Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **3230** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

Charge Density Wave Order and Fluctuations above T_CDW and below Superconducting T_c in the Kagome Metal CsV3Sb5

Monday 6 June 2022 17:00 (15 minutes)

The phase diagram of the kagome metal family AV_3Sb_5 (A = Cs, Rb, K) features both superconductivity and charge density wave (CDW) instabilities, which have generated tremendous recent attention. Nonetheless, significant questions regarding the nature of the CDW states remain. In particular, the temperature evolution and demise of the CDW state has not been extensively studied, and little is known about the co-existence of the CDW with superconductivity at low temperatures. We report an x-ray scattering study of CsV_3Sb_5 over a broad range of temperatures from 300 K to $\sim$ 2 K, below the onset of its superconductivity at $T_c \sim$ 2.9 K. Order parameter measurements of the $2 \times 2 \times 2$ CDW structure show an unusual and extended linear temperature dependence onsetting at $T^* \sim 160$ K, much higher than the susceptibility anomaly associated with CDW order at $T_{CDW} = 94$ K. This implies strong CDW fluctuations exist to $\sim 2 \times T_{CDW}$. The CDW order parameter is observed to be constant from $T = 16$ K to 2 K, implying that the CDW and superconducting order co-exist below T_c, and, at ambient pressure, any possible competition between the two order parameters is manifested at temperatures well below T_c, if at all. Anomalies in the temperature dependence in the lattice parameters coincide with T_{CDW} for $c(T)$ and with T^* for $a(T)$.

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Session Classification: M3-2 Unconventional superconductivity and topology (DCMMP) | Supraconductivité non conventionnelle et topologie (DPMCM)

Track Classification: Technical Sessions / Sessions techniques: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)