Effects of Site Disorder on An Effective Spin-1/2 Triangular-Lattice Antiferromagnet $Ba_3CoSb_2O_9$

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Overview

1. Why $Ba_3CoSb_2O_9$? Why doping with Sr?

2. Results and discussions

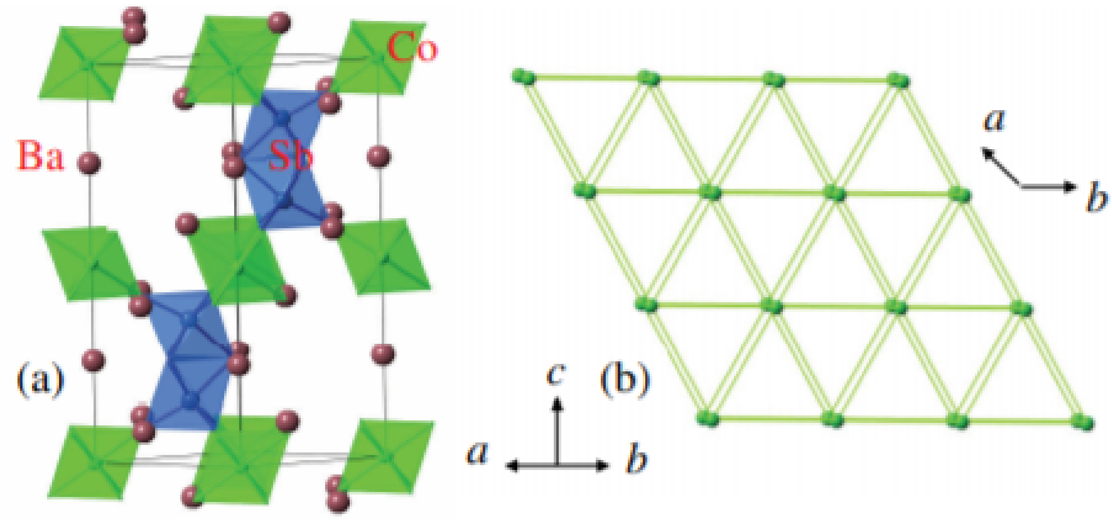
3. Summary

$Ba_3CoSb_2O_9$

1. Triangular-lattice Heisenberg antiferromagnet, with an effective spin-1/2 moment. Ideal triangular lattice, no Dzyaloshinskii– Moriya (DM) effect.

2. Heisenberg coupling J (~18K) is quite appropriate

$T_N = 3.8K$



Space group: P63/mmc

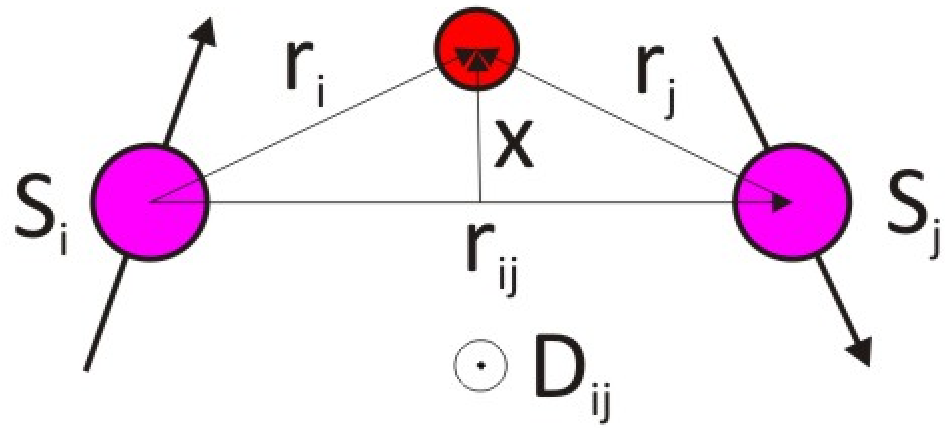
H.D. Zhou, et al. PRL 109, 267206(2012)

Dzyaloshinskii– Moriya (DM) effect.

