Supplementary Materials for

Spontaneous shock waves in pulse-stimulated flocks of Quincke rollers

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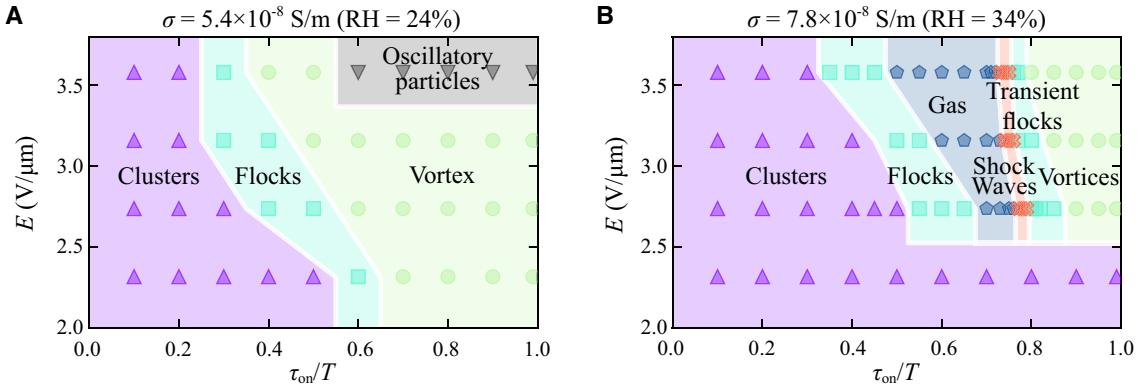

FIG. S 1: Phase diagrams of rollers at different τ_{on} and E in two different conductivities of media. $T = 6.7$ ms. $\phi_0 = 0.11$. The salt concentration in AOT/hexadecane solution is kept at 0.15 mol/L, while the trace amount of water dissolved is tuned by changing the relative humidity (RH) of the working environment. The environment temperature is kept at 23 °C. Any measurements are collected after the system reaches to dynamically equilibrium state when the conductivity σ no longer changes.

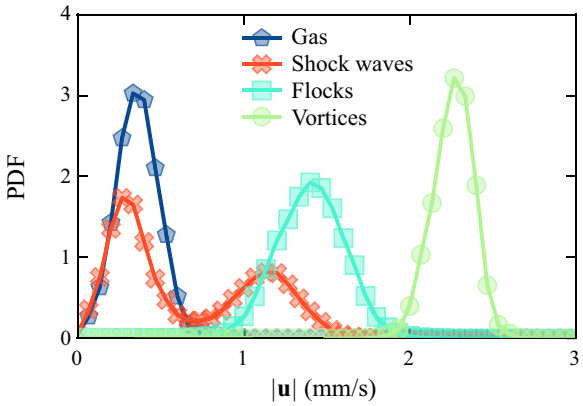

FIG. S 2: Typical probability distribution functions (PDFs) of the particle speed in different phases: ripples ($\tau_{\rm on} = 4.0$ ms; $\tau_{\rm off} = 2.7$ ms), shock waves ($\tau_{\rm on} = 4.9$ ms; $\tau_{\rm off} = 1.8$ ms), flocks ($\tau_{\rm on} = 5.3$ ms; $\tau_{\rm off} = 1.4$ ms) and vortices ($\tau_{\rm on} = 6.6$ ms; $\tau_{\rm off} = 0.1$ ms). The period is kept at $T = 6.7$ ms.

