Supplementary Information

Activity Waves in Condensed Excitable Phases of Quincke Rollers

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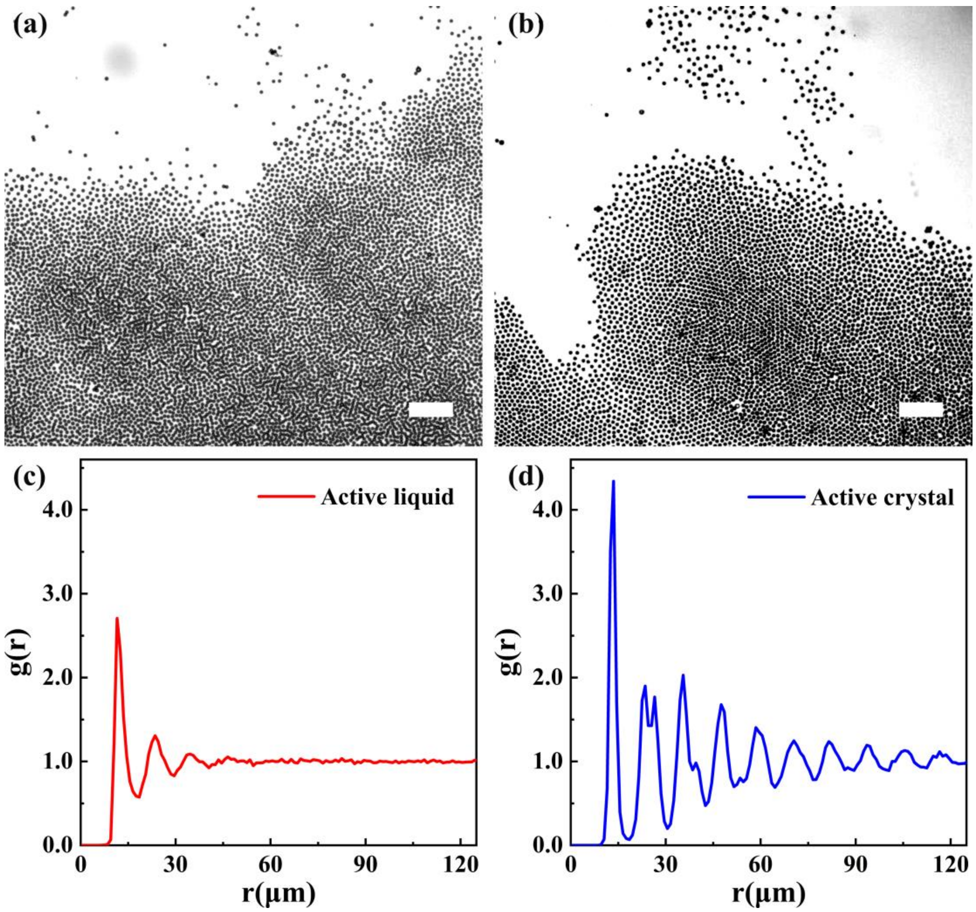

Fig.S1 As the system condensed, an empty region forms between the cell boundary and the condensed phase. a: Active liquid. $E_p = 2.5E_c$ and $f = 100$Hz. b: Active crystal. $E_p = 2.5E_c$ and $= 120$Hz . c: In active liquids, the pair distribution function exhibits no long-ranged correlation. d: The pair distribution function in active crystals exhibits sharp peaks where the second peak consists of two sub-peaks which are the typical sign of a hexagonal symmetry. Scale bar in a and b: 150μm.