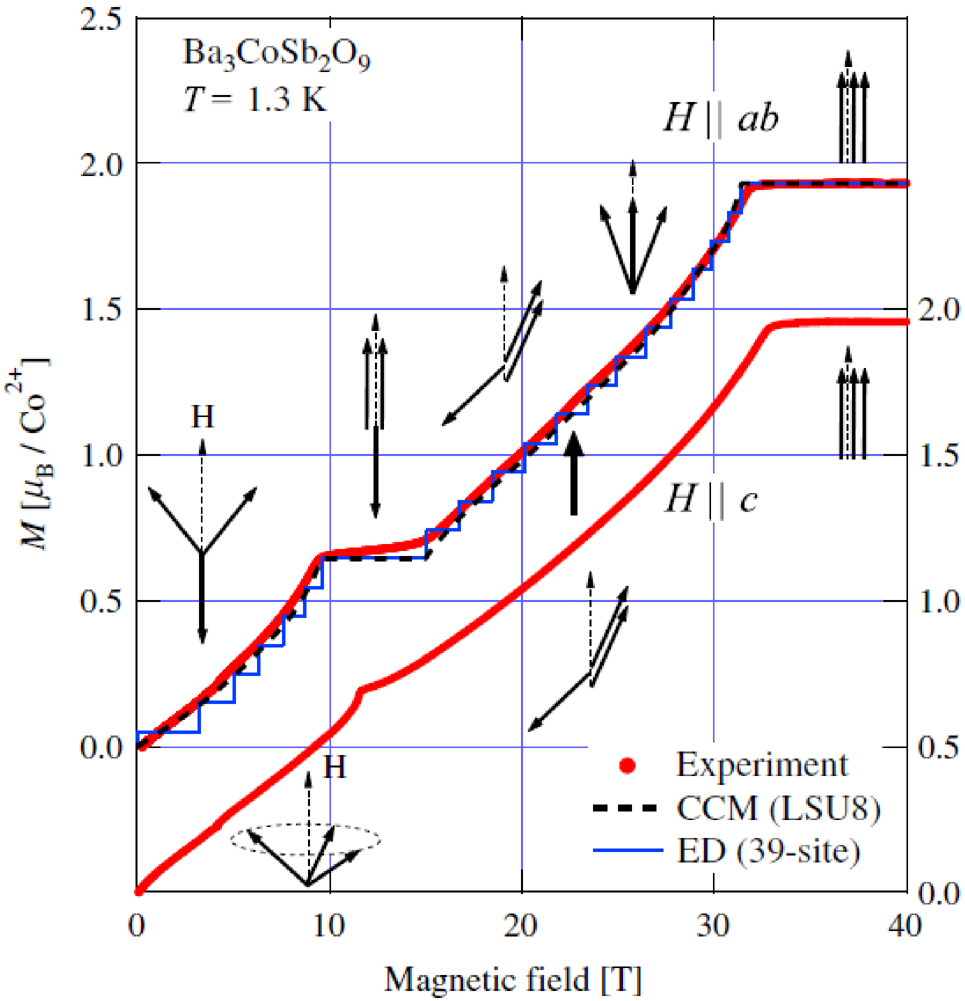
1. The DM effect is a contribution to the total magnetic exchange interaction between two neighboring magnetic spins.

$$H_{DM} = \boldsymbol{D_{ij}} \cdot (\boldsymbol{S_i} \times \boldsymbol{S_j}) \qquad \boldsymbol{D_{ij}} \propto (\boldsymbol{r_i} \times \boldsymbol{r_j})$$

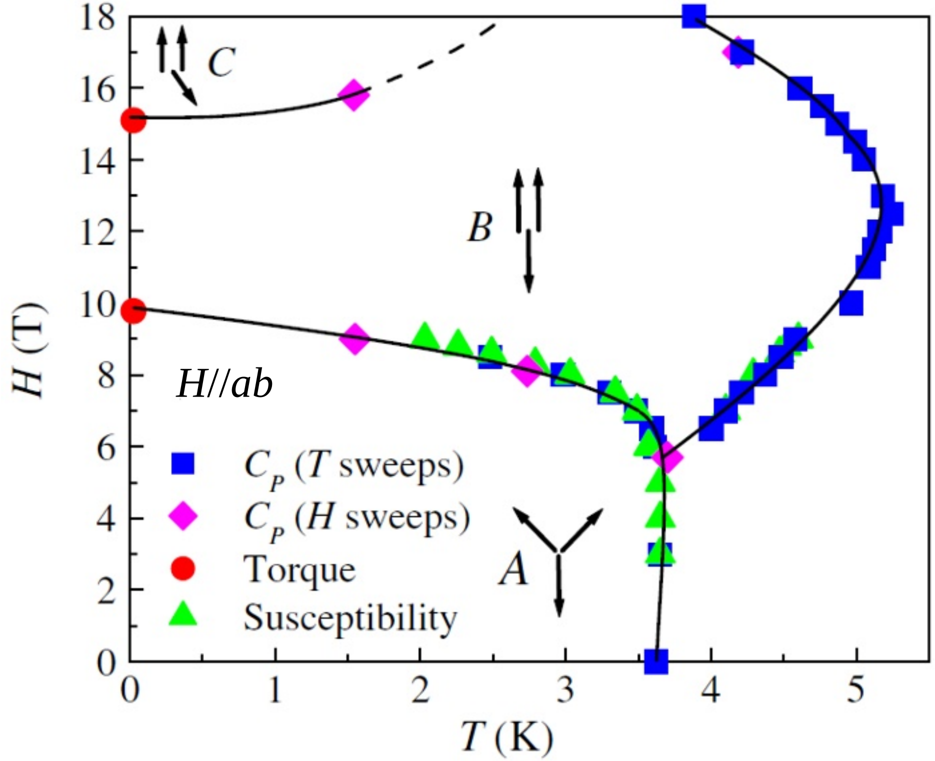
2. It can cause weak ferromagnetic behavior in an antiferromagnet.



