Supporting Information for: Self-Similarity of Plasmon Edge Modes on Koch Fractal Antennas

Edson P. Bellido[1], Gabriel D. Bernasconi[2], David Rossouw[1], Jérémy Butet[2], Olivier J. F. Martin[2], and Gianluigi A. Botton[1] *

[1]Department of Materials Science and Engineering, McMaster University, 1280 Main Street W. Hamilton, ON L8S 4L7, Canada

[2]Nanophotonics and Metrology Laboratory, cole Polytechnique Fdralede Lausanne, 1015 Lausanne, Switzerland

* *Corresponding author.* E-mail: gbotton@mcmaster.ca; Phone: (905) 525-9140 ex 24767

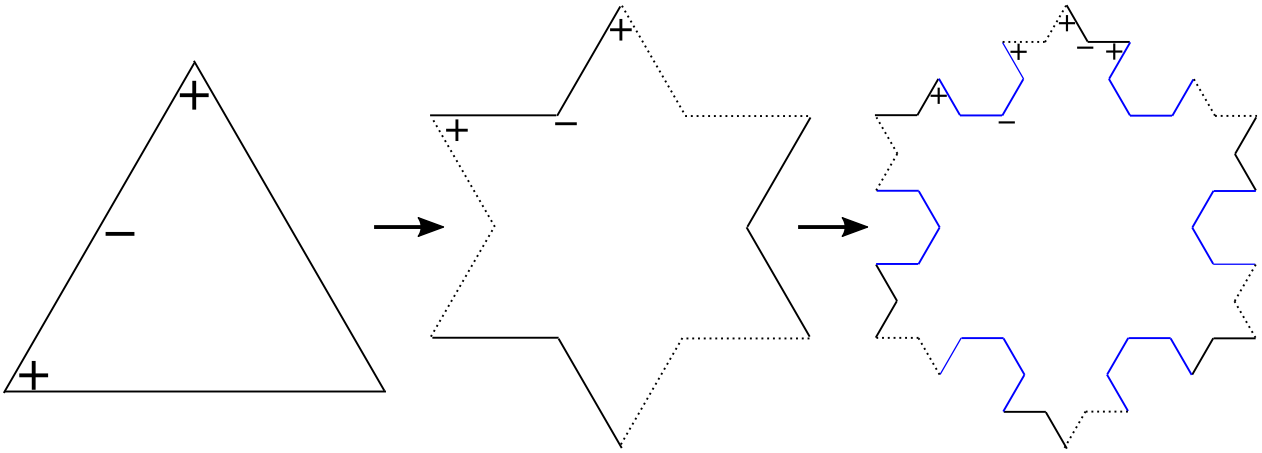

Figure S 1: (Left) Equilateral triangle which is the iteration 0 of the Koch snowflake fractal. (Center) Koch snowflake fractal iteration 1 showing the characteristic "V" edge unit of the structure formed by two line segments at an 120 degrees angle. (Right) Koch snowflake fractal iteration 2 showing its two types of chracteristic edge units: One type is the characteristic "V" shape (in black). The other type is the "U" shape (in blue) formed by two characteristic "V" shapes at 120 degrees angle. The figure shows the charge distribution of an edge mode that is supported in each one of the edges.

