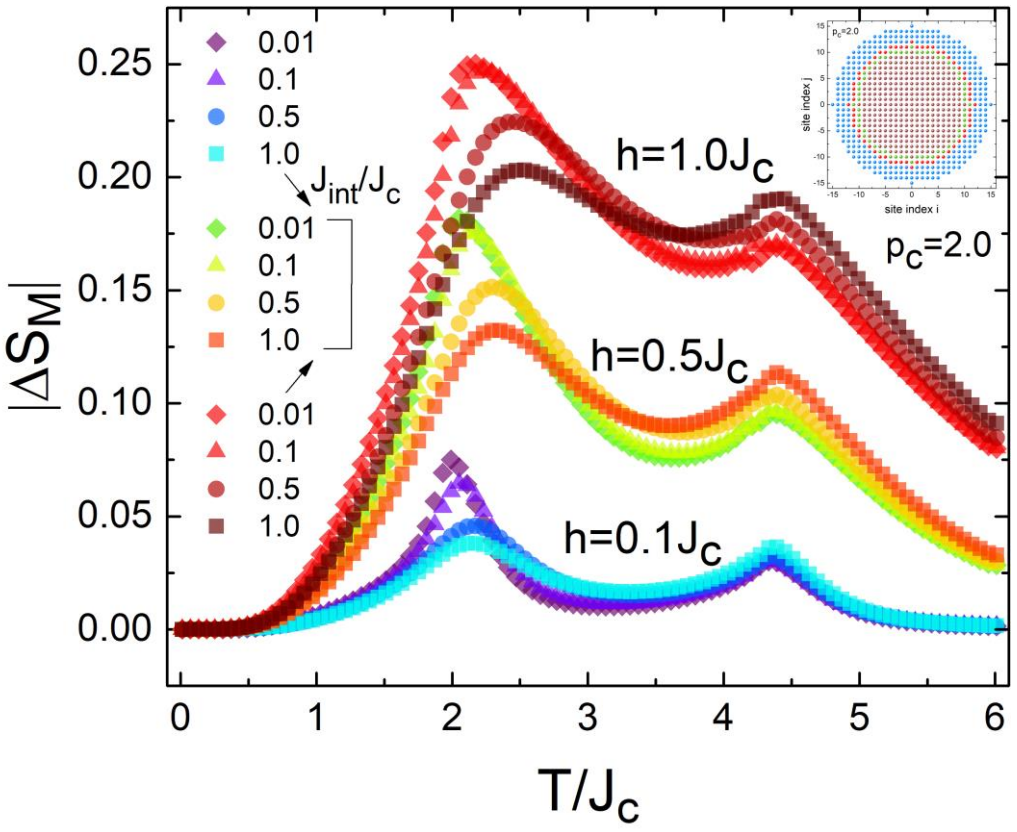


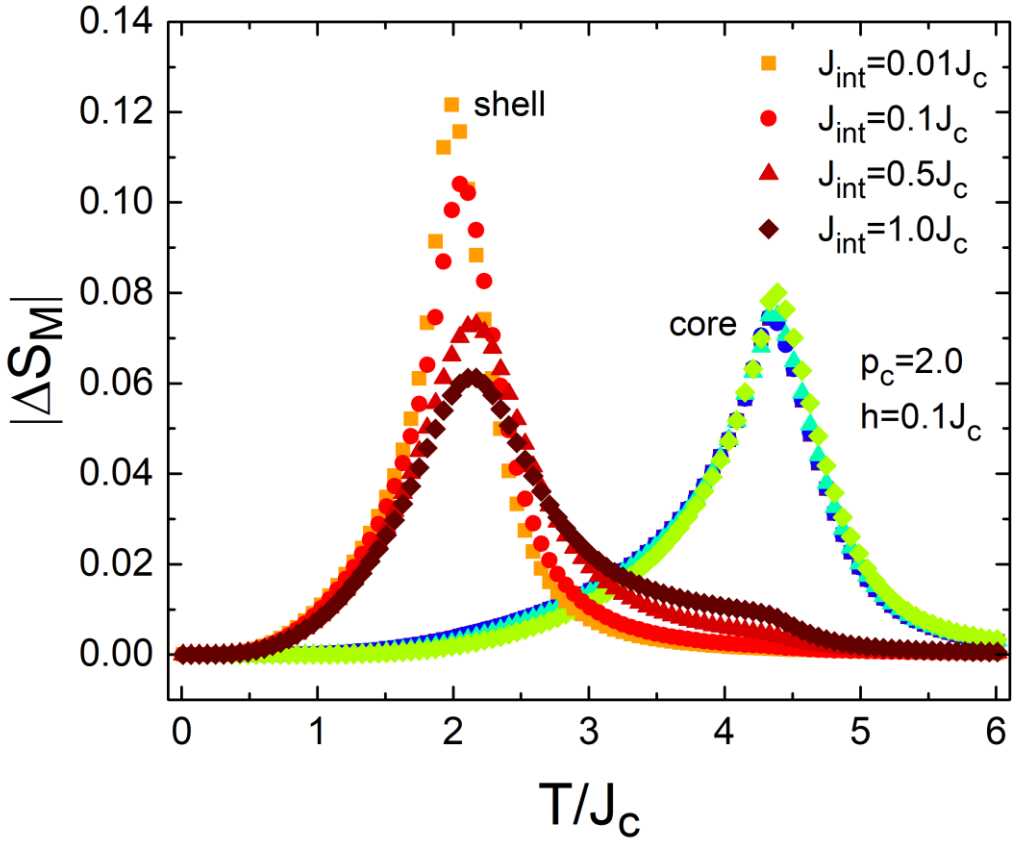
spherical