$Ba_3CoSb_2O_9$, Up up down (UUD) phase

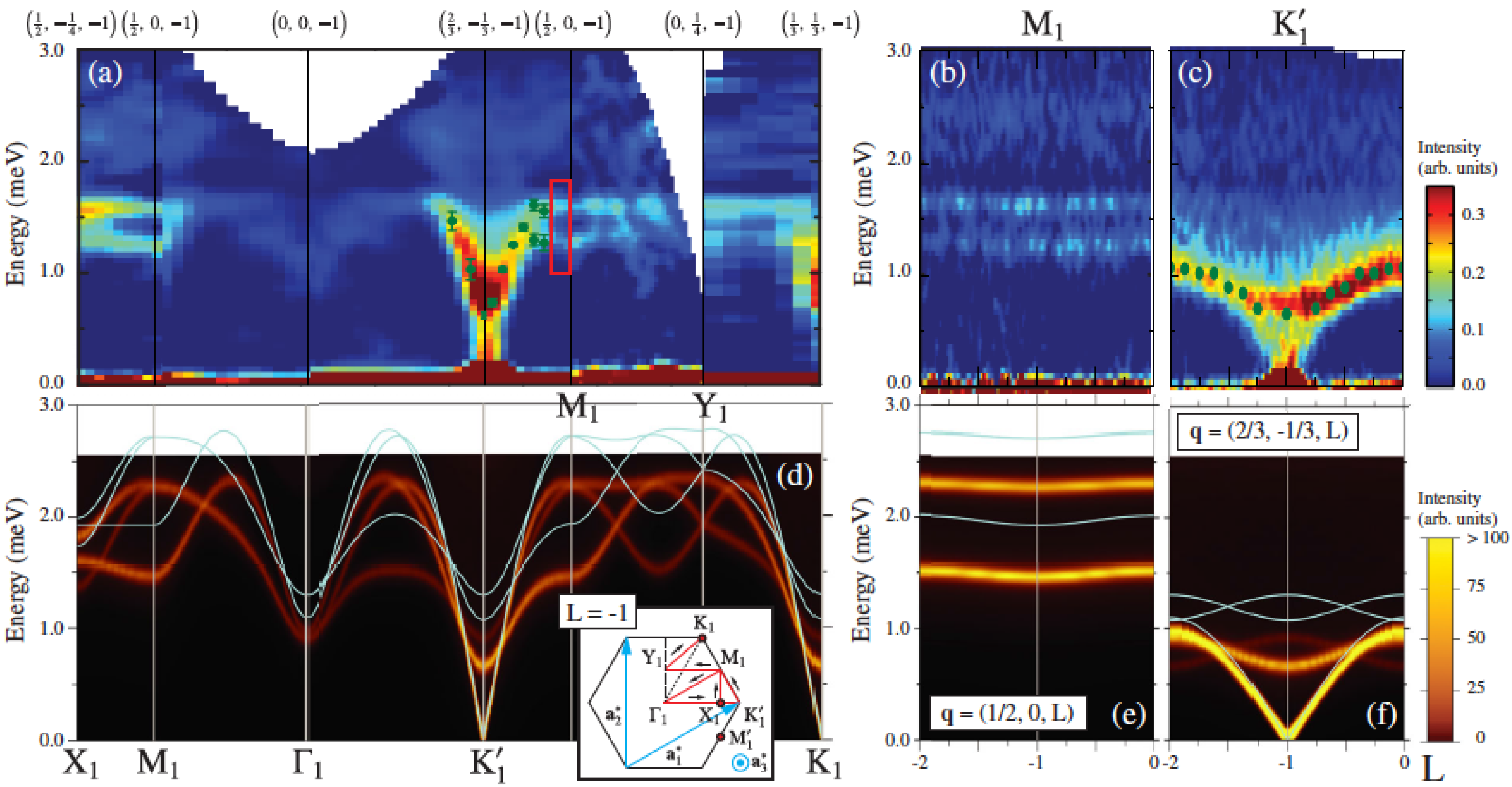


*T. Susuki, et al. PRL **110** 267201 (2013)*



*H.D. Zhou, et al. PRL **109**, 267206(2012);*

$Ba_3CoSb_2O_9$, quantum spin fluctuations

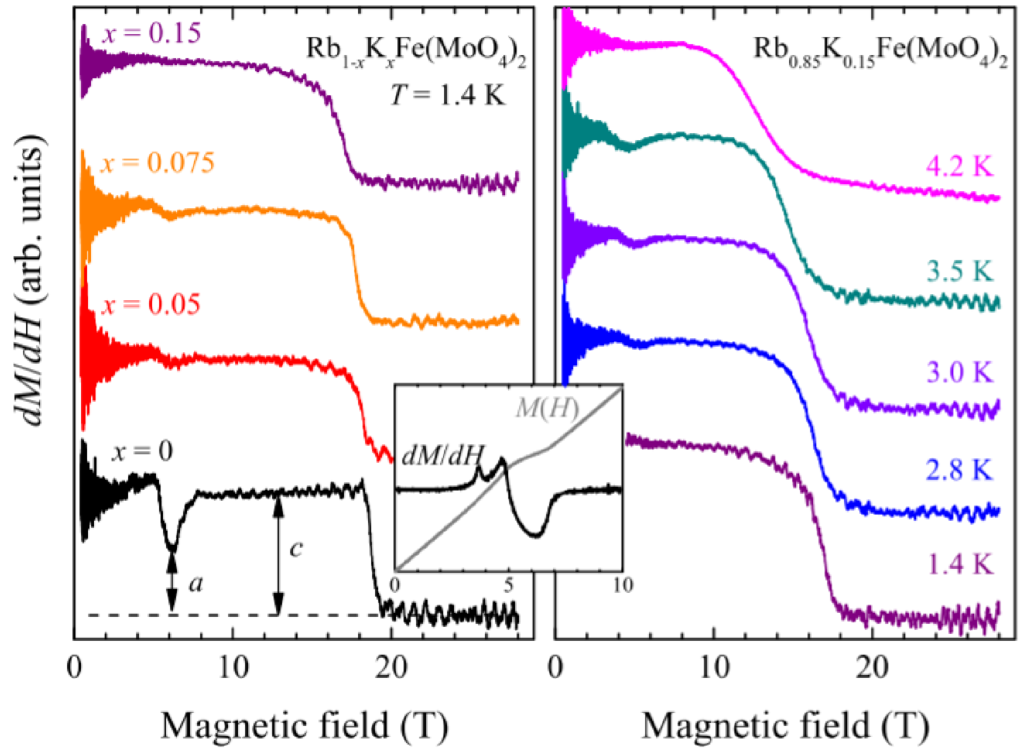


*J. Ma and H. D. Zhou et al. PRL **116** 087201 (2016)*

