Poster

High-Pressure Structural Investigations of $AuSn_4$ and its Potential Chemical Pressure Equivalent $PtSn_4$

Sathea Suweatha M N[1,2*], Sonachalam Arumugam[2,3], Boby Joseph[1†]

[1]Elettra-Sincrotrone Trieste S.C. p. A., S.S. 14, Km 163.5, Basovizza 34149, Italy, [2]Centre for High Pressure Research (CHPR), School of Physics, Bharathidasan University, Tiruchirappalli 620024, India, [3]Tamil Nadu Open University, Chennai 600 015, India

*sathyasweathamn05@gmail.com, †boby.joseph@elettra.eu

Ambient conditions diffraction data of $AuSn_4$ and $PtSn_4$ compounds can be described by an orthorhombic Aba2 (space group 41) structure with identical Wyckoff positions: 4a, for the noble metal and 8b for two types of Sn (I and II) [1], thus making these compounds isomorphous. These compounds come under the new category of materials known as *topological nodal line semimetals* with non-trivial topological features [2,3]. Although isomorphous, these compounds have notable differences in their physical properties. As per our electrical resistivity measurements, at low temperatures the $AuSn_4$ shows superconductivity (T_c ~ 2.4 K) whereas $PtSn_4$ shows magnetoresistance; both observations are in-agreement with earlier reports [2,3]. We have studied these systems under high-pressure (HP) using synchrotron x-ray diffraction (XRD) and Raman spectroscopy. Interestingly, from our HP-XRD and HP Raman measurements, we can consider $PtSn_4$ as a chemical pressure equivalent of $AuSn_4$ at ~ 5 GPa. See for example the HP-Raman data of $AuSn_4$ together with that of the ambient condition $PtSn_4$ (Fig. a) and the pressure dependence of the $AuSn_4$ together with the same of $PtSn_4$ (Figs. b-e). Notably, $AuSn_4$ exhibits signs of starting a structural phase transition at a low pressure, above 2 GPa (see Figs. b & d). Although the $PtSn_4$ which is under a chemical pressure of ~5 GPa with respect to $AuSn_4$, retains the orthorhombic structure at least up to ~ 8 GPa (Fig. c). Our HP Raman data also provided a consistent inference. In the 0 – 8 GPa range, we observed a continuous decrease in orthorhombic lattice parameters for both $AuSn_4$ and $PtSn_4$, incidentally both falling in an identical equation of state curve (see Figure e)), underlining the apparent chemical pressure equivalence. Although this equivalence seems to work, the low-pressure initialisation of a structural phase transition in $AuSn_4$ implies its structural instability [4] and possible polytypsim in this system [5] compared to $PtSn_4$.The relevance of these results on the physical properties of these systems, particularly the pressure dependence will be discussed.

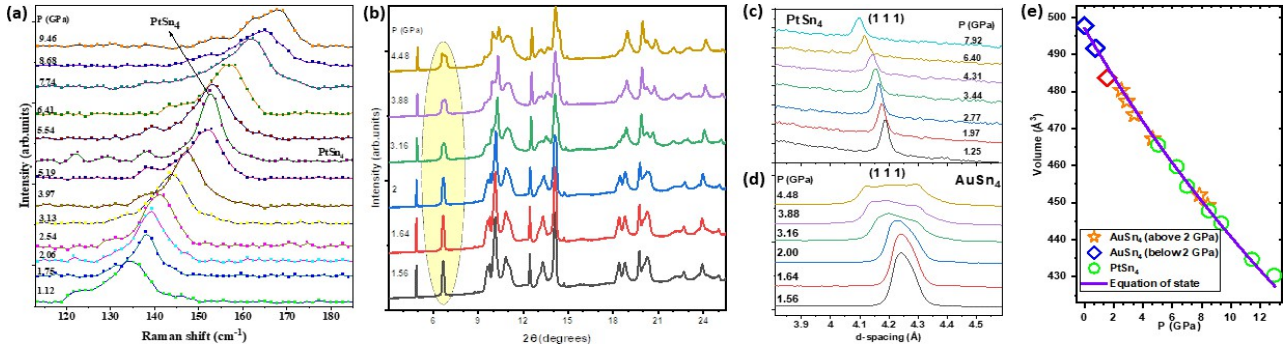

Figure (a) High-pressure Raman spectra of $AuSn_4$ together with the same of the ambient $PtSn_4$ (as indicated by an arrow). (b) High-pressure XRD of $AuSn_4$. Pressure evolution of the (1 1 1) Bragg peaks $PtSn_4$ (c) and $AuSn_4$ (d). (e) Pressure vs volume plot of $AuSn_4$ and $PtSn_4$. Here the ambient pressure data of $PtSn_4$ is assumed to be at a chemical pressure of 5.04 GPa (considering the unit-cell volume) to include both data sets in a single plot.

[1] Kubiak, R., & Wolcyrz, M. (1984). Refinement of the crystal structures of AuSn4 and PdSn4, in *Journal of the Less-Common Metals*

[2] Shen, D., *et al.,* (2020). Two-dimensional superconductivity and magneto transport from topological surface states in AuSn4 semimetal. *Communications Materials*, 1(1). https://doi.org/10.1038/s43246-020-00060-8 & Zhu, W., *et al.*,(2023). Intrinsic surface p-wave superconductivity in layered AuSn4. *Nature Communications*, 14(1). https://doi.org/10.1038/s41467-023-42781-7

[3] Wu, Y., *et al.*, (2016). Dirac node arcs in PtSn4. *Nature Phys* **12**, 667–671. https://doi.org/10.1038/nphys3712 & Luo, X., *et al*. (2018). Origin of the extremely large magnetoresistance in topological semimetal PtSn 4. *Phys. Rev. B*, 97(20). https://doi.org/10.1103/PhysRevB.97.205132

[4] Kubiak, R. (1981). The influence of temperature on the structure of AuSn4 crystal. *in Journal of the Less-Common Metals* (Vol. 80). https://www.sciencedirect.com/science/article/abs/pii/0022508881901016, & Yadav, *et al.,* (2023). Stability of AuSn4 compound in low temperature. http://arxiv.org/abs/2309.10571

[5] Herrera, E., *et al*. (2023). Band structure, superconductivity, and polytypism in AuSn4. *Phys. Rev. Mater.*, 7(2). https://doi.org/10.1103/PhysRevMaterials.7.024804