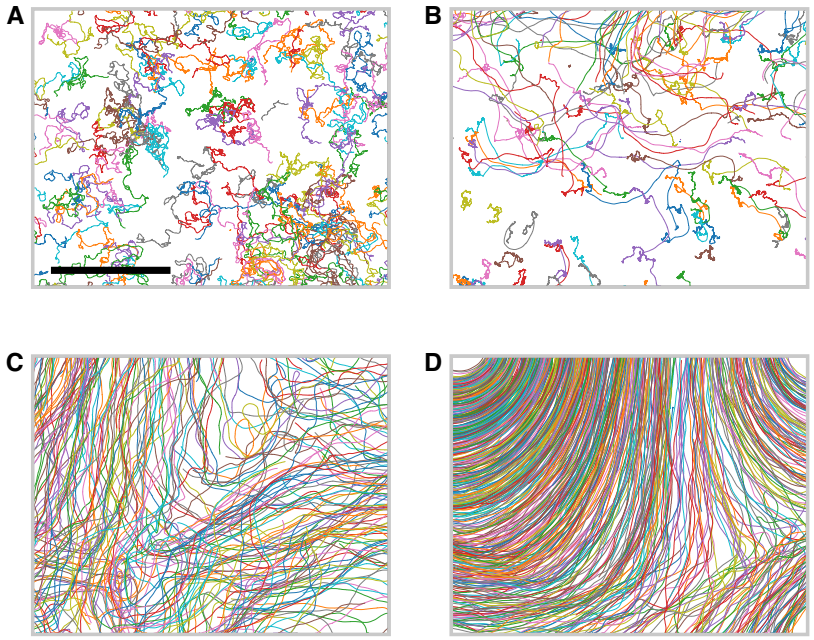

FIG. S 3: Typical particle trajectories in different phases: ripples (a, $\tau_{\mathrm{on}} = 4.0$ ms; $\tau_{\mathrm{off}} = 2.7$ ms), shock waves (b, $\tau_{\mathrm{on}} = 4.9$ ms; $\tau_{\mathrm{off}} = 1.8$ ms), flocks (c, $\tau_{\mathrm{on}} = 5.3$ ms; $\tau_{\mathrm{off}} = 1.4$ ms) and vortices (d, $\tau_{\mathrm{on}} = 6.6$ ms; $\tau_{\mathrm{off}} = 0.1$ ms). The period is kept at $T = 6.7$ ms. Only 1 % of particle trajectories are shown.