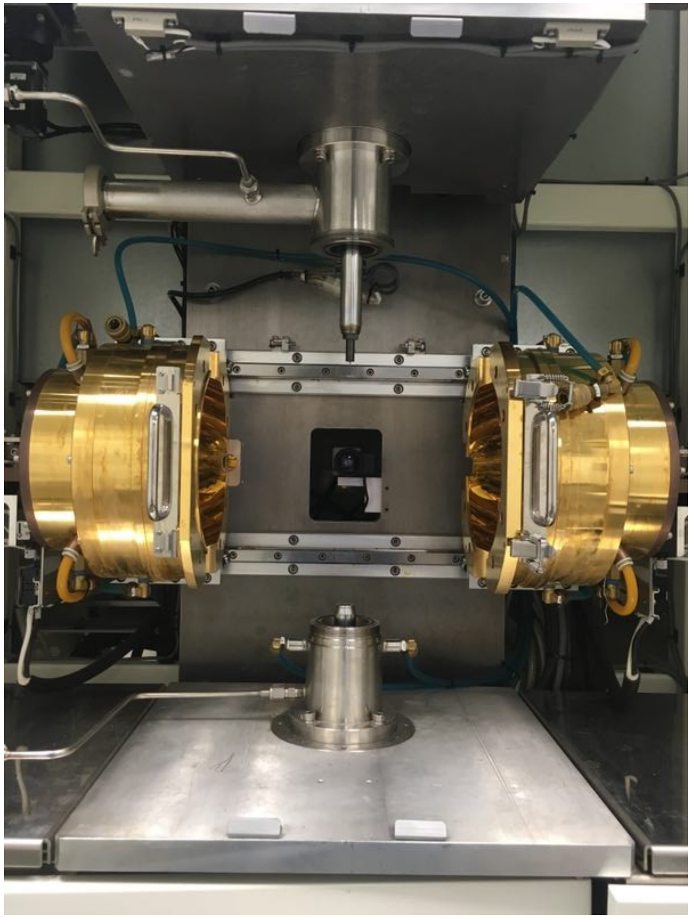
Intrinsic quantum effects: The linear and nonlinear spin-wave theories (SWTs) are inadequate to explain intrinsic linewidth broadening and high-intensity continuum.

Doping with Sr

Recent studies on $RbFe(MoO_4)_2$ show that the site disorder even on non-magnetic site could affect the UUD phase.



