Magnetic properties of the layered structure $Pr_3Os_4Al_{12}$ compound

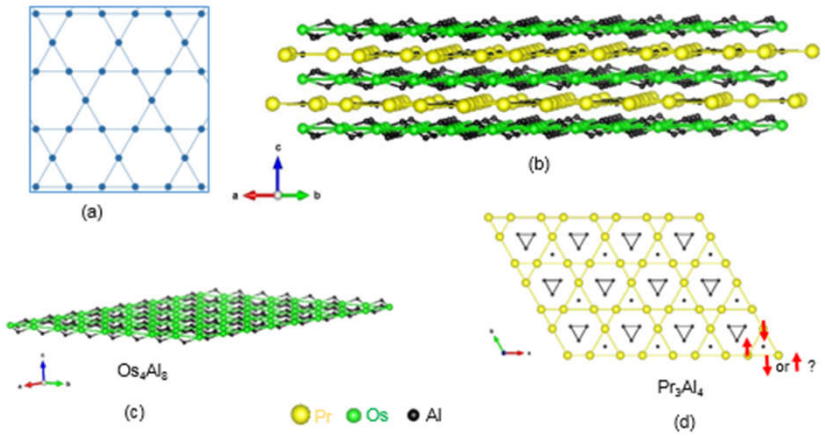
by

Michael Ogunbunmi
Highly Correlated Matter Research Group
Physics Department, University of Johannesburg
South Africa

29 February, 2019

Table of Content

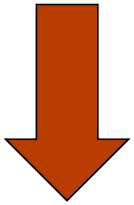
- $Pr_3Os_4Al_{12}$ is a layered structure material with a distorted-Kagomé lattice type.



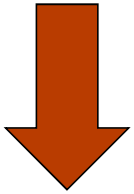
- The projection of the Pr_3Al_4 layer shows the distorted-Kagomé lattice
- The Pr^{3+} ion are placed in a regular triangular arrange making an AFM arrangement of the spins non-trivial.

Niermann, J. and Jeitschko, W. *Z. Anorg. Allg. Chem.* 628 (2002) 2549.
W. Ge. *et al. J. Phys. Conf. Ser.* 344 (2012) 012023.

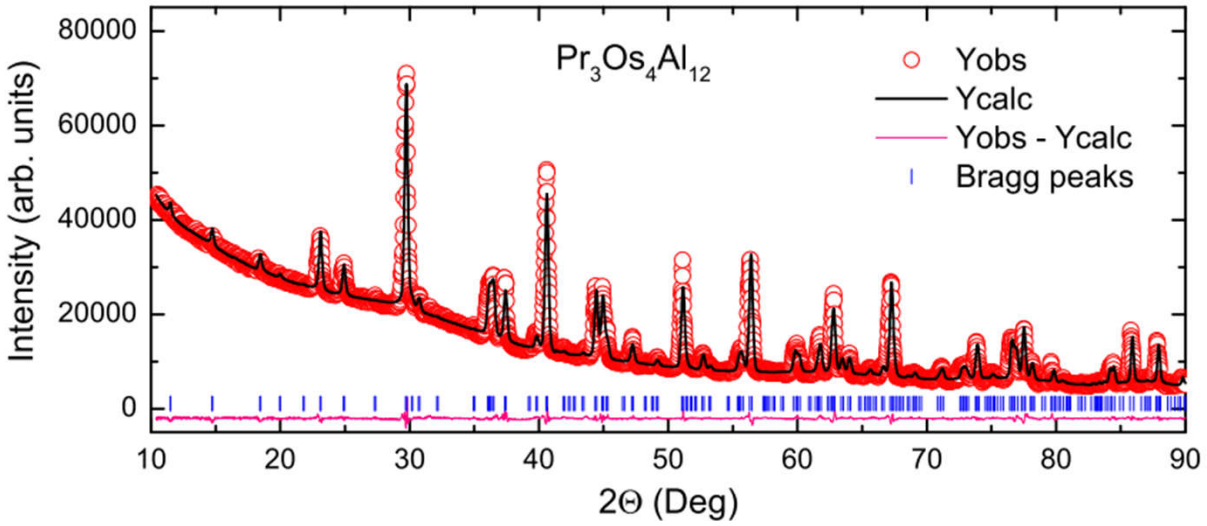
Sample synthesis



Sample quality assessment



- ❑ Magnetometry
- ❑ Physical properties



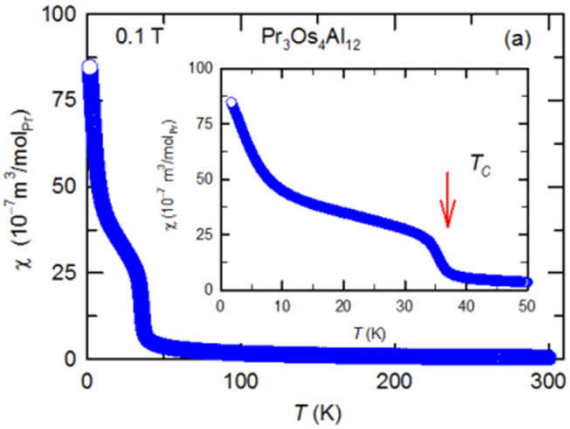
Phase name	$Gd_3Ru_4Al_{12}$
Space group/Number	$P6_3/mmc$ / 194
Pearson Symbol	$hp38$
Z formula units	2

