Spin Wave Dispersion in a Weyl Semimetal Candidate $YbMnBi_2$

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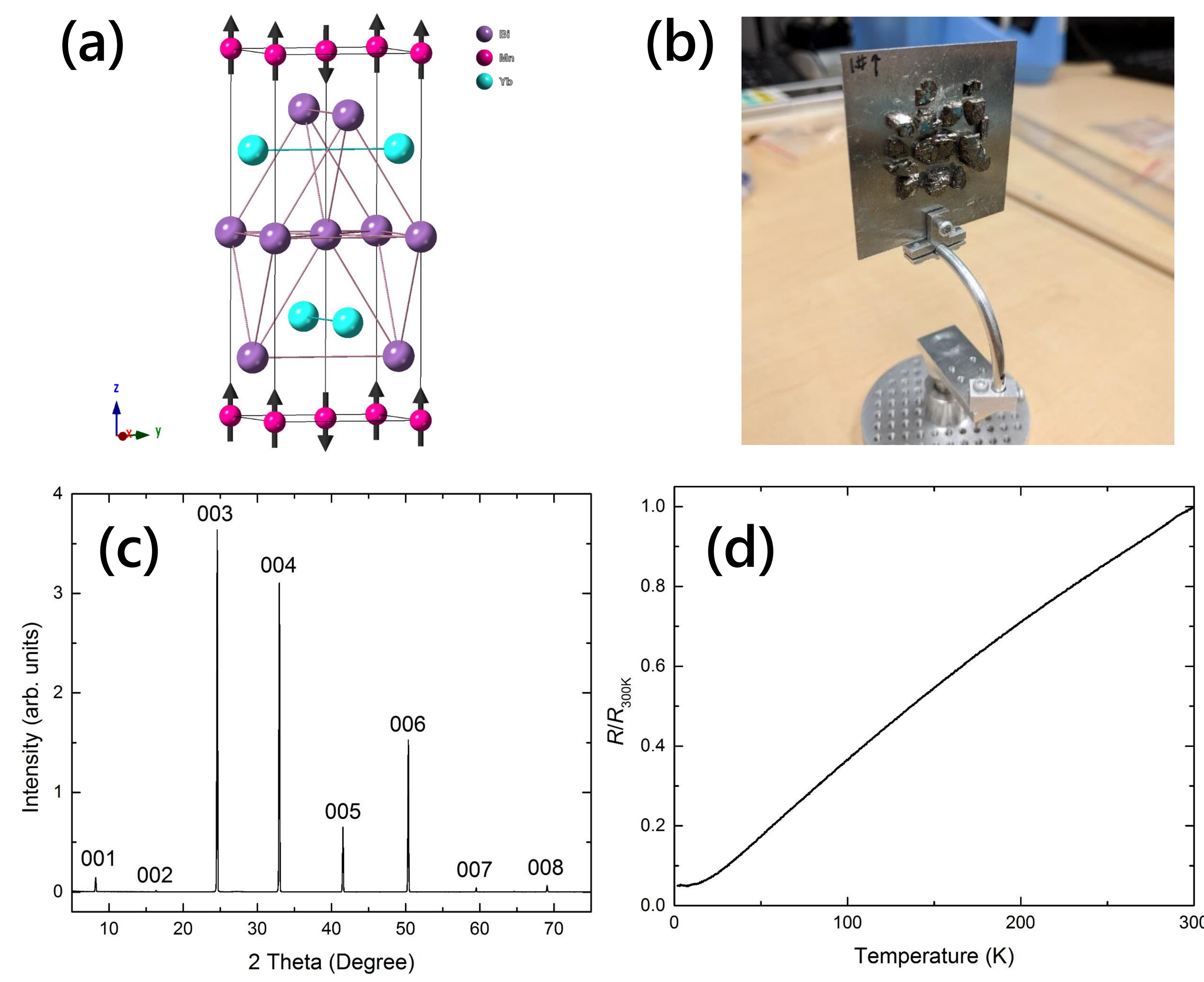
Abstract