A. I. Smirnov, et al. PRL 119, 047204 (2017)



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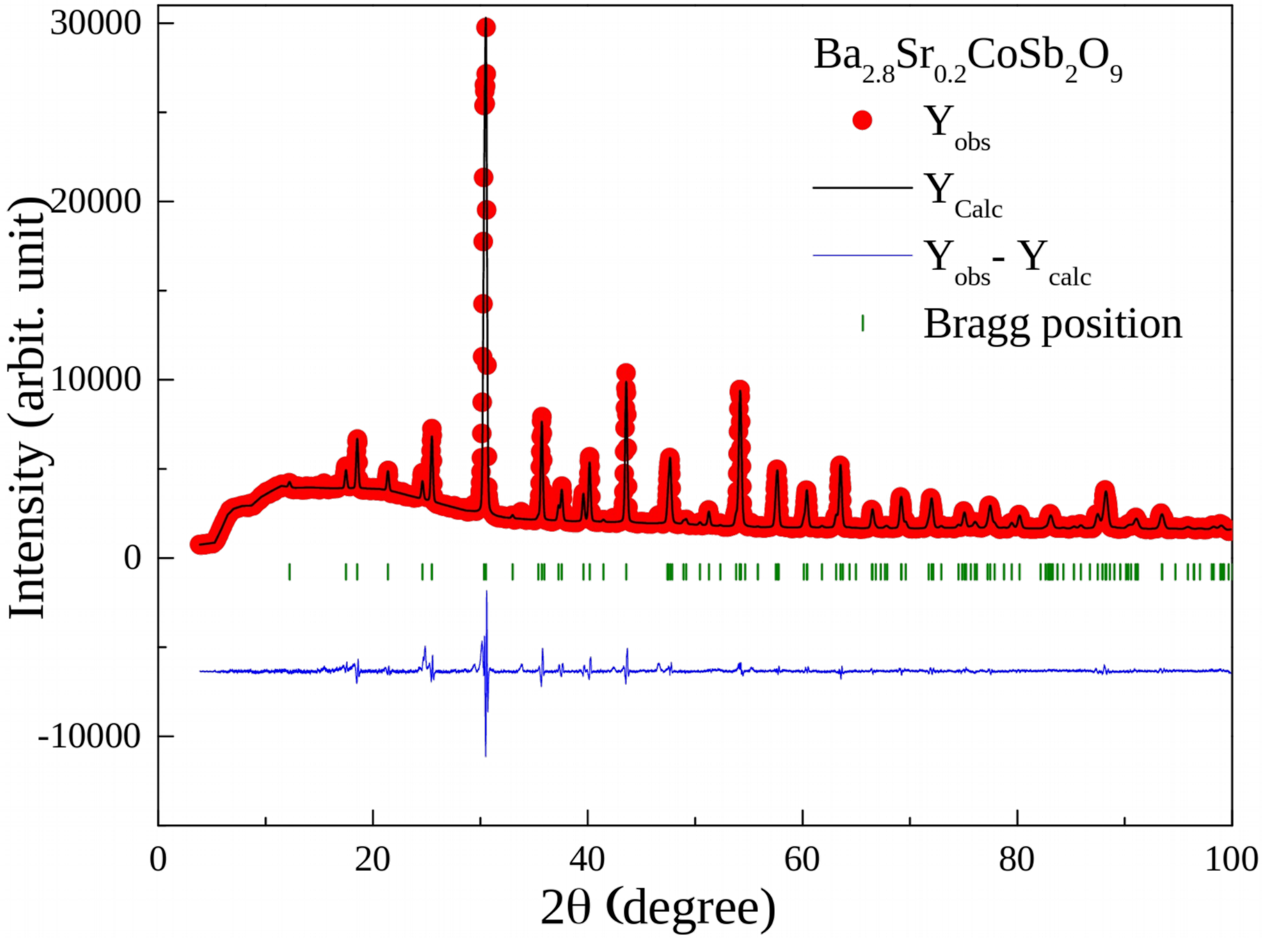
