

# Description of Additional Supplementary Files

## Rolling Microswarms along Acoustic Virtual Walls

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### **This PDF file includes:**

Legends for Supplementary Movies 1 to 6

### **Other supplementary materials for this manuscript include the following:**

Supplementary Movies 1 to 6

**Supplementary Movie 1. Microswarms roll along the acoustic virtual wall.** The acoustic excitation voltage and frequency were  $20 V_{PP}$  and 1.55 MHz, respectively. The magnetic rotational direction was clockwise, and the magnetic rotational velocity and intensity were 18 rpm and 21 mT, respectively.

**Supplementary Movie 2. Dynamic orientation switching of the acoustic standing wave field.** Amplitude modulation: when the excitation voltage of the transducer pair was  $A : B = 20 : 20 V_{PP}$ , the acoustic pressure node tended to be the pressure nodal point; when the excitation voltage of the transducer pair was  $A : B = 20 : 1 V_{PP}$ , the acoustic pressure node tended to be the horizontal pressure nodal line. When the excitation voltage of the transducer pair was  $A : B = 1 : 20 V_{PP}$ , the acoustic pressure node tended to be the vertical pressure nodal line. The acoustic excitation frequency was kept at 1.55 MHz.

**Supplementary Movie 3. Microswarms exhibit bidirectional rolling.** Microswarms executed left-to-right rolling in a clockwise rotational magnetic field, followed by right-to-left rolling upon the rotational direction of the magnetic field was switched to be counterclockwise. Then, microswarms executed bottom-to-top rolling in a counterclockwise rotational magnetic field, followed by top-to-bottom rolling upon the rotational direction of the magnetic field was switched to be clockwise. The acoustic excitation voltage and frequency were  $20 V_{PP}$  and 1.55 MHz, respectively. The magnetic rotational velocity of both demonstrations was 24 rpm and 30 rpm, respectively. The magnetic intensity was 21 mT.

**Supplementary Movie 4. Microswarms synchronously roll at different suspended planes.** The acoustic excitation voltage and frequency were  $20 V_{PP}$  and 1.55 MHz, respectively. The magnetic rotational direction was counterclockwise, and the magnetic rotational velocity and intensity were 12 rpm and 21 mT, respectively.

**Supplementary Movie 5. Trajectory tracking of a single microchain in one rolling cycle.** The acoustic excitation voltage and frequency were  $20 V_{PP}$  and 1.55 MHz, respectively. The magnetic rotational direction was counterclockwise, and the magnetic rotational velocity and intensity were 12 rpm and 21 mT, respectively.

**Supplementary Movie 6. Microswarms write the word “ETH”.** The trajectory of microswarms was controlled by dynamically switching the orientation of the virtual wall and the rotational direction of the magnetic field.