Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.
This journal is © The Royal Society of Chemistry 2014

Supporting Information

Unconventional magnetism in $ThCr_2Si_2$-type phosphides, $La_{1-x}Nd_xCo_2P_2$

Corey M. Thompson,[a,†] Kirill Kovnir,[a,‡] V. Ovidiu Garlea,[b] Eun Sang Choi,[c] H. D. Zhou,[c,§] and Michael Shatruk*[a,c]

[a] *Department of Chemistry and Biochemistry, Florida State University, Tallahassee, FL 32306, USA*
[b] *Quantum Condensed Matter Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA*
[c] *National High Magnetic Field Laboratory, Florida State University, Tallahassee, Florida 32306, USA*

Present addresses:
[†] *Department of Chemistry, McMaster University, Hamilton, Ontario L8S 4M1, Canada*
[‡] *Department of Chemistry, University of California, Davis, One Shields Avenue, Davis, California 95616, USA*
[§] *Department of Physics, University of Tennessee at Knoxville, Knoxville, Tennessee 37966, USA*

Email address: shatruk@chem.fsu.edu

Page

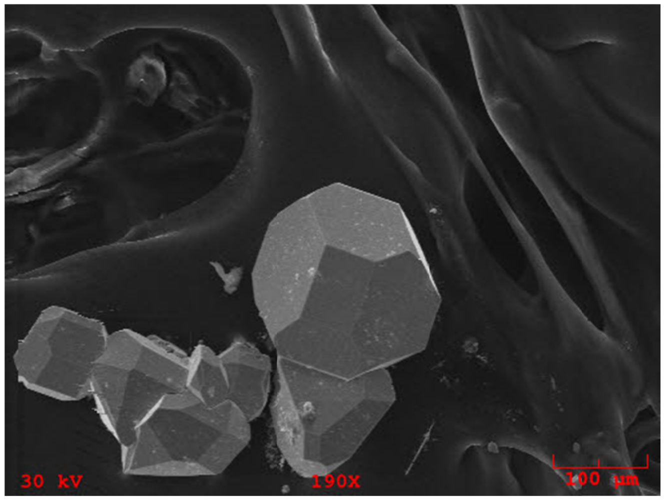

Fig. S1 Typical SEM image of a $La_{1-x}Nd_xCo_2P_2$ crystal.