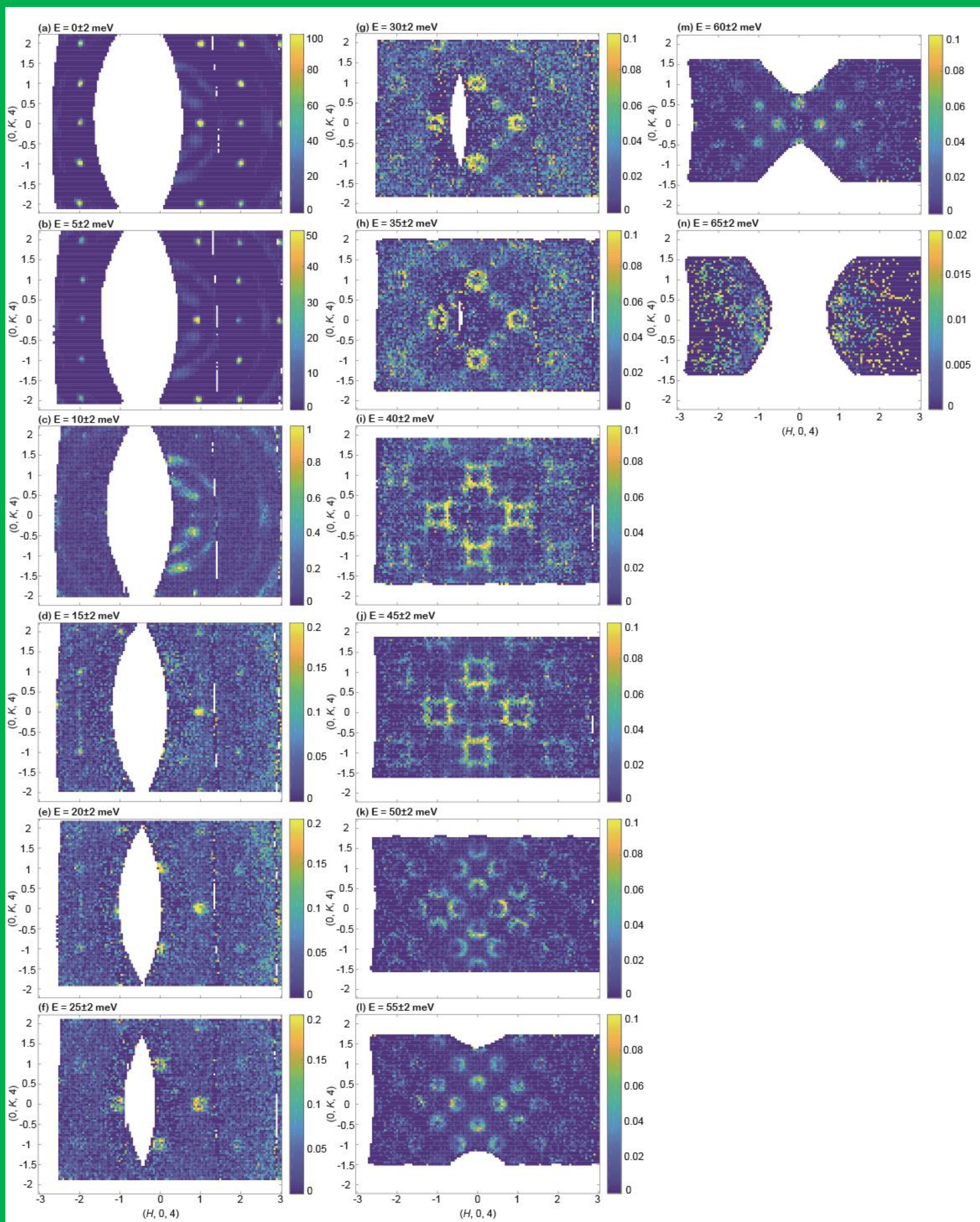
Either the breaking of time reversal symmetry or inversion symmetry is necessary to induce Weyl fermions. While most studied Weyl semimetals are non-centrosymmetric materials which have inversion symmetry breaking, $YbMnBi_2$ is proposed to be the very few Weyl semimetal candidate with time reversal symmetry breaking by magnetism [1]. Here, using inelastic neutron scattering experiments, the spin wave dispersion of $YbMnBi_2$ has been mapped out and the observed spectra can be reproduced by linear spin-wave theory with a Heisenberg Hamiltonian. Furthermore, in-plane exchange coupling parameters as well as the magnetocrystalline anisotropy constant have been determined.

