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(G) Intermediate Valence state in YbB₄ revealed by RXES

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In crystal systems with competing, incongruous, anti-ferromagnetic exchange interactions, geometric frustration is found and often leads to the suppression of long-range magnetic order. On the other hand, in Yb-based systems where the Kondo interaction between local 4f and conduction electrons is dominant, hybridization between these also results in the suppression of long-range magnetic order. When the Kondo interaction is strong enough physical hybridization between the 4f and conduction electrons occurs, resulting in a quantum mechanically degenerate electronic ground-state, a so-called intermediate valence (IV) state. YbB₄ is a rare system where both mechanisms are plausible explanations for the lack of magnetic order down to at least 0.34 K [1]. YbB₄ crystallizes into a tetragonal crystal structure (space group P4/mbm) that can be mapped to the well known geometrically frustrated Shastry-Sutherland Lattice within the ab plane [2]. YbB₄ has also been proposed as a Kondo-dominated system residing in the IV regime but has to date lacked direct confirmation of such via spectroscopic means [3,4]. We study the existence of an IV state in YbB4 using resonant X-ray emission spectroscopy at the Yb $L_{(1)}$ transition and study the temperature dependence of the Yb valence from 12 to 300 K. We confirm that YbB_4 exists in an IV state at all temperatures and observe that the Yb valence increases gradually from $v=2.61\pm0.01$ at 12 K to $v=2.67\pm0.01$ at 300 K. We compare the temperature scaling of the valence with other Yb-based Kondo lattices and find that YbB_4 and other systems within the IV regime do not obey the universal temperature scale of valence change, T_v , observed in weakly mixed-valent Kondo lattices [5]. We find that in the case of IV systems, T_v also does not appear to be linked to the Kondo temperature T_K of the system.

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[5] K. Kummer et al., Nature Communications 9, 2011 (2018).

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