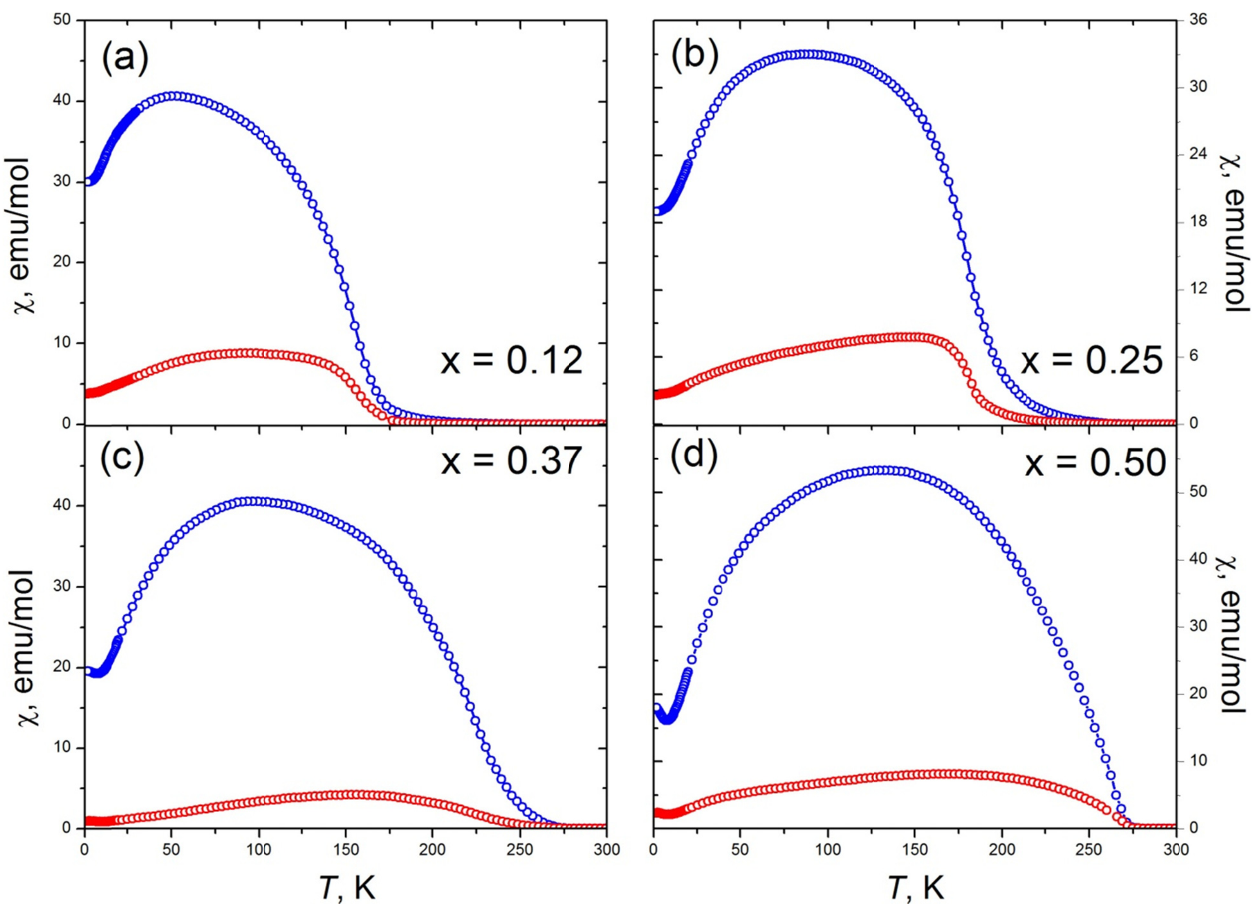

Fig. S2 Temperature dependence of zero-field cooled (red) and field cooled (blue) magnetic susceptibilities at 10 Oe for: a) $La_{0.88}Nd_{0.12}Co_2P_2$; b) $La_{0.75}Nd_{0.25}Co_2P_2$; c) $La_{0.63}Nd_{0.37}Co_2P_2$; and d) $La_{0.50}Nd_{0.50}Co_2P_2$.

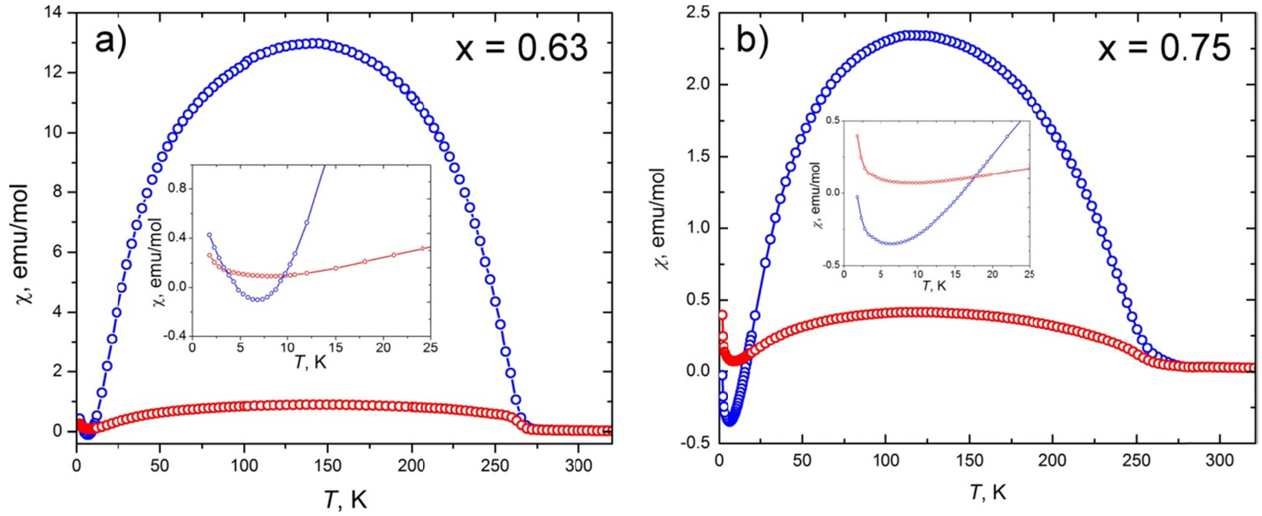

Fig. S3 Temperature dependence of zero-field cooled (red) and field cooled (blue) magnetic susceptibilities at 10 Oe for: a) $La_{0.37}Nd_{0.63}Co_2P_2$ and b) $La_{0.25}Nd_{0.75}Co_2P_2$.