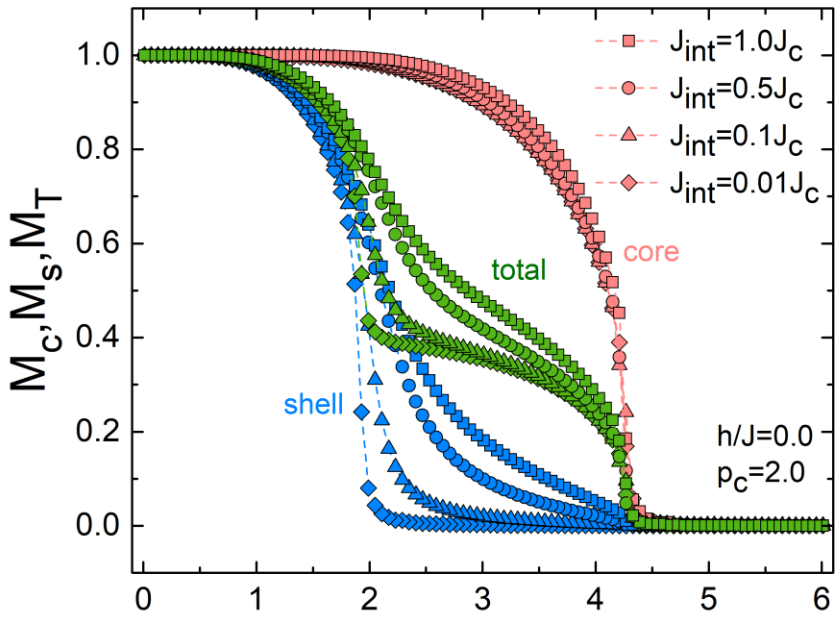


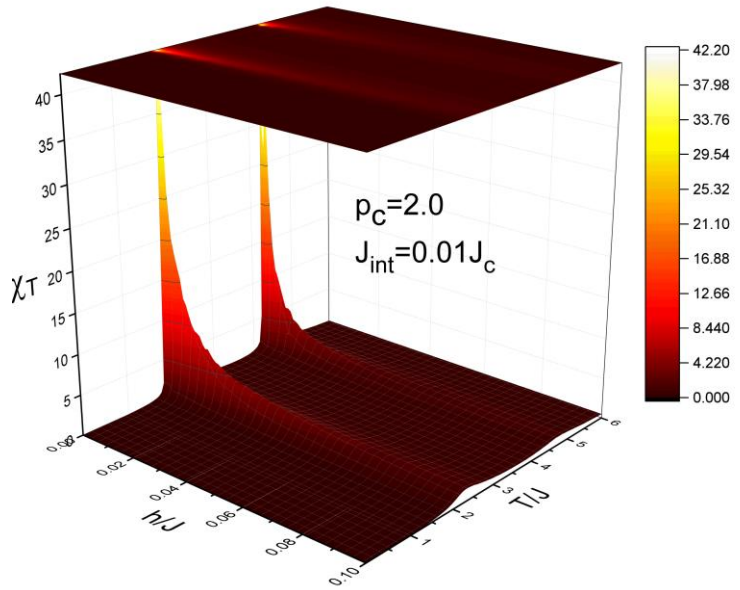
cubic