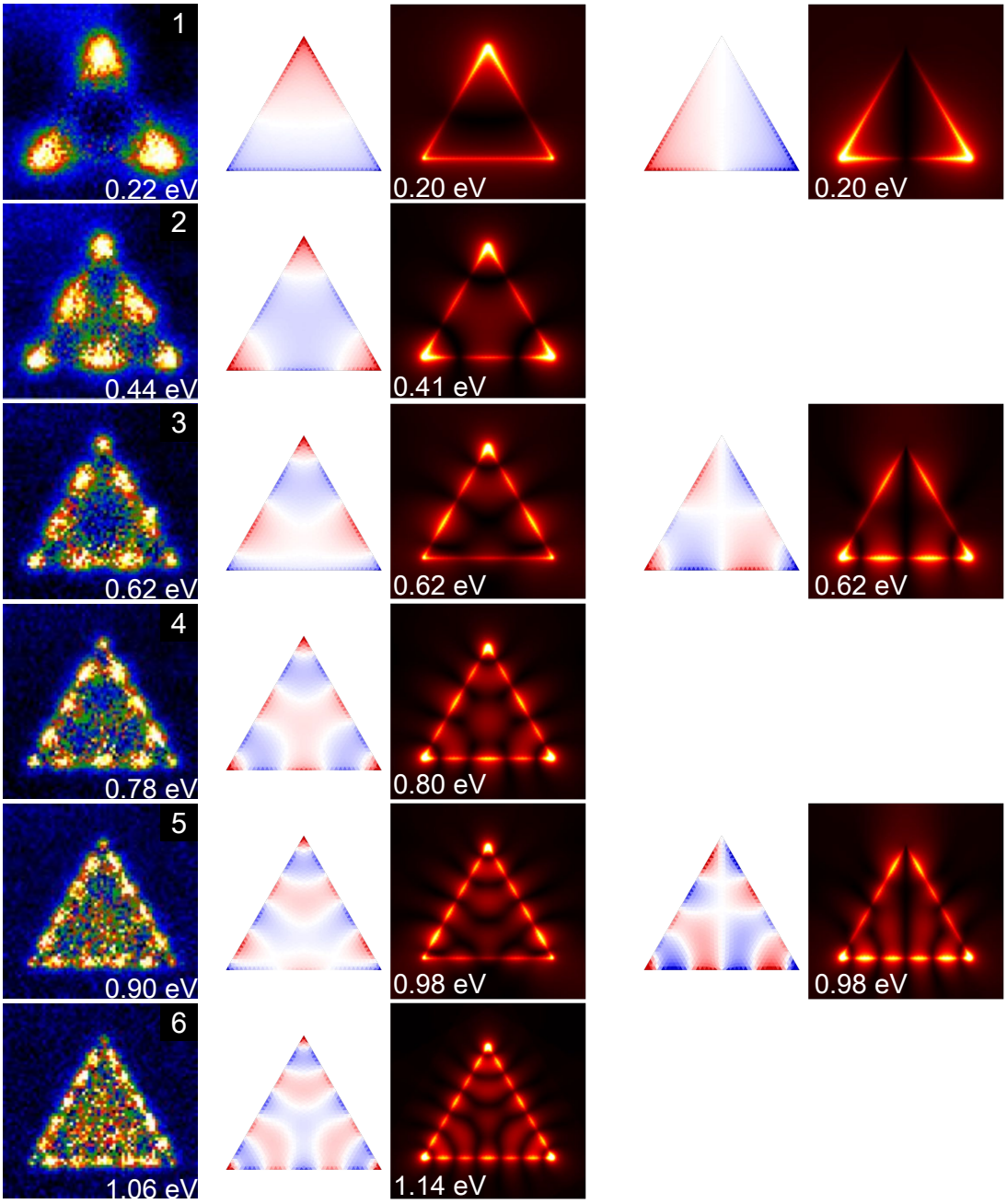

Figure S 2: Measured energy filtered maps of the Koch snowflake fractal iteration 0 and their corresponding calculated eigenmodes and their near-field distribution. The numbers on the EELS maps correspond to resonance peaks in Figure 1a in the main text, and the numbers on the near-field distributions correspond to the eigen-energies.