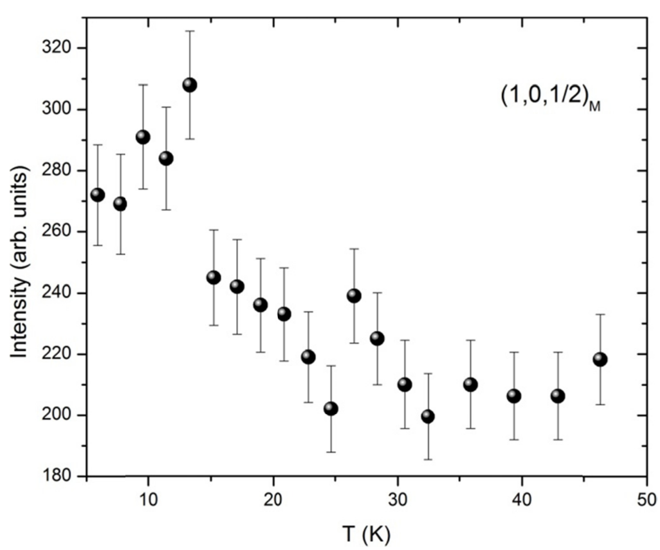

Fig. S4 Temperature dependence of the intensity of the neutron powder diffraction magnetic reflection $(1,0,1/2)_M$ of $La_{0.25}Nd_{0.75}Co_2P_2$.

Table S1 Results of the magnetic structure refinement for $La_{0.50}Nd_{0.50}Co_2P_2$ from neutron powder diffraction data collected at various temperatures with the 2.41 Å wavelength. The results of refinements obtained with the 1.54 Å wavelength are also provided, below the 2.41Å data at 4 K. The results of the simultaneous refinement of both wavelengths are shown in brackets.

Temp. (K)	**Nd position**[≠] Model	$\mathbf{R_{mag}}$* (%)	**Nd moment** μ_B	**Co moment** μ_B
4	(0,0,0) & (1/2,1/2,1/2)[a]	42.0	2.2(1)	0.85(5)
		41.5	2.2(1)	0.74(6)
		[68, 35.2]	[2.2(1)]	[0.80(6)]
	(1/2,1/2,1/2)[b]	61.5	3.1(2)	0.73(5)
		41.2	3.1(2)	0.67(6)
		[66.5, 34.4]	[3.1(2)]	[0.73(6)]
50	(0,0,0) & (1/2,1/2,1/2)[a]	68.6	0.7(2)	0.74(5)
	(1/2,1/2,1/2)[b]	65.0	0.7(2)	0.75(5)
125	(0,0,0) & (1/2,1/2,1/2)[a]	54.2	0.2(3)	0.69(6)
	(1/2,1/2,1/2)[b]	54.2	0.2(3)	0.69(6)

[≠]In both magnetic structure models the order of the cobalt moments along the *c*-axis is the same with the sequence ++--,++--.
[a]This magnetic structure model corresponds to the order of the Nd^{3+} moments ++--,++--.
[b]Every other Nd layer has disordered moments and the sequence is 0-0+,0-0+.

Table S2 Results of the magnetic structure refinement for $La_{0.25}Nd_{0.75}Co_2P_2$ from neutron powder diffraction data collected at various temperatures with the 2.41 Å wavelength. The results of refinements obtained with the 1.54 Å wavelength are also provided, below the 2.41Å data at 4 K. The results of the simultaneous refinement of both wavelengths are shown in brackets.

Temp. (K)	**Nd position**[≠] Model	$\mathbf{R_{mag}}$* (%)	**Nd moment** μ_B	**Co moment** μ_B
4	(0,0,0) & (1/2,1/2,1/2)[a]	59.0	2.03(9)	0.94(7)
		44.8	2.07(8)	0.69(7)
		[59.6, 49.2]	[2.04(9)]	[0.77(7)]
	(1/2,1/2,1/2)[b]	56.9	2.9(1)	0.82(6)
		41.6	2.9(1)	0.60(6)
		[55.7, 45.9]	[2.9(1)]	[0.67(6)]
15	(0,0,0) & (1/2,1/2,1/2)[a]	62.6	1.6(1)	0.88(8)
	(1/2,1/2,1/2)[b]	57.9	2.2(2)	0.81(9)
50	(0,0,0) & (1/2,1/2,1/2)[a]	60.9	0.9(2)	0.8(1)
	(1/2,1/2,1/2)[b]	56.5	1.2(3)	0.7(1)
100	(0,0,0) & (1/2,1/2,1/2)[a]	70.4	0.5(3)	0.7(1)
	(1/2,1/2,1/2)[b]	69.6	0.6(3)	0.7(1)
125	(0,0,0) & (1/2,1/2,1/2)[a]	62.3	0.3(2)	0.88(7)
	(1/2,1/2,1/2)[b]	61.4	0.4(2)	0.88(7)

* Note that the residual factors for the magnetic phase (R-mag) are quite large due to the small intensities of the magnetic reflections as compared to the nuclear Bragg peaks.