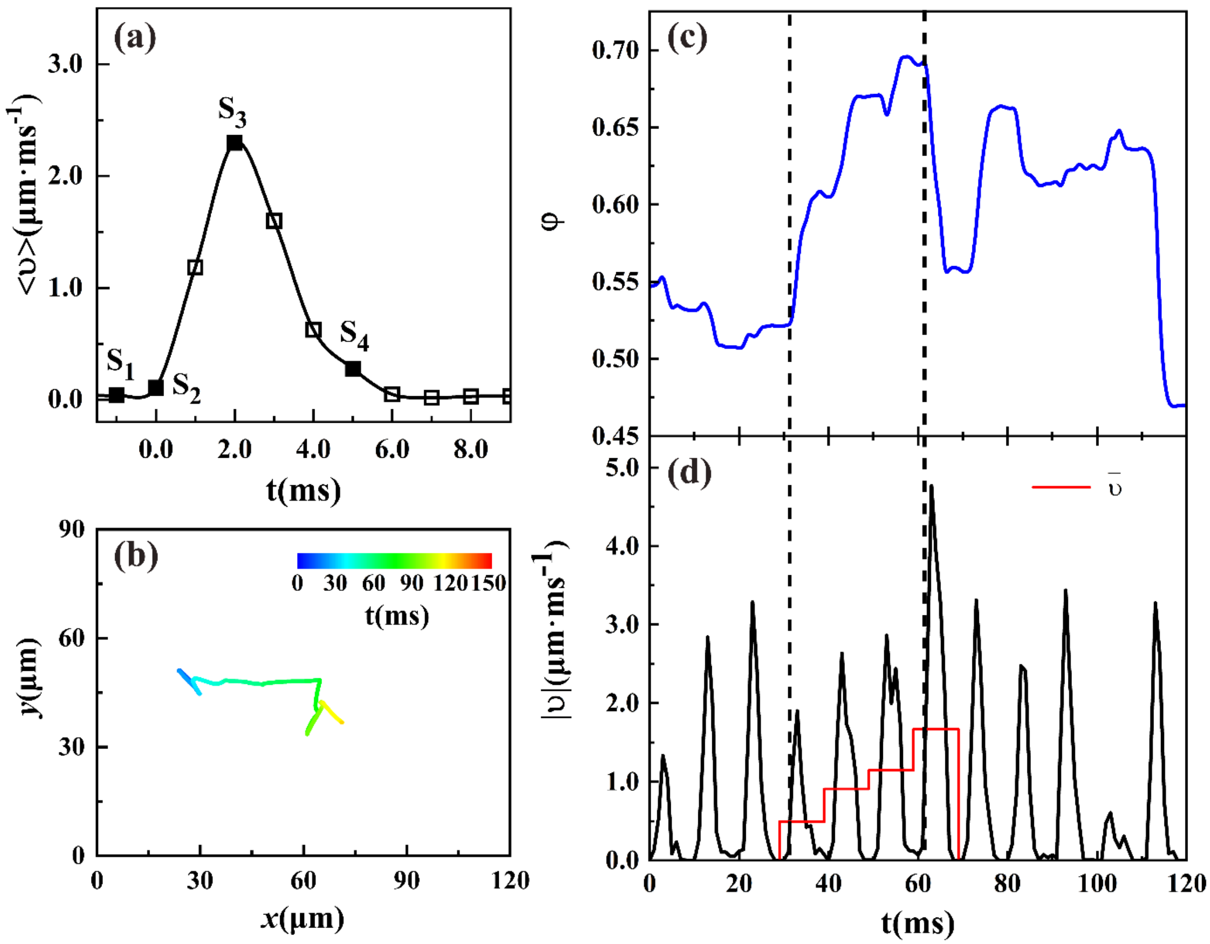

Fig.S2 a. Mean speed of particles in active liquid as a function of time in one cycle when no wave passes. $E_p = 2.5E_c$ and $f = 100$Hz. The four points S_1,S_2,S_3,S_4 are the corresponding times of snapshots shown in Fig.3a-d where one wave passes. b. A typical trajectory of particles in wave. As particles are included in the wave, their motions become persistently directed in the following cycles. Before and after the wave passes, their motions are randomly driven in each cycle. The directed displacements of wave particles are around 30μm which is much smaller than the width of wave. c. The local density observed by one wave particle experiences a sharp increase as it is included in the wave front, and a sharp drop as it is separated from the wave by splitting. d. The maximum transient speed of wave particles is much higher than the peak value measured in the absence of wave. Nevertheless, the speed of wave particles varies not only with time but also with their positions in the wave. Therefore, the speed curves of wave particles as a function of time are characterized by different shapes in different cycles. The mean speed (red line) of wave particles in each cycle is significantly smaller than the mean wave speed. In active fluids, a wave passes one particle by three cycles in most cases.