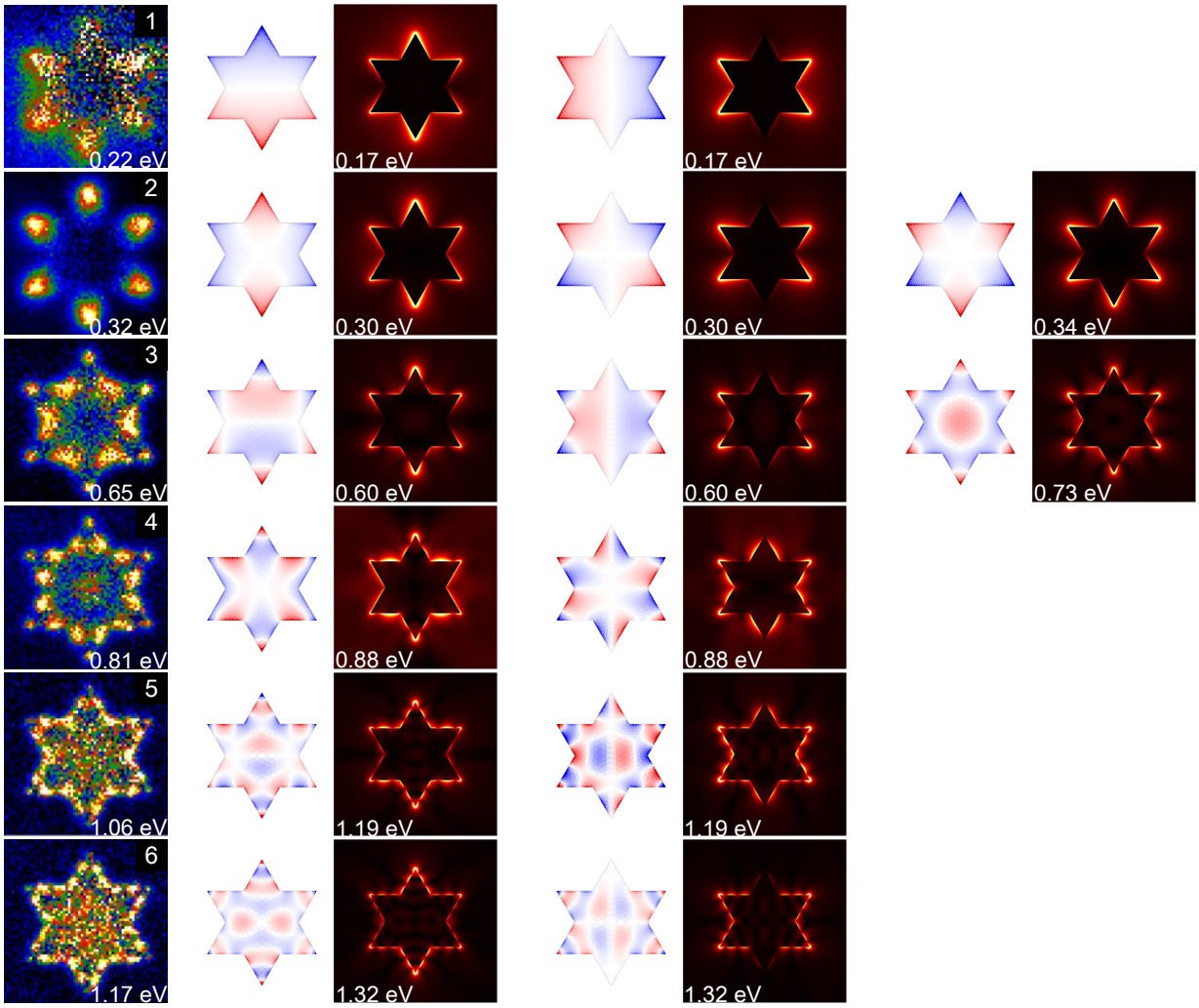

Figure S 3: Measured energy filtered maps of the Koch snowflake fractal iteration 1 and their corresponding calculated eigenmodes and their near-field distribution. The numbers on the EELS maps correspond to resonance peaks in Figure 2a in the main text, and the numbers on the near-field distributions correspond to the eigen-energies.