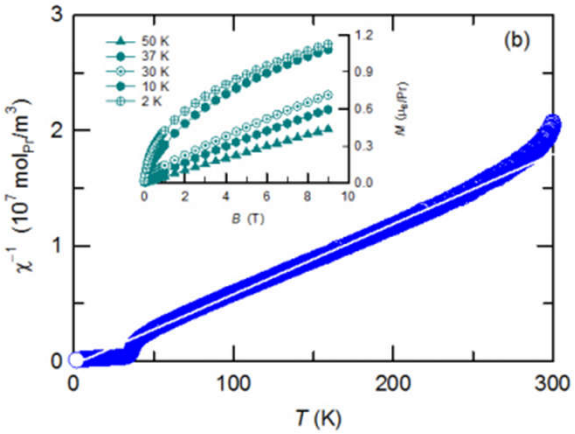
Compound	a(Å)	c(Å)	v(Å^3)	R_p (%)	R_{wp}(%)	χ^2
$Pr_3Os_4Al_{12}$	8.879	9.608	655.94	2.743	4.187	7.574

Site notation	Atom	Wyckoff site	Point symmetry	x	y	z	Occupancy
Al(1)	Al	12k	m	0.1617	0.3235	0.5780	0.8291
Al(2)	Al	6h	$mm2$	0.5608	0.1217	1/4	0.4145
Al(3)	Al	4f	$3m$	1/3	2/3	0.0161	0.2764
Al(4)	Al	2b	$-6m2$	0	0	1/4	0.1704
Pr	Pr	6h	$mm2$	0.1945	0.3889	1/4	0.3366
Os(1)	Os	6g	$2/m$	1/2	0	0	0.3178
Os(2)	Os	2a	$-3m$	0	0	0	0.0735
Os(3)	Os	6h	$mm2$	0	0	1/4	0.0281

Gladyshevskii, R.E *et al. Acta Crystallogr. B* 49 (1993) 474.

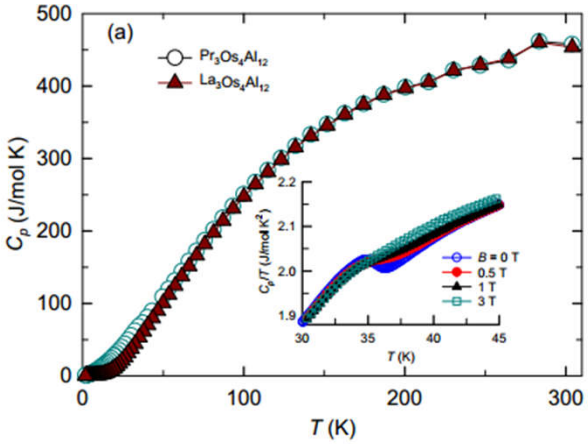
Magnetic susceptibility and Specific heat