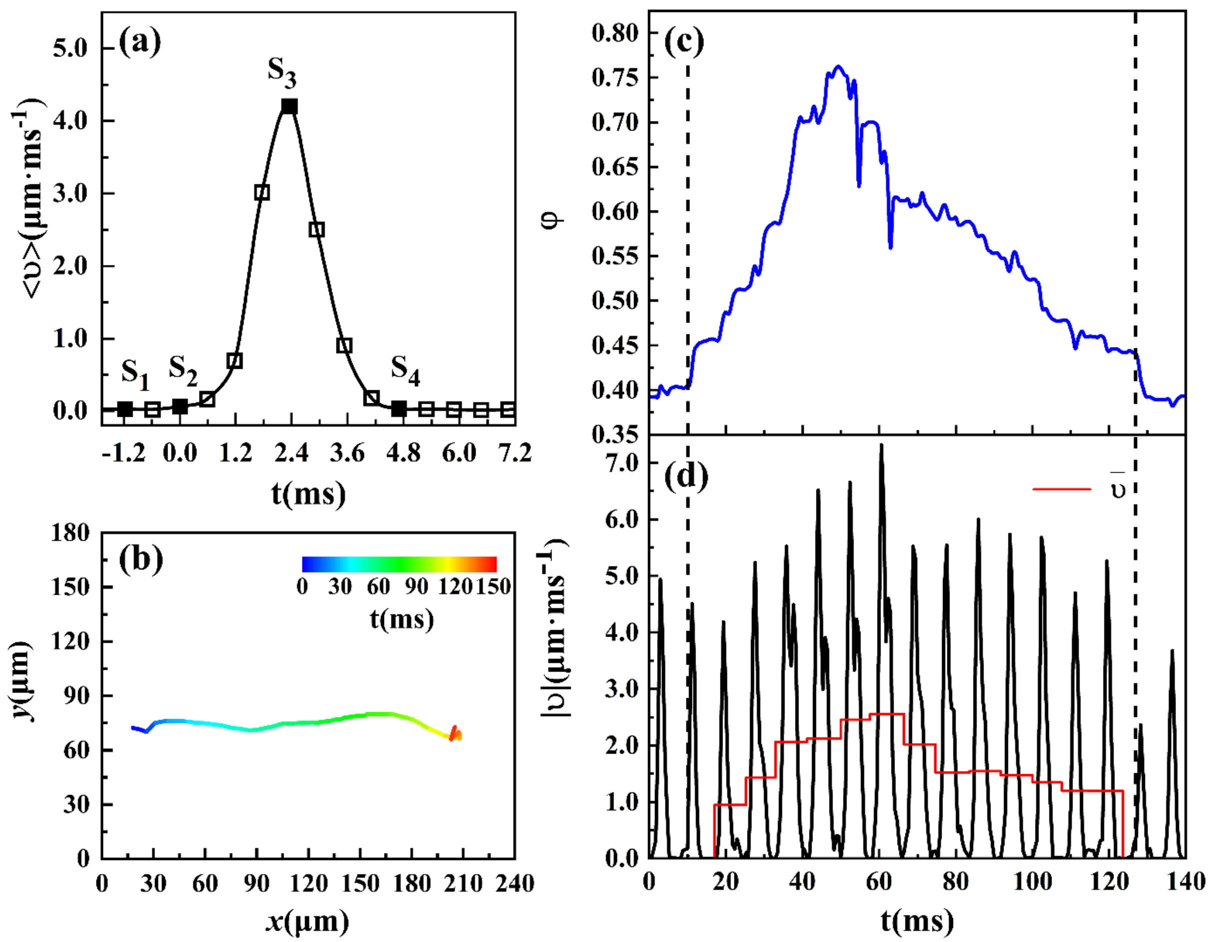

Fig.S3 Mean speed of particles in active crystals as a function of time in one cycle when no wave passes. $E_p = 2.5E_c$ and $f = 120$Hz. The four points marked by S_1,S_2,S_3,S_4 are the corresponding times of snapshots shown in Fig.4a-d where one wave passes. b. A typical trajectory of particles in wave. The displacements of wave particles can be as high as 180μm which is also much smaller than the width of wave. c. The local density observed by one wave particle. As one particle is involved in the wave front, the density increases sharply above 0.45. As it drops off from the wave tail, the density drops down to 0.40. d. The maximum transient speed of wave particles is much higher than the peak value measured in the absence of wave. The transient speed of wave particles varies with time and their positions in the wave. The mean speed (red line) of wave particles in each cycle is much smaller than the mean wave speed. In active crystals, a wave passes one particle by more than ten cycles. However, both the width of wave and the number of cycles experienced by wave particles vary from case to case.

