

Description of Additional Supplementary Files

Supplementary Movie 1: Geometric reconfiguration of the disclination loops during translation. When the two surfaces are completely overlapped, the formed disclination loops are circular. After the top surface is translated along the x-axis, the shape of the disclination loops becomes elliptical.

Supplementary Movie 2: Asymmetric rotation and chirality conversion of colloidal entanglement for top surface being shifted one period. The colloidal particle with left-twist entanglement is pushed by the laser tweezer to move along the loop in CCW direction. The entanglement rotates in CW sense and changes the chirality 5 times in the upper half of the loop. And in the lower half of the loop, it rotates in CCW direction once and remains the chirality of right-twist.

Supplementary Movie 3: Simulation for asymmetric chirality conversion of colloidal entanglement when top surface is shifted one period. The entanglement starts with an initial chirality of left-twist. When the entanglement moves along the loop in CCW direction, it changes the chirality 5 times in the upper half of the loop and remains its chirality in the lower half of the loop.

Supplementary Movie 4: Asymmetric rotation and chirality conversion of colloidal entanglement for top surface being shifted two periods. The colloidal particle with left-twist entanglement is pushed by the laser tweezer to move along the loop in CCW direction. It rotates in CW sense and changes the chirality 7 times in the upper half of the loop. And in the lower half of the loop, it rotates in CCW direction for 3 times. It firstly remains the chirality of right-twist, and change its chirality in the later 2 rotations.

Supplementary Movie 5: Programmable asymmetric rotation and chirality conversion of the entanglement (3 times in CCW and 5 times in CW). In the designed loop, the colloidal entanglement starts with a chirality of left-twist. When it is pushed by the laser tweezer to move along the loop in CCW direction, the entanglement rotates in CCW sense and changes the chirality 3 times in the upper half of the loop. And in the lower half of the loop, it rotates in CW sense for 5 times. It firstly remains the chirality of right-twist, and change its chirality in the later 4 rotations.

Supplementary Movie 6: Simulation for programmed asymmetric chirality conversion of the entanglement (3 times in upper half and 4 times in lower half). The entanglement starts with an initial chirality of left-twist. When the entanglement moves along the loop in CCW direction, it changes the chirality 3 times in the upper half of the loop. In the lower half of the loop, it firstly remains its chirality and then changes the chirality for 4 times.

Supplementary Movie 7: Programmable asymmetric rotation and chirality conversion of the entanglement (4 times in CCW and 2 times in CW). In the designed loop, the colloidal entanglement starts with a chirality of right-twist. When it is pushed by the laser tweezer to move along the loop in CCW direction, the entanglement rotates in CCW sense and changes the chirality 4 times in the upper half of the loop. And in the lower half of the loop, it rotates in CW sense for 2 times. It firstly remains the chirality of right-twist, and change its chirality in the later one rotation.

Supplementary Movie 8: Simulation for programmed asymmetric chirality conversion of the entanglement (4 times in upper half and 1 time in lower half). The entanglement starts with an initial chirality of right-twist. When the entanglement moves along the loop in CCW direction, it changes the chirality 4 times in the upper half of the loop. In the lower half of the loop, it firstly remains its chirality and then changes the chirality once.

Supplementary Movie 9: Programmable asymmetric rotation and chirality conversion of the entanglement (2 times in CCW and 4 times in CW). In the designed loop, the colloidal entanglement starts with a chirality of right-twist. When it is pushed by the laser tweezer to move along the loop in CCW direction, the entanglement rotates in CCW sense and changes the chirality 2 times in the upper half of the loop. And in the lower half of the loop, it rotates in CW sense for 4 times. It firstly remains the chirality of right-twist, and change its chirality in the later 3 rotations.

Supplementary Movie 10: Simulation for programmed asymmetric chirality conversion of the entanglement (2 times in upper half and 3 time in lower half). The entanglement starts with an initial chirality of right-twist. When the entanglement moves along the loop in CCW direction, it changes the chirality 2 times in the upper half of the loop. In the lower half of the loop, it firstly remains its chirality and then changes the chirality for 3 times.

Supplementary Movie 11: Programmable non-equilibrium asymmetric dynamics of colloidal entanglement under a full cycle of disclination motion (Once in the upper half and 5 times in the lower half). When the sample is irradiated by linearly polarized light (LPL), the disclination line undergoes non-equilibrium rotation, as the top uniform alignment is modified by illumination. By controlling the disclination to rotate CCW for a full cycle, the colloidal particles ($d=5\text{ }\mu\text{m}$) on the line will follow its motion, rotating CCW once in the upper half and five times in the lower half.

Supplementary Movie 12: Programmable non-equilibrium asymmetric dynamics of colloidal entanglement under a full cycle of disclination motion (0 rotations in the upper half and 2 rotations in the lower half). By controlling the disclination to rotate one full cycle CCW under illumination, the colloidal particles ($d=5\text{ }\mu\text{m}$) introduced on the designed disclination line will follow its motion, exhibiting no rotation in the upper half and two times rotation in the lower half.

Supplementary Movie 13: Programmable non-equilibrium asymmetric dynamics of colloidal entanglement under opposite disclination motions. (Once in the upper half and 3 times in the lower half). When the designed disclinations in the upper and lower parts of the pattern are controlled to rotate in opposite directions, the colloidal particles ($d=5\text{ }\mu\text{m}$) on both sides will follow the disclination motion. The colloids on the upper side rotate once during this process, while those on the lower side rotate three times.

Supplementary Movie 14: Programmable non-equilibrium asymmetric dynamics of colloidal entanglement under opposite disclination motions. (3 times in the upper half and 6 times in the lower half). When the designed disclinations in the upper and lower parts of the pattern are controlled to rotate in opposite directions, the colloids on the upper side rotate three times during this process, while those on the lower side rotate six times.