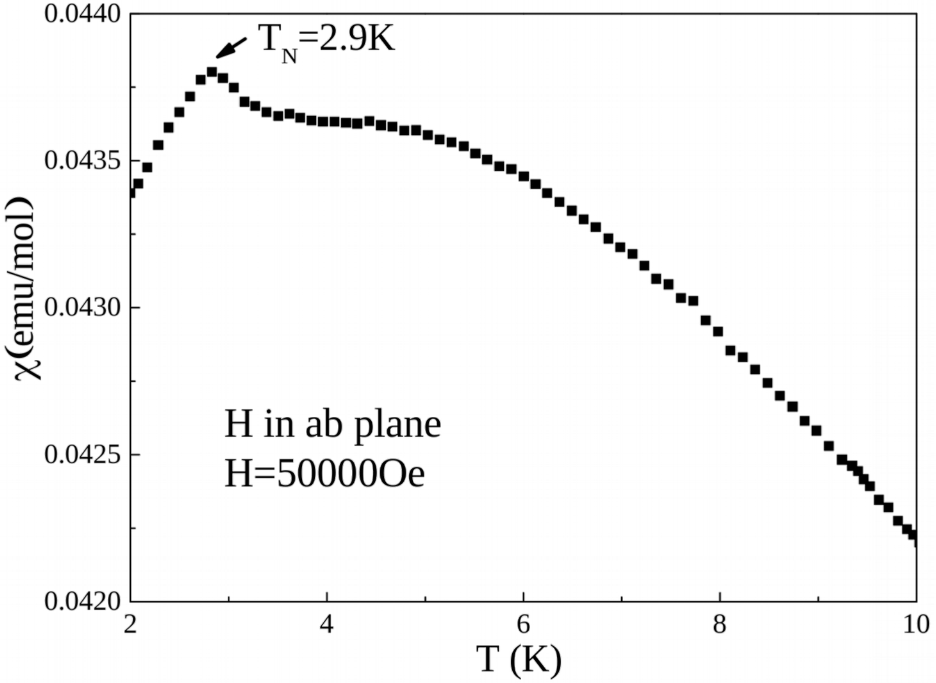
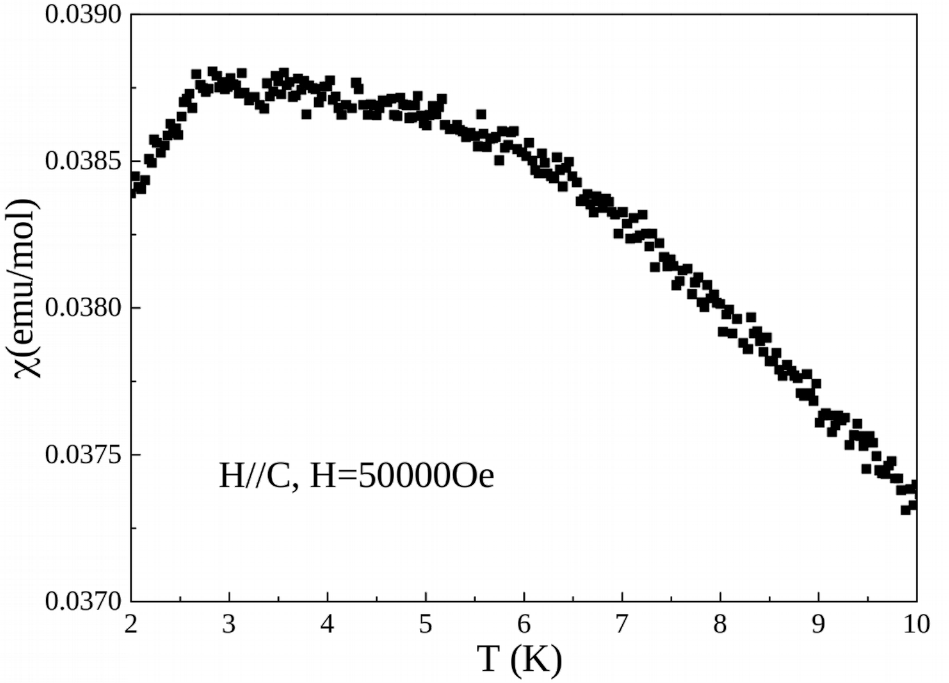
$Ba_{2.8}Sr_{0.2}CoSb_2O_9$, crystal structure