I. $YbMnBi_2$ Sample and Characteristics



(a) The crystal and magnetic structure of $YbMnBi_2$ below T_N. **(b)** Photo of $YbMnBi_2$ single crystals co-aligned in the (*H0L*) zone. **(c)** XRD pattern of the cleavage plane. **(d)** Resistivity measurements on $YbMnBi_2$ single crystal.

II. The Dispersion of the Spin Excitations



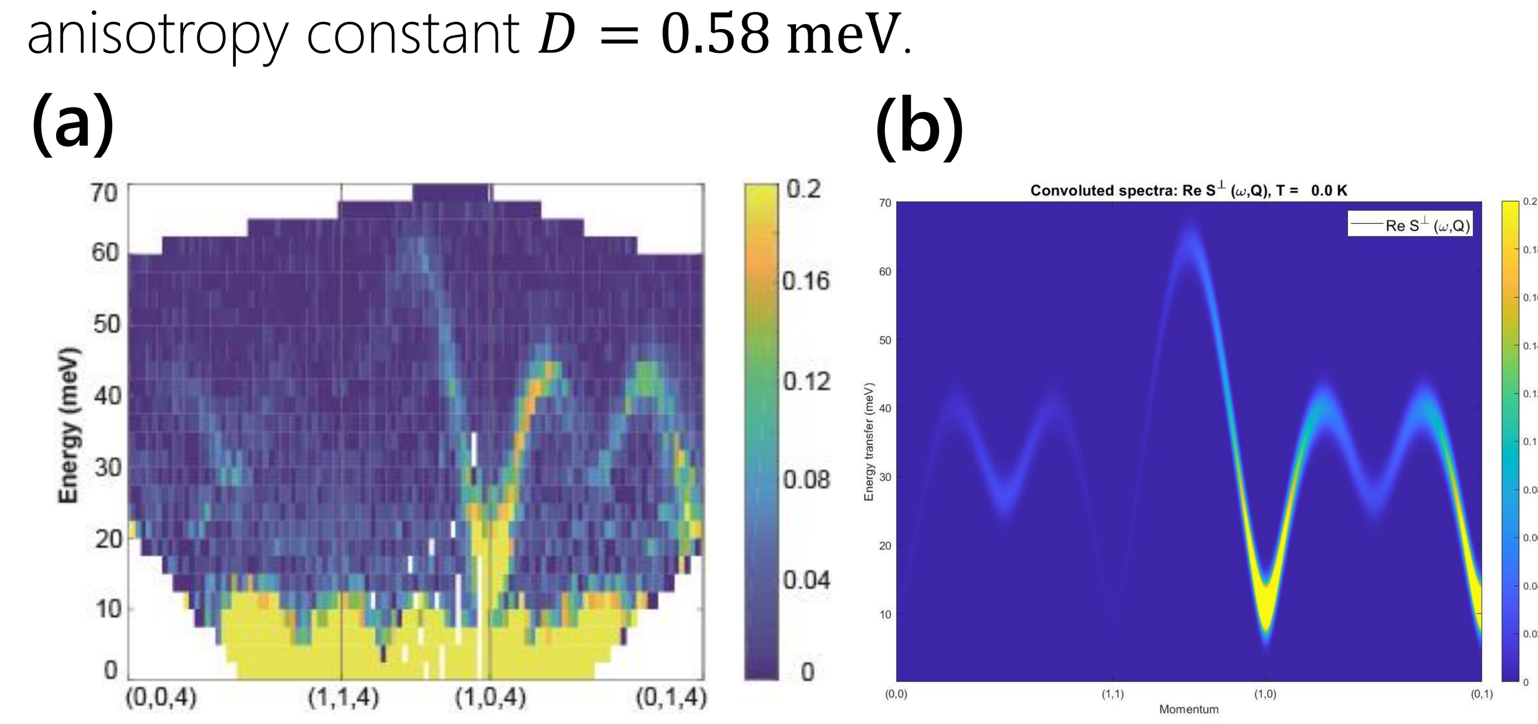
In-plane momentum dependence of the spin excitations in $YbMnBi_2$ at T = 4 K. **(a)-(n)** Constant energy slices acquired at 4 K and at indicated energies. The color bar indicates scattering intensity in arbitrary units.