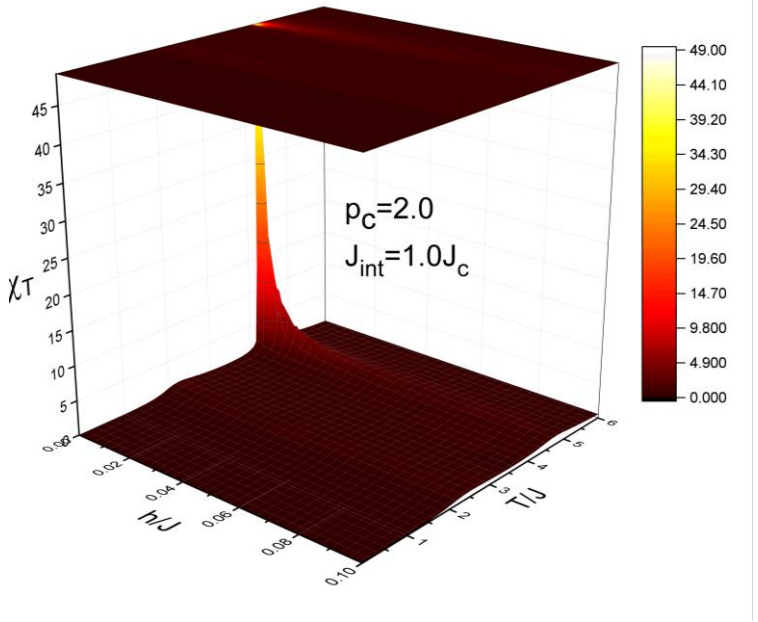
a spherical particle: influence of magnetic field