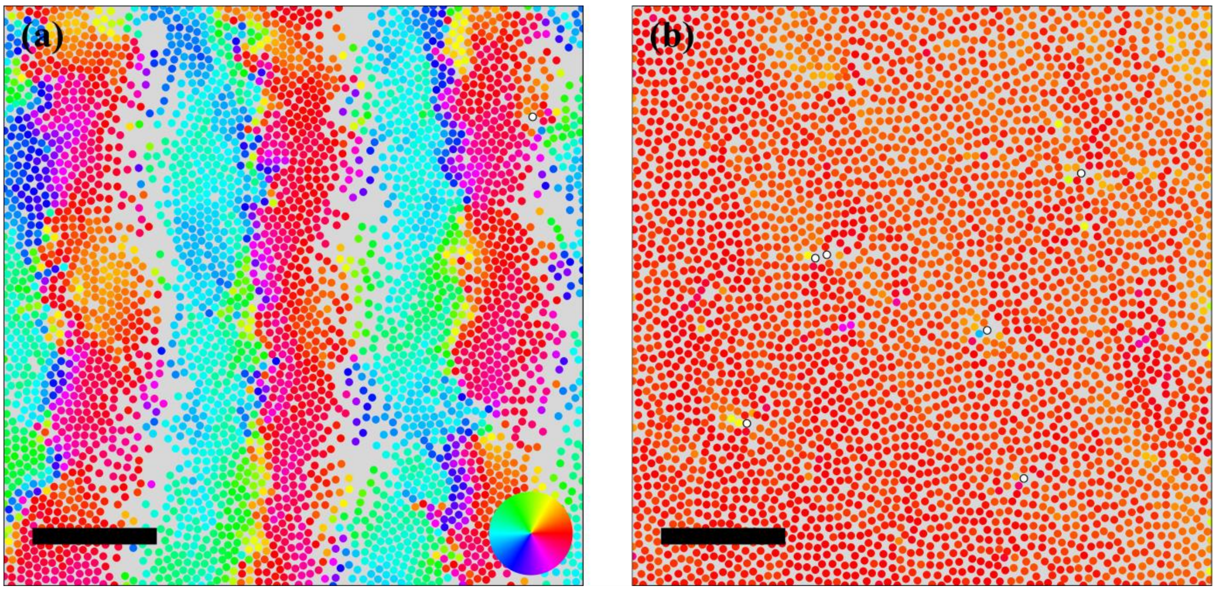

Fig.S4 Snapshots of phases. a. Oscillating stripes. b. Flocking in which particles move continuously Particles are colored according to their directions of velocity. Scale bar: 150μm.

Movie S1: Active liquid. $E_p = 2.1E_c$, $E_g = 0$ and $f = 90$ Hz. The movie runs for 100 ms of real time. The field of view is 800×800 μm^2. Scale bar: 150 μm.

Movie S2: Active crystal. $E_p = 2.1E_c$, $E_g = 0$ and $f = 125$ Hz. The movie runs for 100 ms of real time. The field of view is 800×800 μm^2. Scale bar: 150 μm.

Movie S3: Emergence of Sound wave. $E_p = 2.2E_c$, $E_g = 0$ and $f = 95$ Hz. The movie runs for 230 ms of real time. The field of view is 500×500 μm^2. Scale bar: 150 μm.

Movie S4: Emergence of Shock wave. $E_p = 2.3E_c$, $E_g = 0$ and $f = 100$ Hz. The movie runs for 1400 ms of real time. The field of view is 500×500 μm^2. Scale bar: 150 μm.

Movie S5: Traveling band in liquid. $E_p = 2.5E_c$, $E_g = 0$ and $f = 100$ Hz. The movie runs for 250 ms of real time. The field of view is 800×600 μm^2. Scale bar: 150 μm.

Movie S6: Traveling band in crystal. $E_p = 2.5E_c$, $E_g = 0$ and $f = 120$ Hz. The movie runs for 153 ms of real time. The field of view is 800×600 μm^2. Scale bar: 150 μm.

Movie S7: Reactivation of shock wave. $E_p = 2.25E_c$, $E_g = 0$ and $f = 125$ Hz. The movie runs for 520 ms of real time. In the movie, the static state from the time 2s to 8s represents the freezing of shock wave, which in the real experiment lasts for 30 minutes. The field of view is 1400×1080 μm^2. Scale bar: 150 μm.

Movie S8: Collision of sound waves. $E_p = 2.19E_c$, $E_g = 0$ and $f = 120$ Hz. The movie runs for 120 ms of real time. The field of view is 1320×1080 μm^2. Scale bar: 150 μm.

Movie S9: Collision of shock waves. $E_p = 2.5E_c$, $E_g = 0$ and $f = 95$ Hz. The movie runs for 220 ms of real time. The field of view is 1320×1080 μm^2. Scale bar: 150 μm.

Movie S10: Oscillating stripes. $E_p = 2.3E_c$, $E_g = 0$ and $f = 60$ Hz. The movie runs for 100 ms of real time. The field of view is 700×700 μm^2. Scale bar: 150 μm.

Movie S11: Flocking. $E_p = 1.9E_c$, $E_g = 0$ and $f = 180$ Hz. The movie runs for 200 ms of real time. The field of view is 700×700 μm^2. Scale bar: 150 μm.