

Description of Additional Supplementary Files

File Name: Supplementary Movie 1

Description: Motion of a normal round-shaped skyrmion driven by a 400-ps-long pulse of $j = 100 \text{ MA cm}^{-2}$ and $\mathbf{p} = +x$. Here $K_d/K = 1$.

File Name: Supplementary Movie 2

Description: Hopping motion of a square-shaped skyrmion driven by a 400-ps-long pulse of $j = 100 \text{ MA cm}^{-2}$ and $\mathbf{p} = +x$. Here $K_d/K = 0.5$.

File Name: Supplementary Movie 3

Description: Deformation of a square-shaped skyrmion driven by a 400-ps-long pulse of $j = 100 \text{ MA cm}^{-2}$ and $\mathbf{p} = +x$. Here $K_d/K = 0.2$.

File Name: Supplementary Movie 4

Description: Hopping motion of a square-shaped skyrmion driven by a 100-ps-long pulse of $j = 100 \text{ MA cm}^{-2}$ and $\mathbf{p} = -y$. Here $K_d/K = 0.5$. The skyrmion do not show the skyrmion Hall effect during its motion.

File Name: Supplementary Movie 5

Description: Hopping motion of a square-shaped skyrmion driven by a sequence of 100-ps-long pulse of $j = 100 \text{ MA cm}^{-2}$ and $\mathbf{p} = -y$. The pulse spacing is 900 ps. Here $K_d/K = 0.5$. The skyrmion moves straightly toward the +x direction.

File Name: Supplementary Movie 6

Description: Hopping motion of a square-shaped skyrmion driven by a 500-ps-long pulse of $j = 100 \text{ MA cm}^{-2}$ and $\mathbf{p} = -y$. Here $K_d/K = 0.5$. The skyrmion show the skyrmion Hall effect during its motion.

File Name: Supplementary Movie 7

Description: Deformation of a square-shaped skyrmion driven by a 200-ps-long pulse of $j = 100$ MA cm⁻² and $\mathbf{p} = -y$. Here $K_d/K = 0.2$. The square-shaped skyrmion is transformed to an elongated skyrmion.

File Name: Supplementary Movie 8

Description: Deformation of a square-shaped skyrmion driven by a 400-ps-long pulse of $j = 100$ MA cm⁻² and $\mathbf{p} = -y$. Here $K_d/K = 0.2$. The square-shaped skyrmion is transformed to a L-shaped skyrmion.

File Name: Supplementary Movie 9

Description: Deformation of a square-shaped skyrmion driven by a 500-ps-long pulse of $j = 100$ MA cm⁻² and $\mathbf{p} = -y$ at a damping parameter of 0.3. Here $K_d/K = 0.2$. The square-shaped skyrmion is transformed to a L-shaped skyrmion.

File Name: Supplementary Movie 10

Description: Deformation of a square-shaped skyrmion driven by a 500-ps-long pulse of $j = 100$ MA cm⁻² and $\mathbf{p} = -y$ at a damping parameter of 0.4. Here $K_d/K = 0.2$. The square-shaped skyrmion is transformed to an elongated skyrmion.

File Name: Supplementary Movie 11

Description: Increasing the length of a rectangle-shaped skyrmion by a 200-ps-long pulse of $j = 100$ MA cm⁻² and $\mathbf{p} = -y$ at a damping parameter of 0.3. Here $K_d/K = 0.2$.