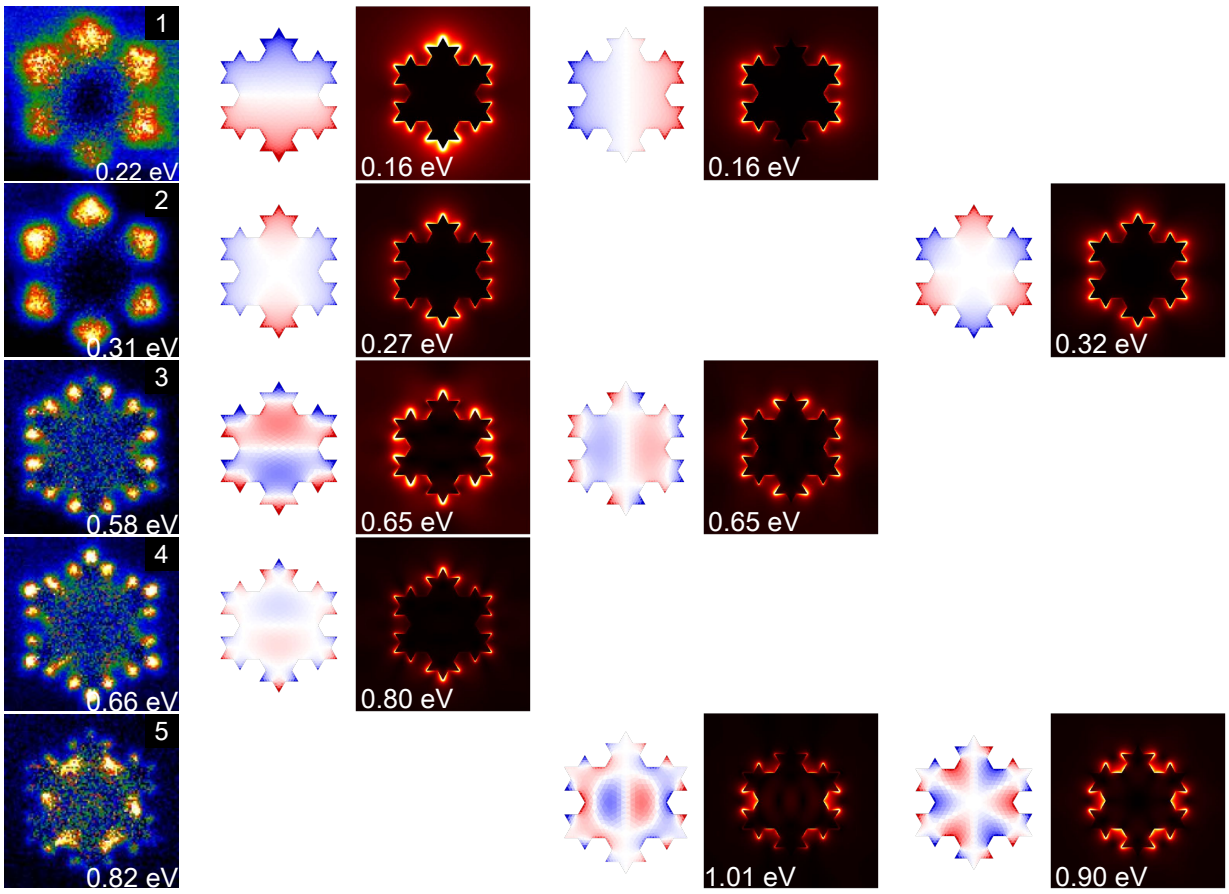

Figure S 4: Measured energy filtered maps of the Koch snowflake fractal iteration 2 and their corresponding calculated eigenmodes and their near-field distribution. The numbers on the EELS maps correspond to resonance peaks in Figure 5a in the main text, and the numbers on the near-field distributions correspond to the eigen-energies.

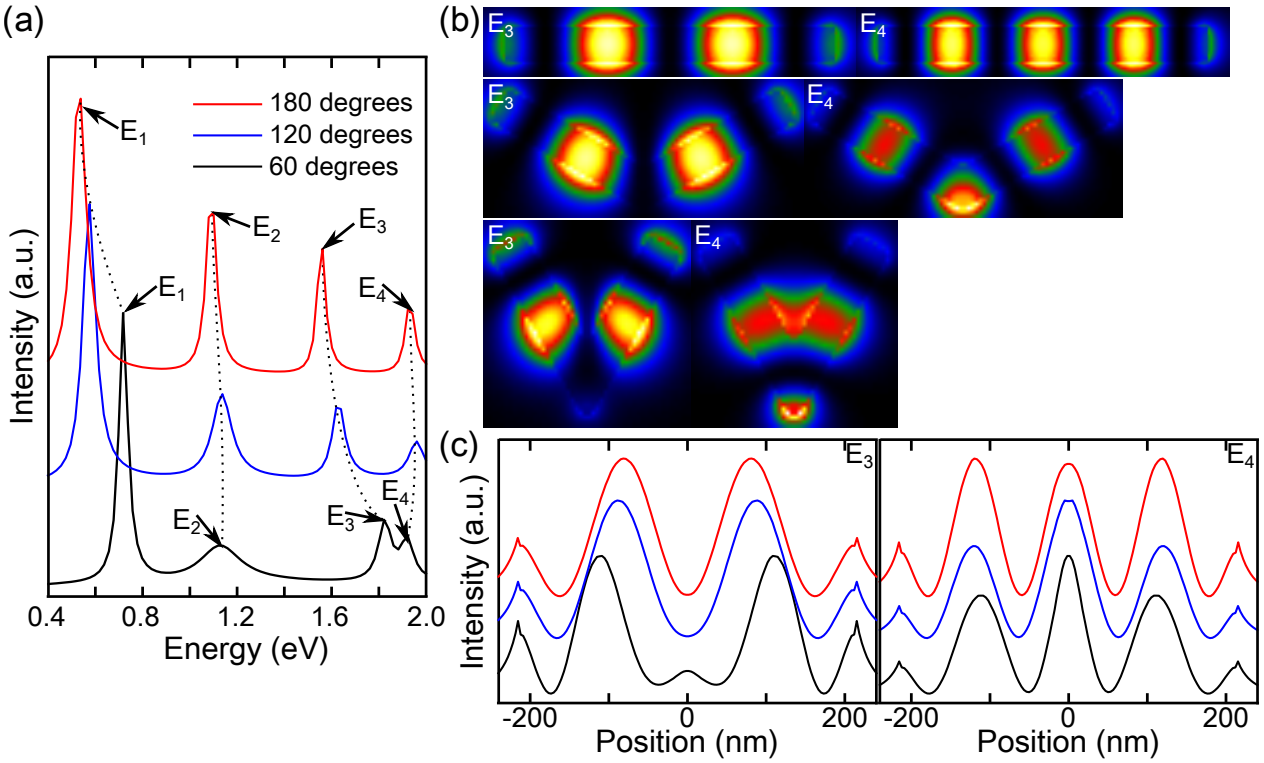

Figure S 5: Simulated EELS spectra (a) and energy filtered maps (b) of bent silver nanowires $222x44x30nm^3$. We observe that as the angle decreases from 180 to 60 degrees the odd edge modes shift to higher energies. The maps (b) show that the nodal distribution of the modes is preserve in the 120 degrees bent nanowire. However in the case of the 60 degrees bent nanowire the nodal distribution is distorted due to the interaction of the fields in each side of the nanowire. Intensity crosscuts of the E_3 and E_4 modes taken from the side of the bent nanowires.