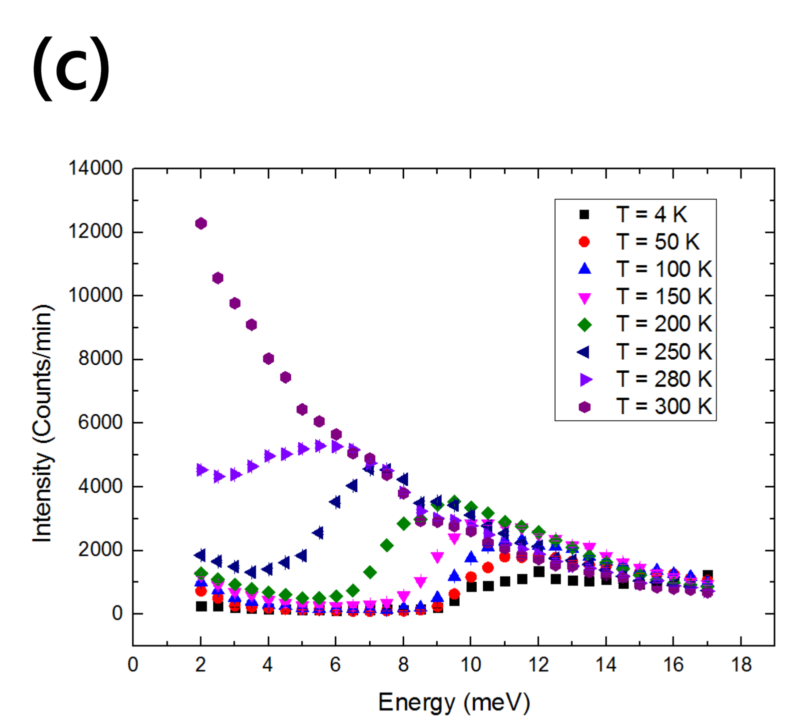
III. Spin-wave Calculations and Temperature Dependence

The Hamiltonian used for spin-wave calculations:

$$\hat{H} = \sum_{<i,j>} J_{ij}\hat{J}_i \cdot \hat{J}_j - D\left(\hat{S}_i^z\right)^2$$

The parameters we include in the calculation are the nearest-neighbor coupling $J_1 = 25.0$ meV, the next-nearest-neighbor coupling $J_2 = 9.2$ meV and the anisotropy constant $D = 0.58$ meV.





(a) The dispersion of the spin excitations along high symmetry directions in $YbMnBi_2$ at T = 4 K. **(b)** The corresponding spin-wave spectrum generated from the previous Hamiltonian using the SPINW programme. **(c)** The temperature dependence of energy scans at Q = (1, 0, 0).

Reference
[1] Sergey Borisenko, et al. arXiv: 1507.04847 (2015)