	Pure	Doped
a	5.85475(3)	5.85236(4)
b	5.85475(3)	5.85236(4)
c	14.4498(1)	14.4583(1)
α	90	90
β	90	90
γ	120	120

$Ba_{2.8}Sr_{0.2}CoSb_2O_9$, DC and AC susceptibility





The transition temperature is 2.9K, lower than pure sample.

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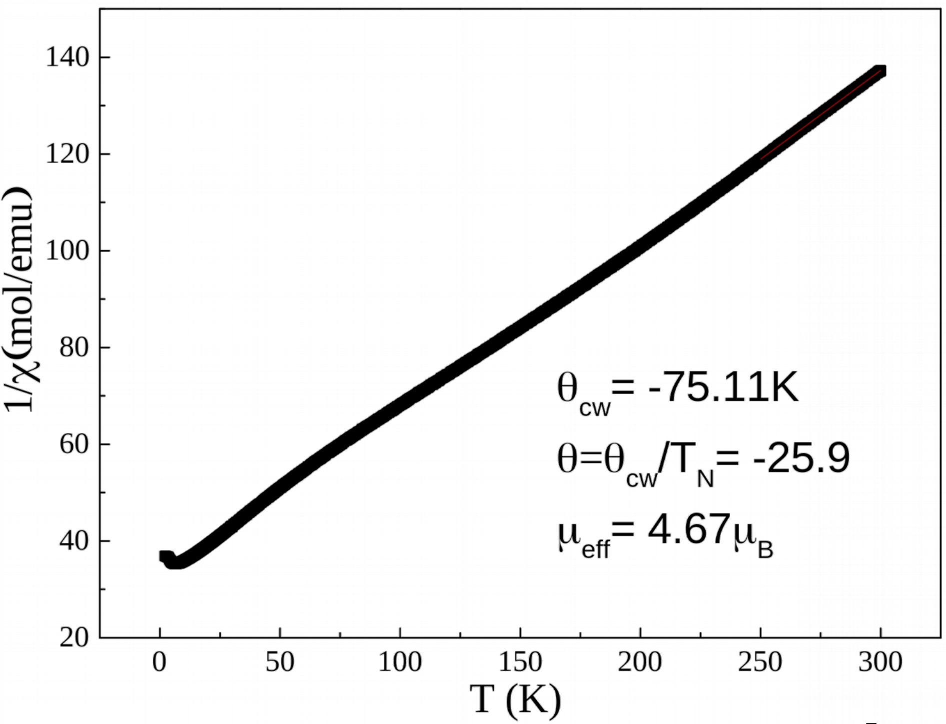
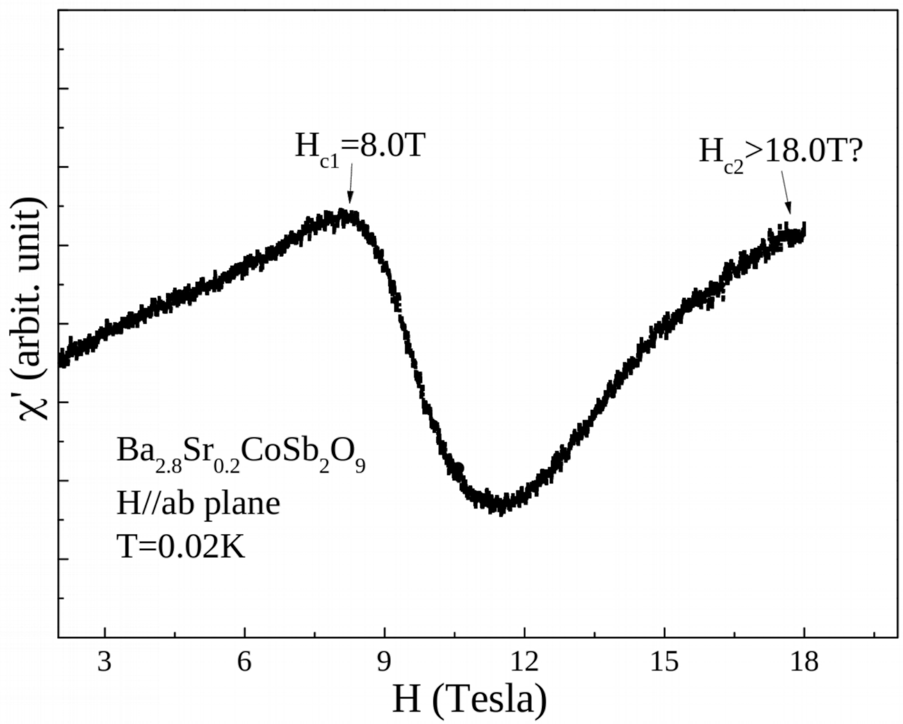
$Ba_{2.8}Sr_{0.2}CoSb_2O_9$, DC and AC susceptibility