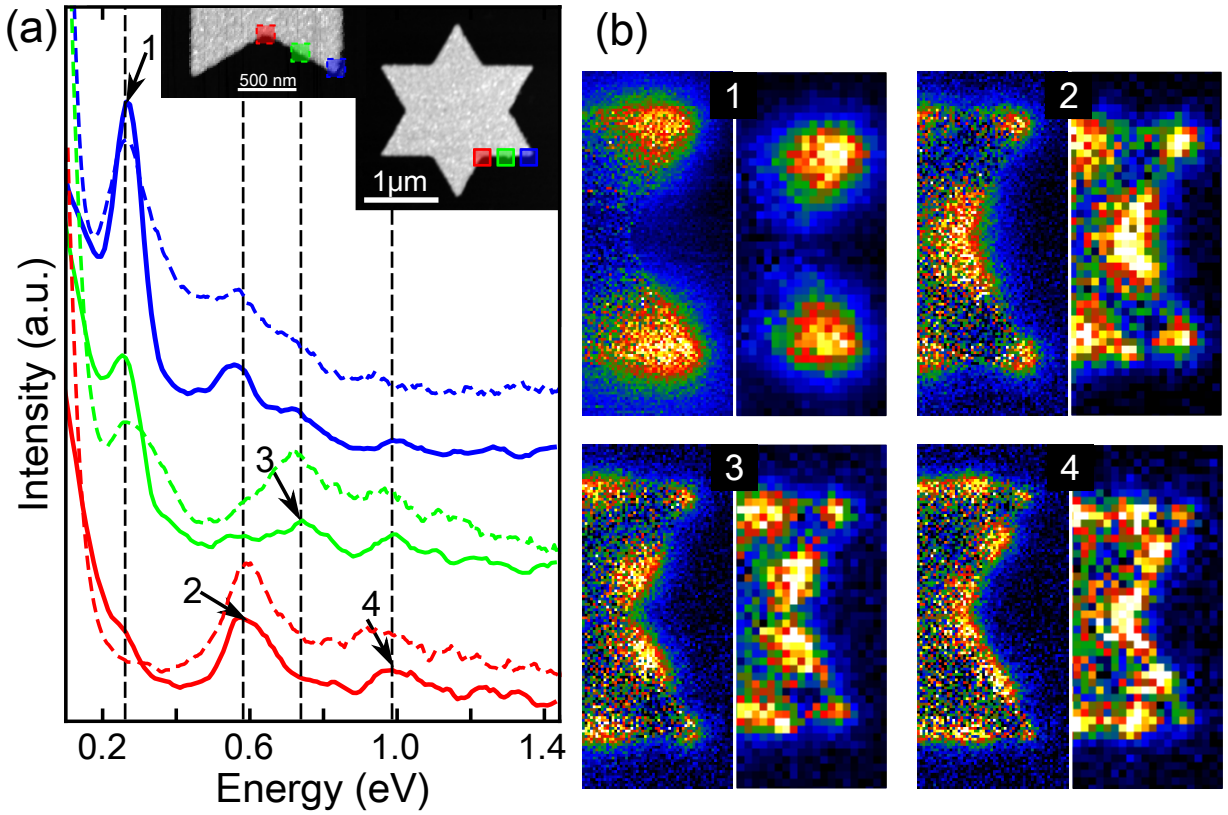

Figure S 6: Side-to-side comparison of the modes in the isolated characteristic edge units in the 50 μm silver strips (dashed lines) and in the full Koch snowflake fractals (solid lines) of iteration 1. (a) EELS spectra acquired at the positions marked on the insets. The spectra of the full Koch snowflake fractal is red shifted 70 meV to align the E_1 modes of both structures. (b) Comparison of the EELS energy filtered maps of the isolated characteristic edge units (left) and of the full snowflake (right) showing that the modes on both structures are equivalent.