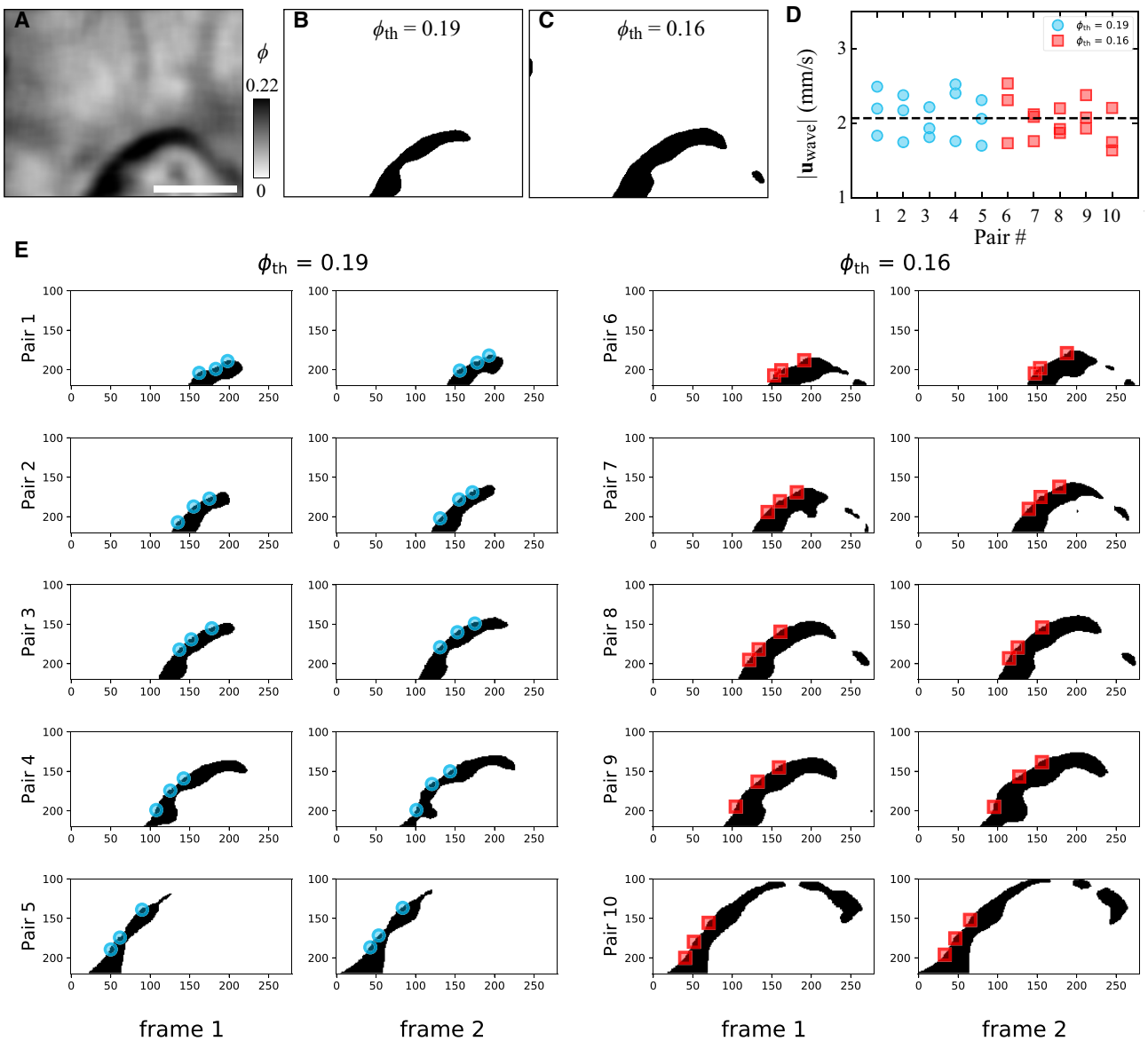

FIG. S 4: Measurements of the speed of shock waves. (a) Particle density map of a typical shock wave. Since high density regions coexist with high speed regions of show waves as shown in Fig. 2, the shock waves can be presented as high density regions. $E = 3.2$ V/μm. $\phi_0 = 0.11$. $\sigma = 7.8 \times 10^{-8}$ S/m. (b-c) Shock waves identified by two different threshold values of area fractions. (d) Wave speed measured based on the propagation of wave fronts shown in (e). The dash line shows the average speed of 2.1 mm/s.

Movies

Movie S1

Ripples. The electric field strength $E = 3.2$ V/μm. $\tau_{\text{on}} = 4.0$ ms; $\tau_{\text{off}} = 2.7$ ms; $T = 6.7$ ms. The frame size is 1.5 mm by 1.2 mm. The movie is 0.27X as the real speed.

Movie S2

Multiple shock waves. The electric field strength $E = 3.4$ V/μm. $\tau_{\text{on}} = 4.2$ ms; $\tau_{\text{off}} = 1.4$ ms; $T = 5.6$ ms. The frame size is 2 mm by 1.5 mm. The movie is 0.67X as the real speed.

Movie S3

One shock wave. The electric field strength $E = 3.2$ V/μm. $\tau_{\text{on}} = 4.9$ ms; $\tau_{\text{off}} = 1.8$ ms; $T = 6.7$ ms. The frame size is 1.5 mm by 1.2 mm. The movie is 0.27X as the real speed.

Movie S4

Flocks. The electric field strength $E = 3.2$ V/μm. $\tau_{\text{on}} = 3.4$ ms; $\tau_{\text{off}} = 3.3$ ms; $T = 6.7$ ms. The frame size is 1.5 mm by 1.2 mm. The movie is 0.27X as the real speed.

Movie S5

Vortices. The electric field strength $E = 3.2$ V/μm. $\tau_{\text{on}} = 6.6$ ms; $\tau_{\text{off}} = 0.1$ ms; $T = 6.7$ ms. The frame size is 3.2 mm by 2.6 mm. The movie is 0.4X as the real speed.

Movie S6

Excitation of a shock wave. The electric field strength $E = 3.2$ V/μm. $\tau_{\text{on}} = 5.1$ ms; $\tau_{\text{off}} = 1.6$ ms; $T = 6.7$ ms. The frame size is 1 mm by 1 mm. The movie is 0.1X as the real speed.

Movie S7

2D movie of shock waves in simulations.

Movie S8

3D movie of shock waves in simulations.