Controlled Evolution of Three-Dimensional Magnetic States in Strongly Coupled Cylindrical Nanowire Pairs

J Fullerton, A Hierro-Rodriguez, C Donnelly, D Sanz-Hernández, L Skoric, D A MacLaren and A Fernández-Pacheco

S1 Growth simulations energy profiles and transitions

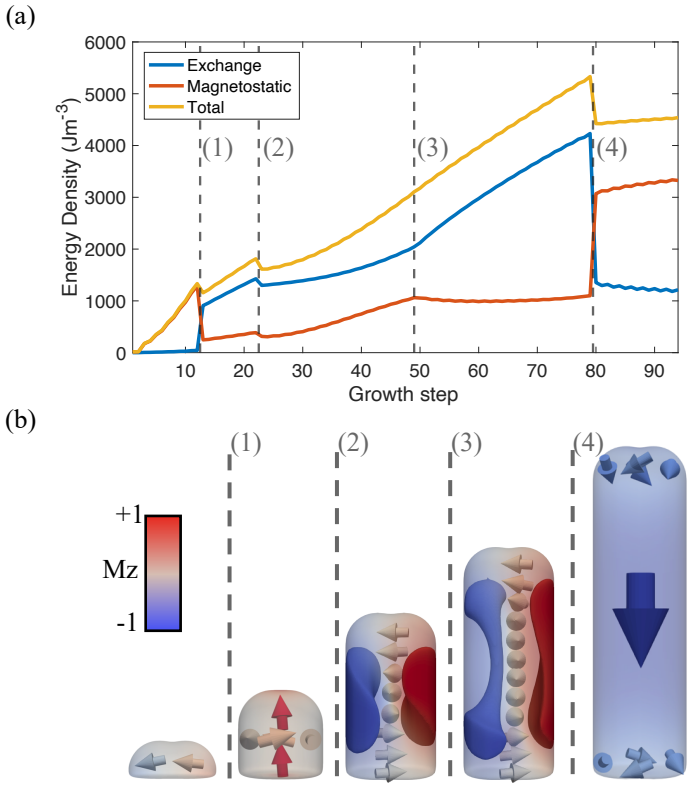

Figure S1: (a) Plot of exchange, magnetostatic and total energy density vs. growth step for the simulated fabrication of a nanowire with a separation of 20 nm. Dotted grey lines are overlaid to show locations of transitions between states. Transitions 1, 2 and 4 are located via sharp changes in the energy profiles. Transition 3 corresponds to the formation of the Landau pattern state, and is therefore located by a levelling off in magnetostatic energy while exchange energy continues to grow. (b) Vector representation of the magnetic states seen for this nanowire pair, coloured by the M_z component: Planar, Vortex, Helical DW, Landau pattern and Parallel.

S2 Further growth of the Helical domain wall

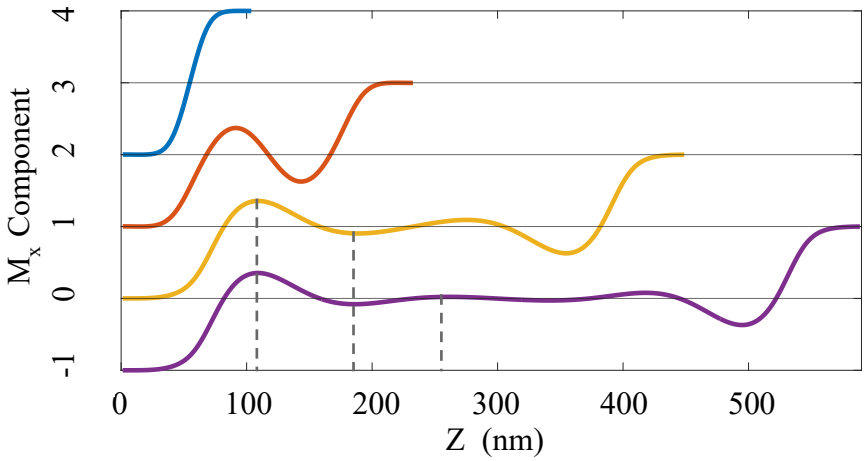

Figure S2: Line plots of M_x component vs z-coordinate for simulations of a Helical DW state with increasing height (blue – 111.25 nm, orange – 240 nm, yellow – 456.25 nm and purple – 597.5 nm) to show changes to domain wall profile. The M_x component for each simulation is offset vertically for clarity.

Figure S2 shows how the profile of the DW in the Helical DW state evolves with increasing height (lines are offset vertically for clarity). The blue line in figure S2 displays a continuous rotation of spins when going from the bottom to the top of the structure (like the DWs in references 48 and 49) when the state first forms. The orange line corresponds to the "fully grown" state plotted in figure 3d of the main text after the modulation in the DW has appeared (now deviating from the previously observed DWs [48,49]). The yellow and purple plots show how this modulation develops beyond the height discussed so far. It is observed that a smaller modulations with decreasing amplitude appear in the middle of the first. The locations (Z coordinate) of the first peaks for the yellow and purple plots are highlighted by grey dashed lines. Once fully formed, each peak does not change position while growth continues (displayed by the first and second peaks for yellow and purple profiles). We understand this to be because the first modulation forms to oppose the charges created by the Néel caps and is therefore bound to it. The subsequent modulations form to oppose any charges created by the previous one. Hence, the distance between each modulation (and the end of the Néel cap and the first peak) is constant, and for this system is equal to 75nm.