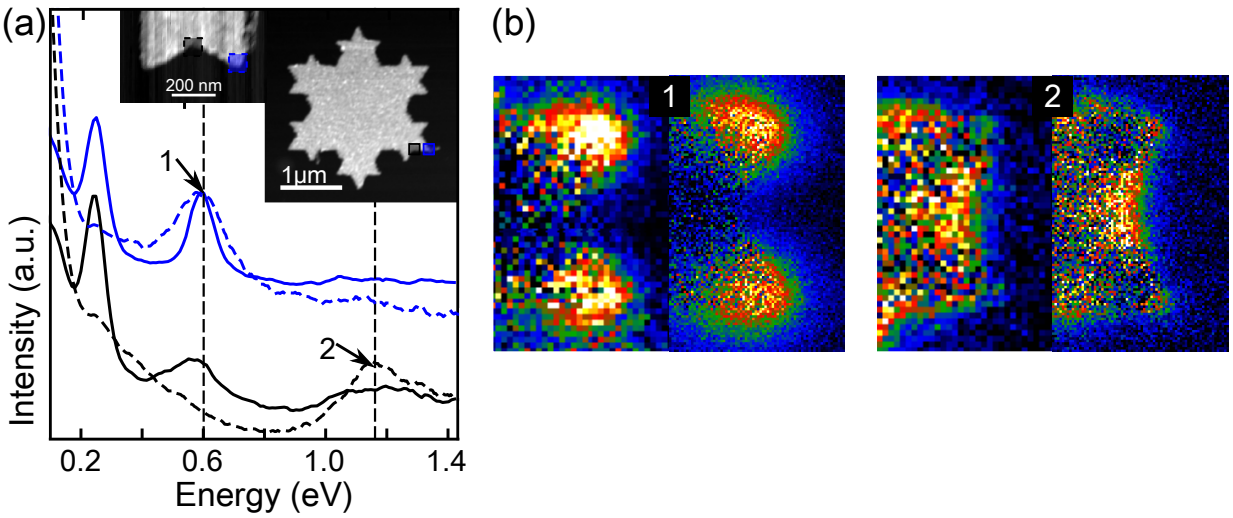

Figure S 7: Side-to-side comparison of the modes in the isolated characteristic edge unit in the 50 μm silver strips (dashed lines) and in the full Koch snowflake fractals (solid lines) of iteration 2. (a) EELS spectra acquired at the positions marked on the insets. The spectra of the full Koch snowflake fractal is red shifted 70 meV to align the E_1 modes of both structures. (b) Comparison of the EELS energy filtered maps of the isolated characteristic edge unis (right) and of the full snowflake (left) showing that the modes on both structures are equivalent.