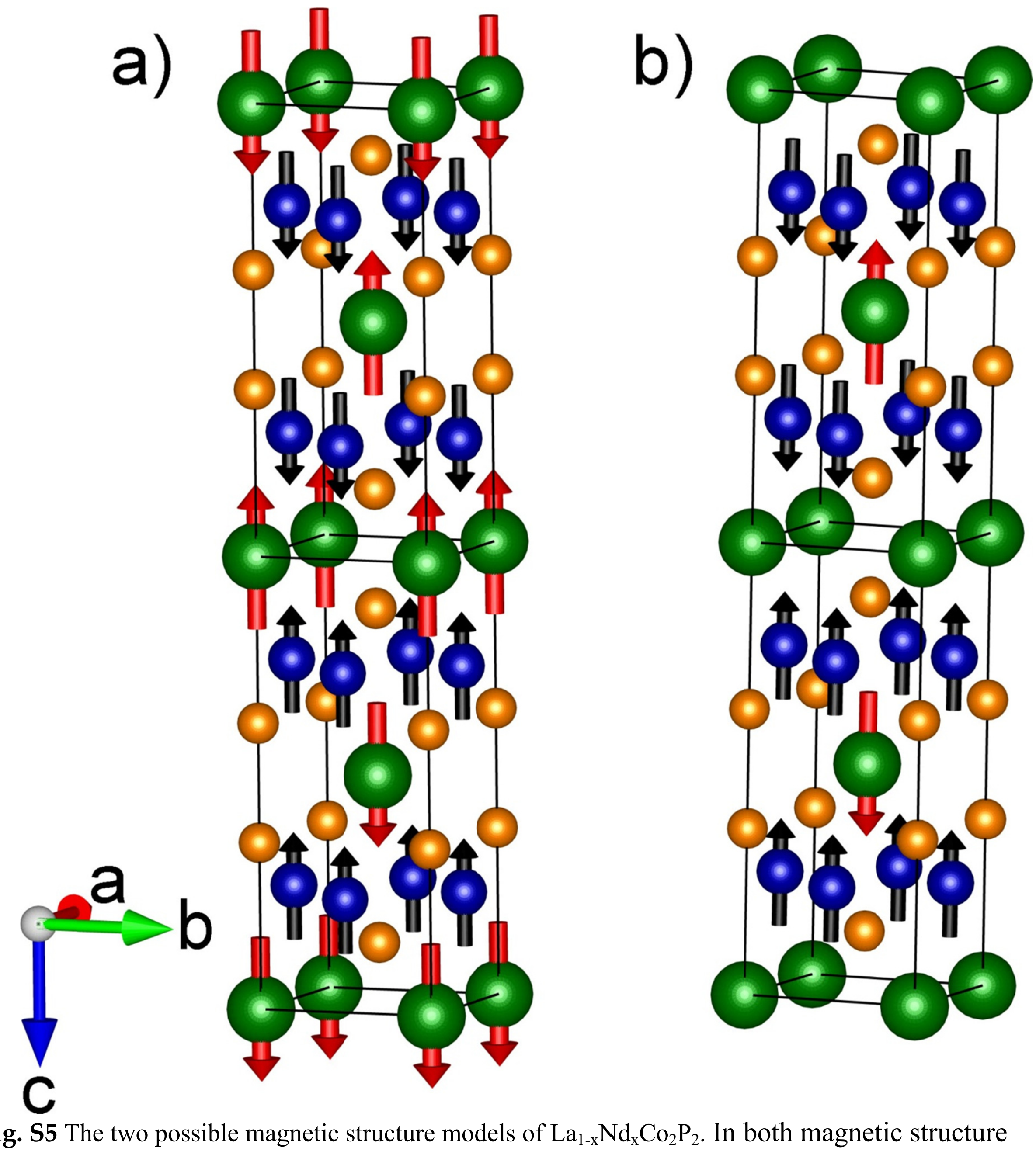

Fig. S5 The two possible magnetic structure models of $La_{1-x}Nd_xCo_2P_2$. In both magnetic structure models the order of the cobalt moments along the *c*-axis is the same with the sequence ++--,++--. a) This magnetic structure model corresponds to the order of the Nd^{3+} moments ++--,++-- (Nd positions (0,0,0 & ½,½,½)). b) Every other Nd layer has disordered moments and the sequence is 0-0+,0-0+ (Nd position (½,½,½)).