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Influence of interstitial Mn on spin order and dynamics in the room-temperature ferromagnet $Mn_{1+\delta}Sb$

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$Mn_{1+\delta}Sb$ is a well-known, high Curie temperature, ferromagnetic metal. It has particular importance because it, and closely related MnBi, show promise as alternatives to rare-earth-containing permanent magnets, and as magneto-optic media. To exploit these materials useful properties, it is desirable to tune and optimize the magnetic properties [1]. To achieve this, the magnetic interactions, and the effects of doping and defects must be understood. In $Mn_{1+\delta}Sb$ the magnetic order is highly sensitive to the interstitial Mn ion content, δ, suggesting a route to tune the properties [2]. However, detailed theoretical and experimental investigations of the effect of the interstitial ion, Mn2, have been lacking, probably due to a prevailing view in the literature that the Mn2 site is nonmagnetic [3,4]. We examine the magnetic state of Mn2, and its influence on the magnetic properties of $Mn_{1+\delta}Sb$. We use a combination of neutron scattering techniques alongside detailed calculations to show that the Mn2 site is in-fact magnetic, and has a dramatic impact on the magnetic dynamics in $Mn_{1+\delta}Sb$. An unusual, broad, intense feature is identified in the magnetic dynamics which cannot be explained by the long-range symmetry of the material. This reveals an area in which current theoretical/modeling techniques limit our ability to understand the magnetic excitations revealed by neutron scattering. This investigation elucidates important aspects of the behavior of $Mn_{1+\delta}Sb$, whilst highlighting requirements for future research to understand the major influence of the interstitial ion on the magnetic properties. [1] A. E. Taylor et al., Phys. Rev. B, 91, 224418 (2015). [2] T. Okita and Y. Makino, J. Phys. Soc. Jpn. 25, 120 (1968). [3] Y. Yamaguchi et al., J. Phys. Soc. Jpn. 45, 846 (1978). [4] W. Reimers et al., J. Phys. Chem. Solids 44, 195 (1983).