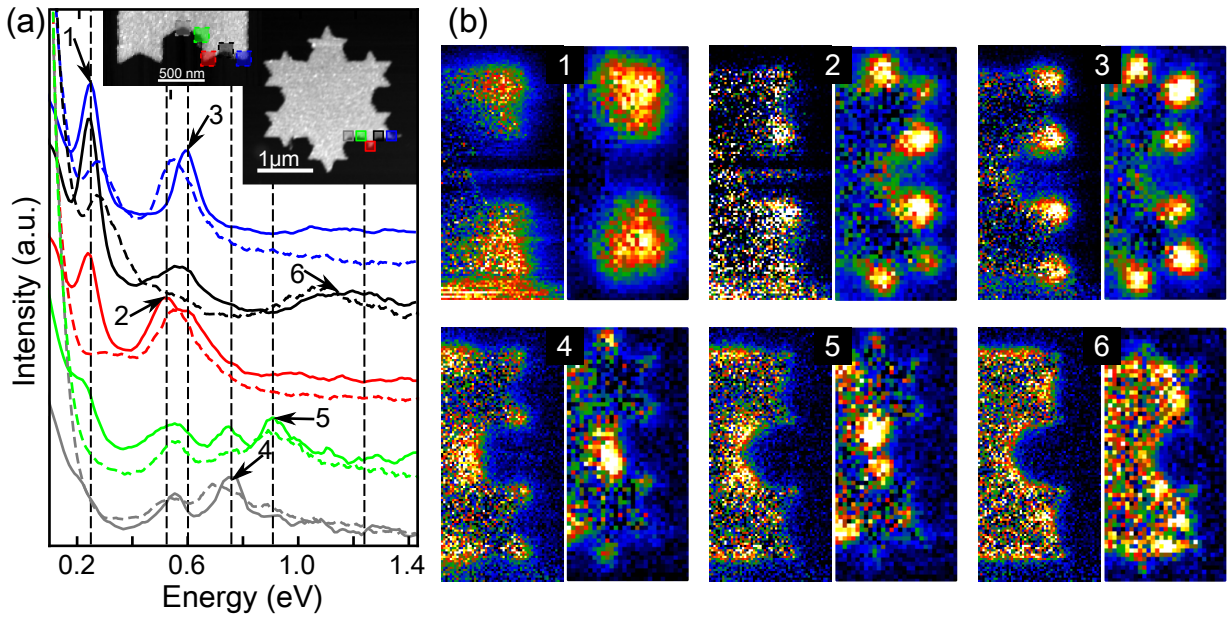

Figure S 8: Side-to-side comparison of the modes in the isolated characteristic edge units in the 50 μm silver strips (dashed lines) and in the full Koch snowflake fractals (solid lines) of iteration 2. (a) EELS spectra acquired at the positions marked on the insets. The spectra of the full Koch snowflake fractal is red shifted 70 meV to align the E_1 modes of both structures. (b) Comparison of the EELS energy filtered maps of the isolated characteristic edge units (left) and of the full snowflake (right) showing that the modes on both structures are equivalent.

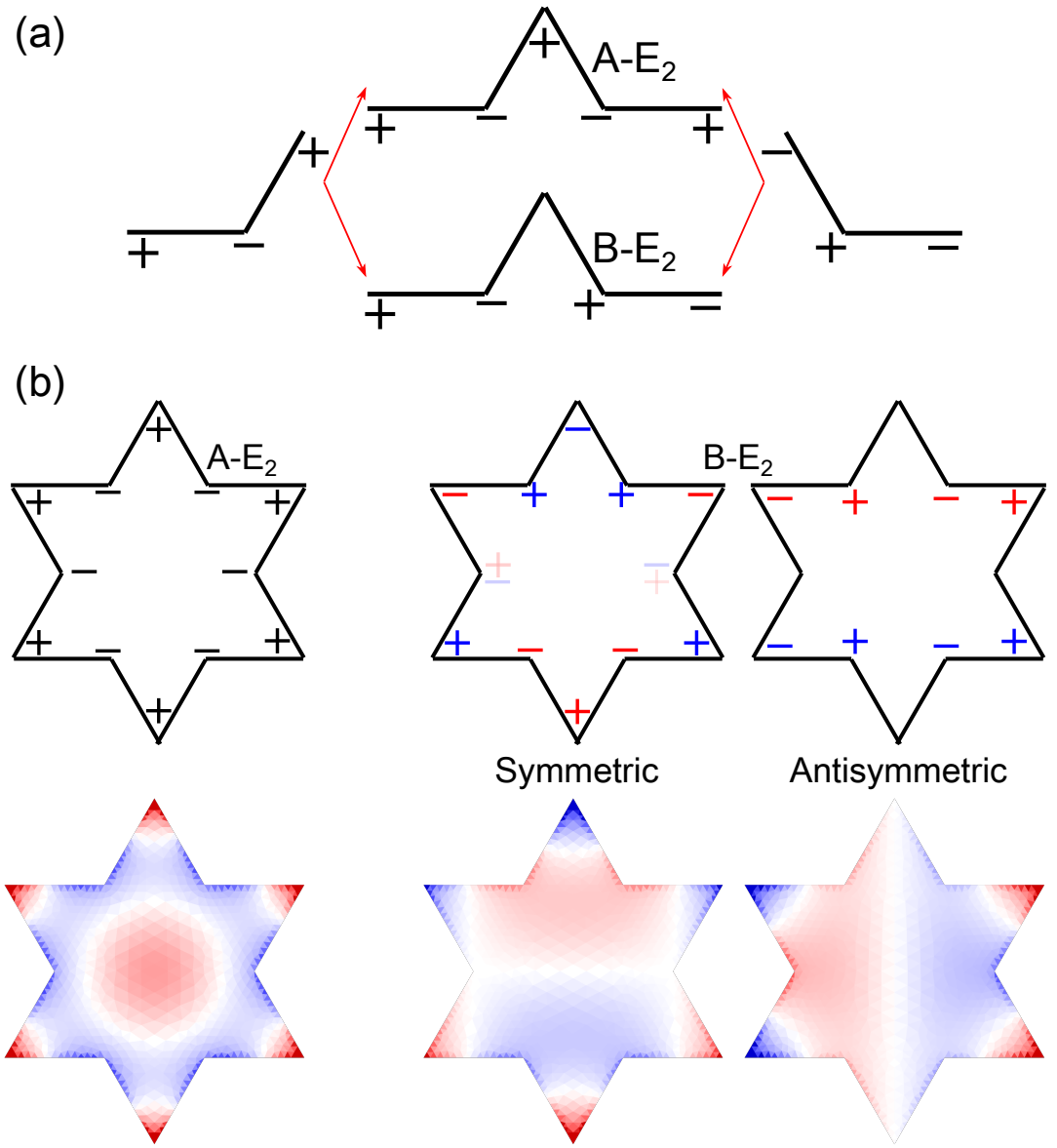

Figure S 9: (a) Energy diagram (not to scale) showing the formation of bonding and antibonding modes due to coupling of E_2 edge modes. (b) Charge distribution diagrams and calculated eigenmodes of the bonding (B) and antibonding (A) E_2 modes in Koch fractal iteration 1. Due to the symmetry of the structure the bonding mode supports two degenerate eigenmodes, and the antibonding mode one non-degenerate eigenmode.