For comparison, in pure sample

θ_{cw}= -51K and μ_{eff} = 5.23 $\mu_{B,}$ θ= -12.5

Yoshihiro Doi et al 2004 J. Phys.: Condens. Matter 16 8923

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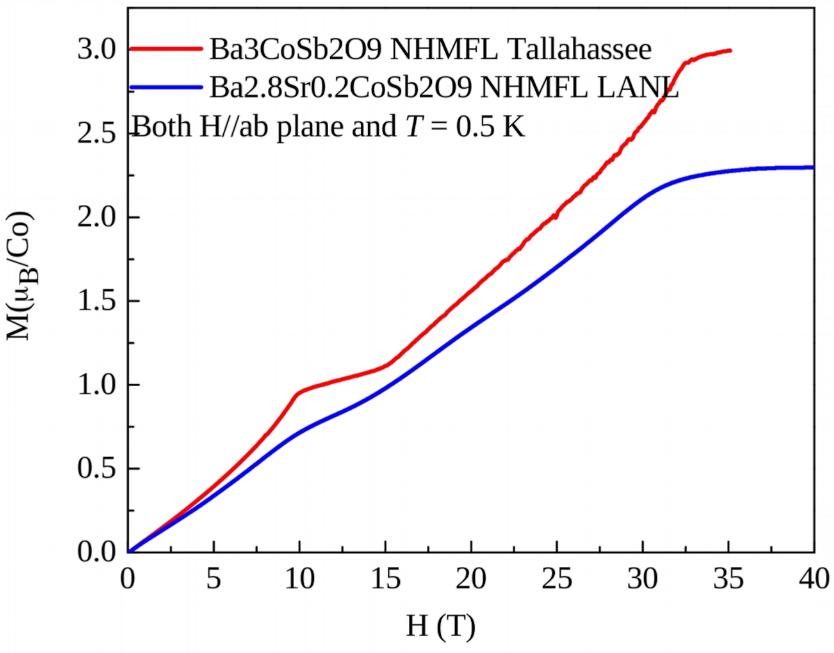
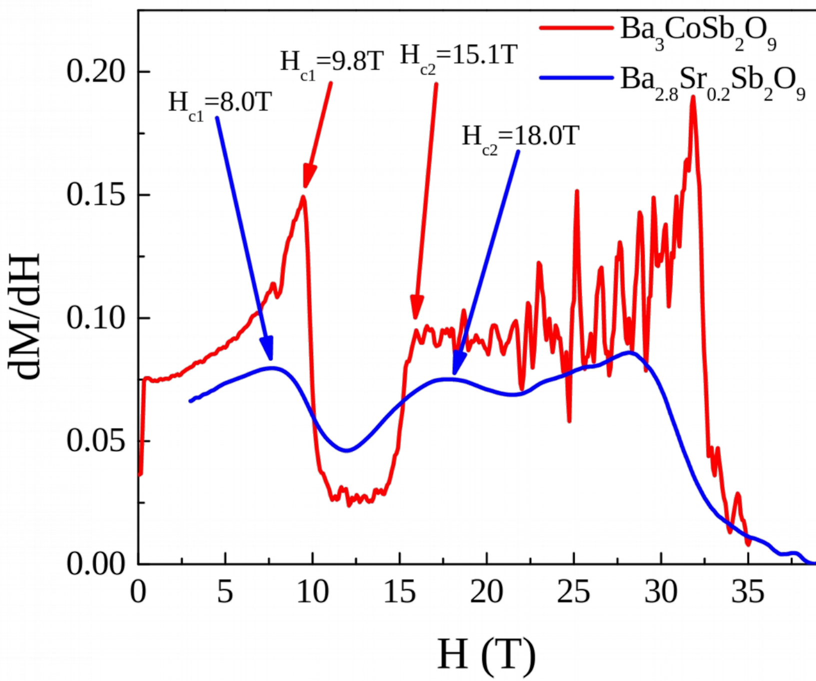
$Ba_{2.8}Sr_{0.2}CoSb_2O_9$, Magnetization





The UUD phase becomes weak or likely to disappear.

Summary

Results:

1.The transition temperature decreases by doping Sr

2.The UUD phase becomes weak or likely to disappear. **Order by site disorder!**

3.Doped sample has stronger quantum fluctuations. Interesting when compared with upper result.

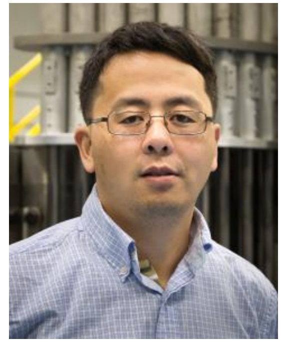
Future plan:

1.Conduct elastic neutron scattering measurement and solve the magnetic structure at zero and finite fields

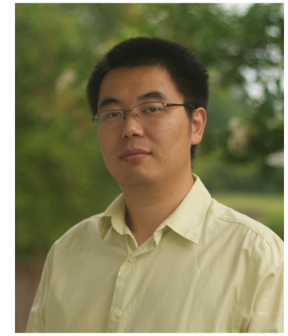
2.Conduct inelastic neutron scattering measurement to study the effects of site disorder on spin dynamics

Acknowledgements:

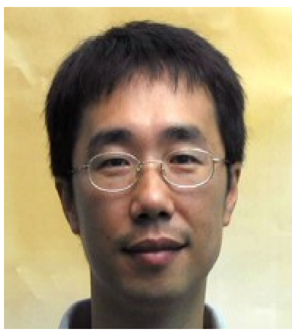
Haidong Zhou, UTK



Tao Hong, ORNL

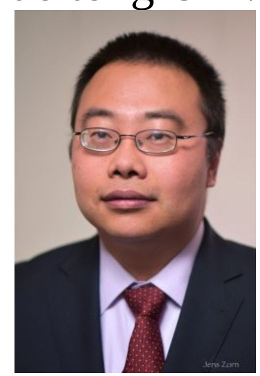


Jie Ma, Shanghai Jiao tong Univ



Eun Sang Choi, NHMFL

Zhilun Lu, HZB



Lu Li, University of Michigan

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