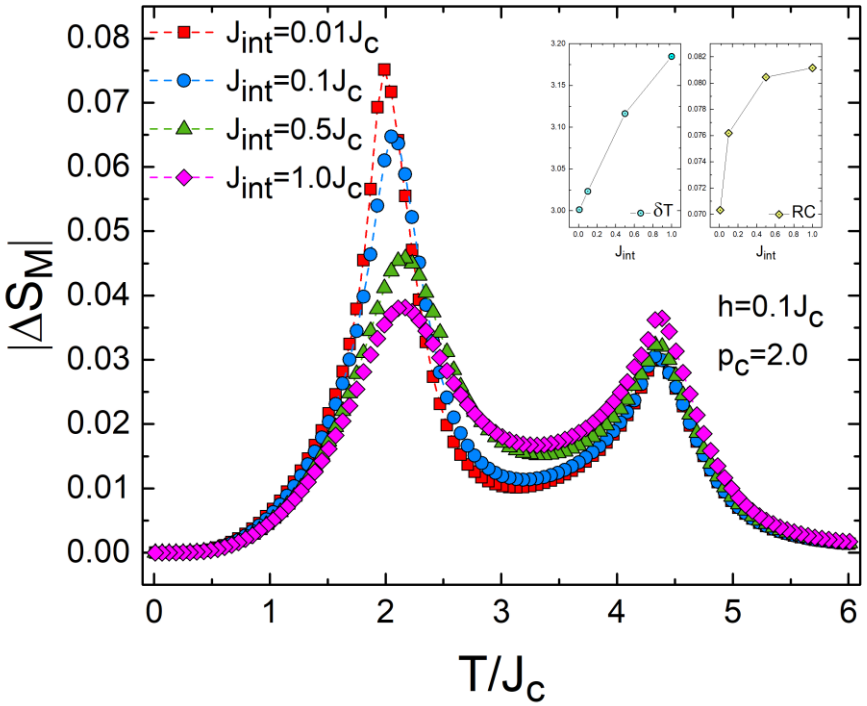




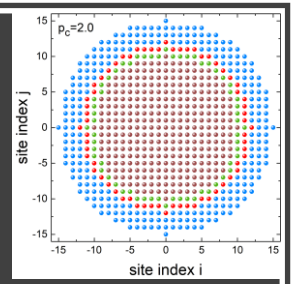


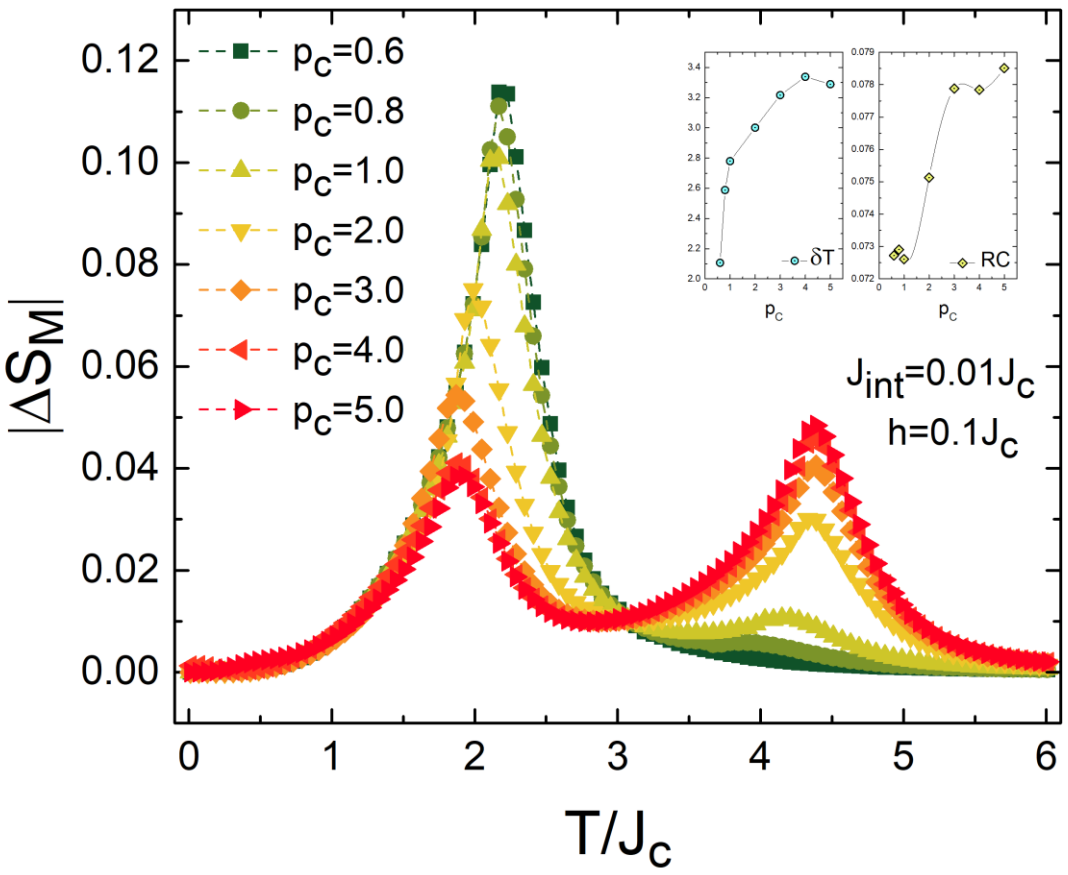






influence of the interface

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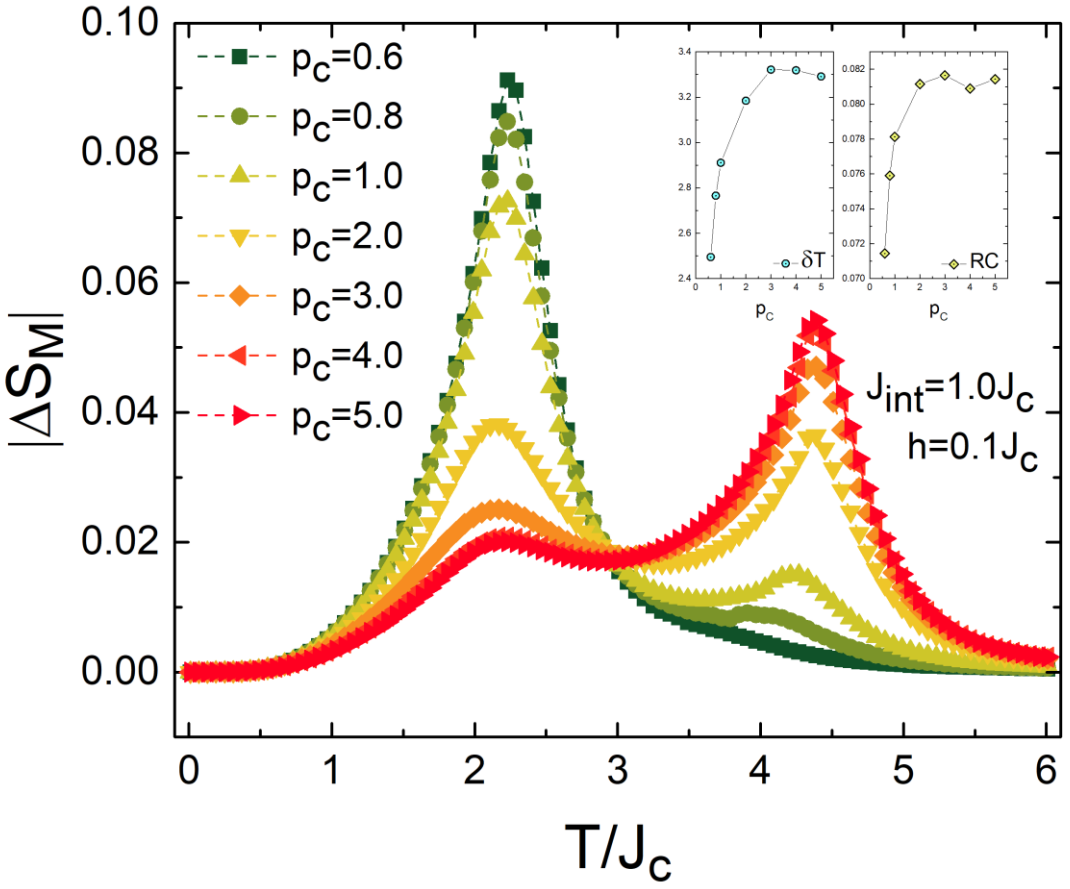
p_c=0.8
p_c=1.0
p_c=2.0
p_c=3.0
p_c=4.0
p_c=5.0
J_{int}=0.01J_c
h=0.1J_c
δT
RC
p_c
$|\Delta S_M|$
T/J_c


p_c=0.6
p_c=0.8
p_c=1.0
p_c=2.0
p_c=3.0
p_c=4.0
p_c=5.0
J_{int}=1.0J_c
h=0.1J_c
δT
RC
p_c
$|\Delta S_M|$
T/J_c

Thank you for your attention