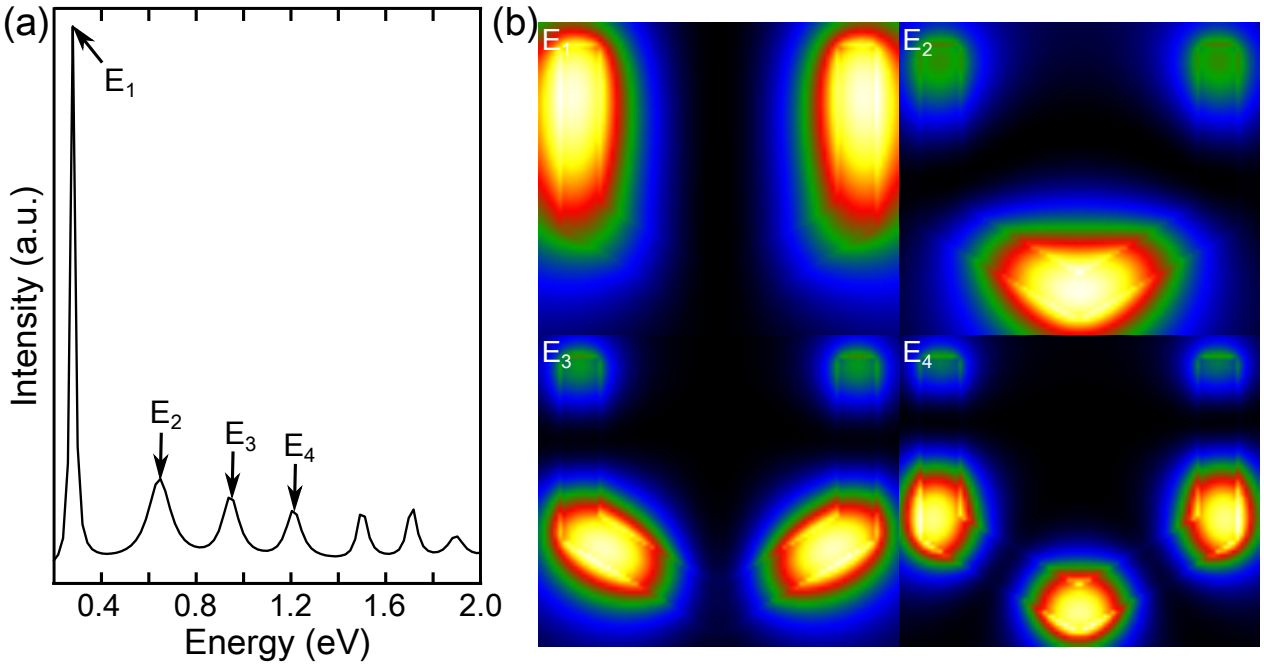

Figure S 10: Simulated EELS spectra (a) and energy filtered maps (b) of a $444x44x30nm^3$ silver nanowire bent in a "U" shape formed by joining two 120 degrees bent nanowires. The maps (b) show that the nodal distribution of a straight nanowires is maintained in the "U" shaped nanowire.

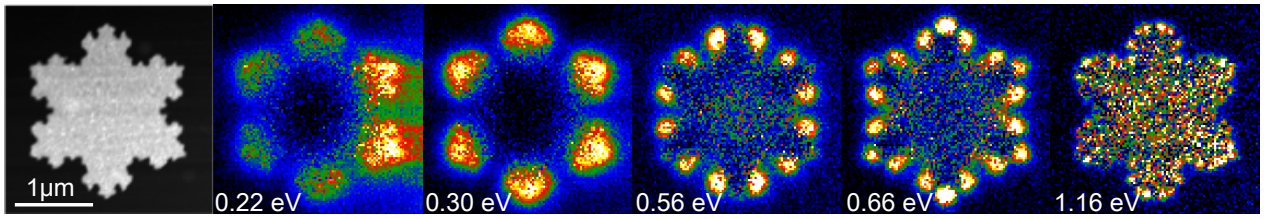

Figure S 11: ADF image on Koch snowflake fractal iteration 3 on the left, and EELS energy filtered maps of the E_1 modes in this fractal structure. The EELS maps have an energy window of 60 meV, with exception of the last map at 1.16 eV that has an energy window of 100 meV.