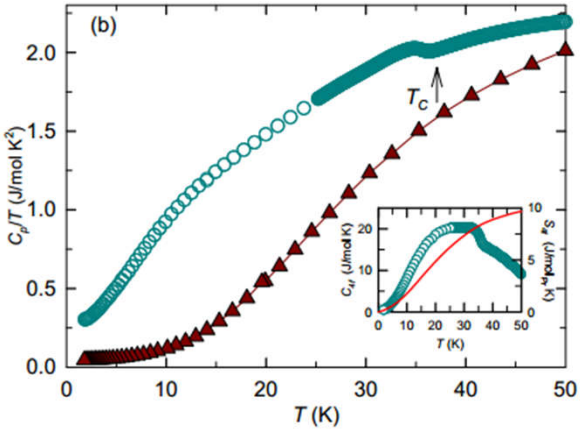




$$\chi(T) = \frac{N_A \mu_{\text{eff}}^2}{3k_B(T-\theta_p)}$$

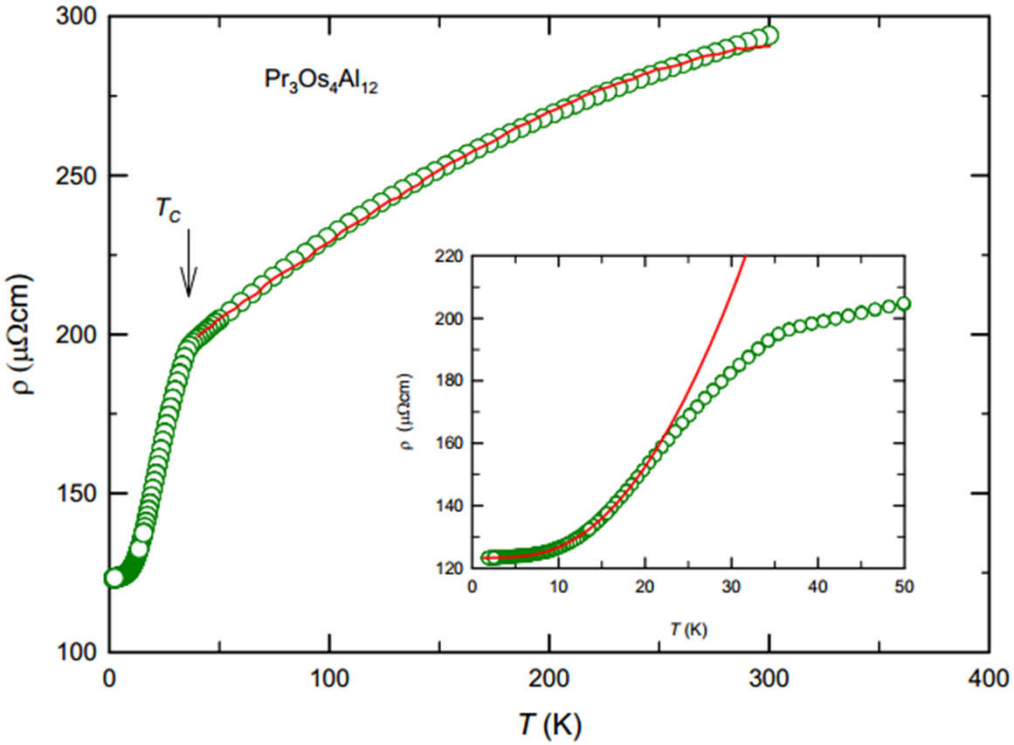
- Θ_p = 13 K
- μ_{eff} = 3.45 μ_B/Pr
- T_C = 37 K





$$C_p(T) = \gamma T + \beta T^3$$

- T_C = 37 K
- S_{4f} = 0.6Rln(9) is recovered at T_C



Bloch-Grüneissen-Mott model

$$\rho(T) = \rho_0 + \frac{4K}{\Theta_R}\left(\frac{T}{\Theta_R}\right)^5 \int_0^{\Theta_R/T} \frac{x^5 dx}{(e^x - 1)(1 - e^{-x})} - \alpha T^3$$

- ρ_0 = 189.3 μΩcm
- Θ_D = 40.63 K
- K = 33.17 μΩcm.K
- α = 1.622 × 10 ^{6} μΩcm/K^3

Spin-gap model

$$\rho(T) = \rho_0 + aT^2 + bT\Delta\left(1 + \frac{2T}{\Delta}\right)\exp\left(\frac{-\Delta}{T}\right)$$

- ρ_0 = 123.6 μΩcm
- Δ = 11.45 K
- *b* = 0.073 μΩcm/K^2
- α = 0.038 μΩcm/K^2

Mott, N.F. and Jones, H. *The Theory of the Properties of Metals and Alloys,* Dover publications, inc., Oxford England, 1958.
Andersen, N.H. *Crystalline Electric Field and Structural Effects in f-electron Systems*, Plenum, New York, 1980.

- We have investigated the physical and magnetic properties of $Pr_3Os_4Al_{12}$
- The compound shows a ferromagnetic ordering at $T_C = 37$ K
- The entropy recovered at T_C is 0.6Rln(9) suggesting that nearly all the levels are populated at T_C
- The electrical transport shows the opening of a spin gap below T_C
- Future works will focus on investigating the compound using synchrotron X-ray source as well as neutron scattering to further understand the magnetic structures and crystal field excitations present.

Acknowledgement

- I appreciate my Ph.D. supervisor, Prof. André M. Strydom for his mentorship and for giving me access to research facilities.
- I appreciate all the members of the Highly Correlated Matter Research Group, Physics Department, UJ for their supports.
- UJ-URC and NRF bursaries are appreciated.

References

1. Niermann, J., Jeitschko, W., *Z. Anorg. Allg. Chem.* 628 (2002) 2549.
2. Ge, W., Ohta, H., Michioka, C., Yoshimura, K., *J. Phys. Conf. Ser.* 344 (2012) 012023.
3. Gladyshevskii, R.E., Strusievicz, O.R., Cenzual, K., Parth´e, E., *Acta Crystallogr. B* 49 (1993) 474.
4. Rodriguez-Carvajal, J. (1990) In *satellite meeting on powder diffraction of the XV congress of the IUCr* (Vol. 127). Toulouse, France:[sn].
5. Mott N.F., Jones H., *The Theory of the Properties of Metals and Alloys,* Dover publications, inc., Oxford England 1958.
6. Andersen, N.H., *Crystalline Electric Field and Structural Effects in f-electron Systems,* Edited by Crow, J.E., Guertin, R.P., and Mihalisin, T.W., Plenum, New York, 1980.

Thank you for your attention