Vacancy dynamics in 2D vibrating granular systems

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Introduction

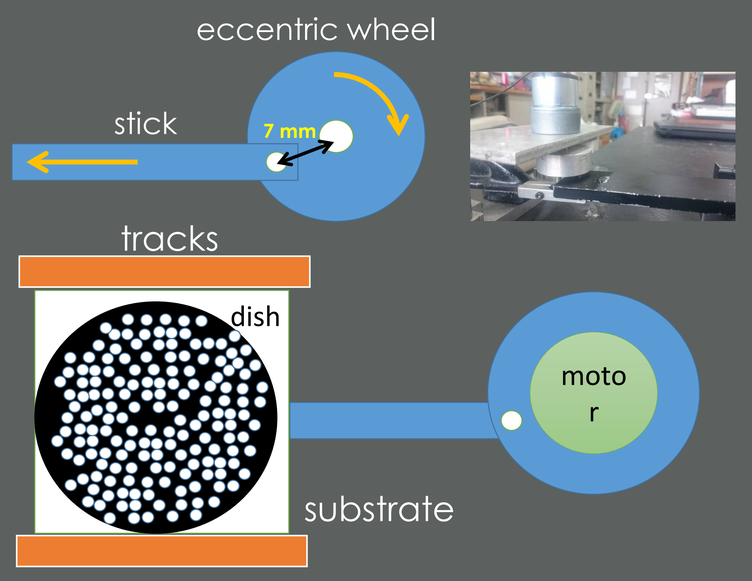
In a 2D granular system, we have known that the structure is triangular, and there are caged and hopping motions. We want to know the process of its micro-motion. We give a periodic force by a motor and an eccentric wheel.

Our work

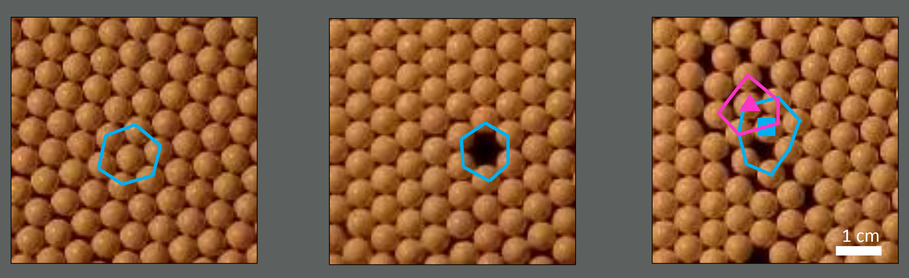
We track the position of particles and do the analysis. We use trajectory field to know the micro-motion and vortex in our system. Furthermore, we describe the particle motion near a vacancy by Mean Square Displacement (MSD).

Experiment

We use a motor and an eccentric wheel to make a periodic force in x-axis. The frequency of the motor (200 rpm) determines the frequency of the periodic force. The radius of the eccentric wheel (7 mm) determines the amplitude of periodic force. The periodic force makes particles collide each other, and collisions make particles do the random motion. We set particles on a circle dish (300 mm), and we make dish move on one axis with two tracks. We give a strong and uniform light source and use camera to take videos. We use image J to track particles by light intensity.

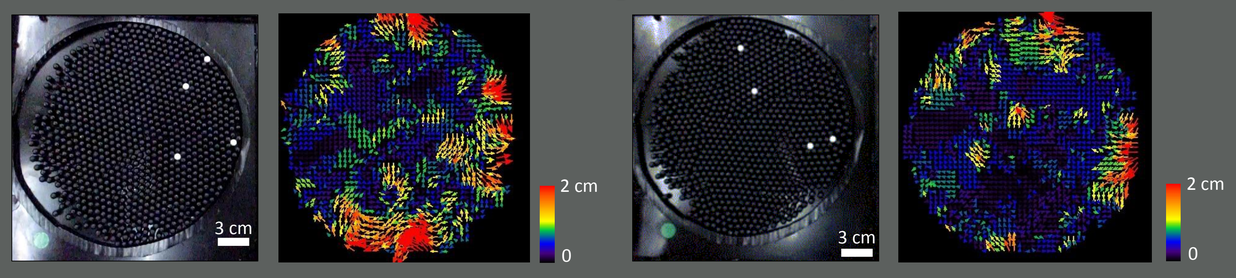


Particle structure in the 2D granular system



Hexagonal crystal　Hexagonal vacancy　5 and 7 fold defects

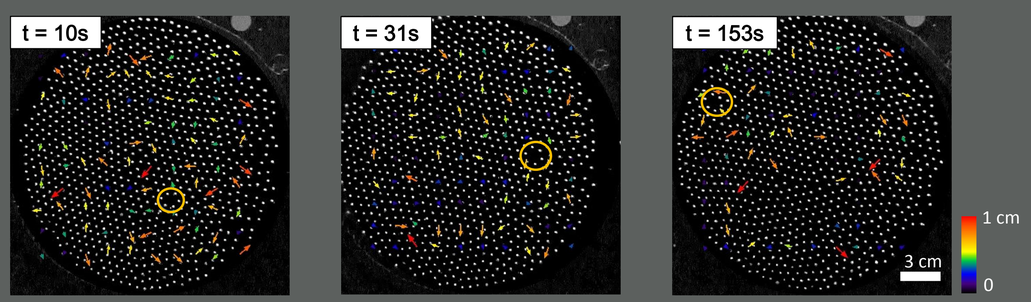
Vortex in the 2D granular system



Frequency = 3.3 Hz　Frequency = 4 Hz

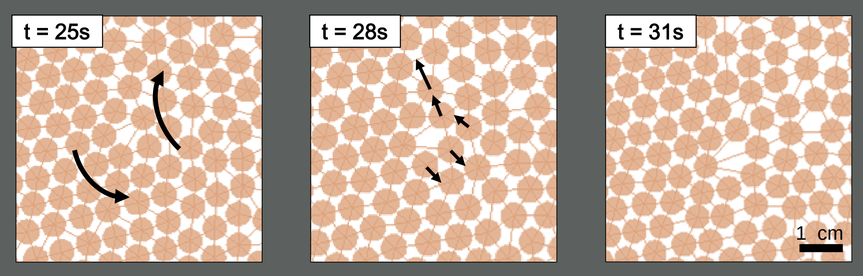
Micro-motion in different regions

Background field of vacancy



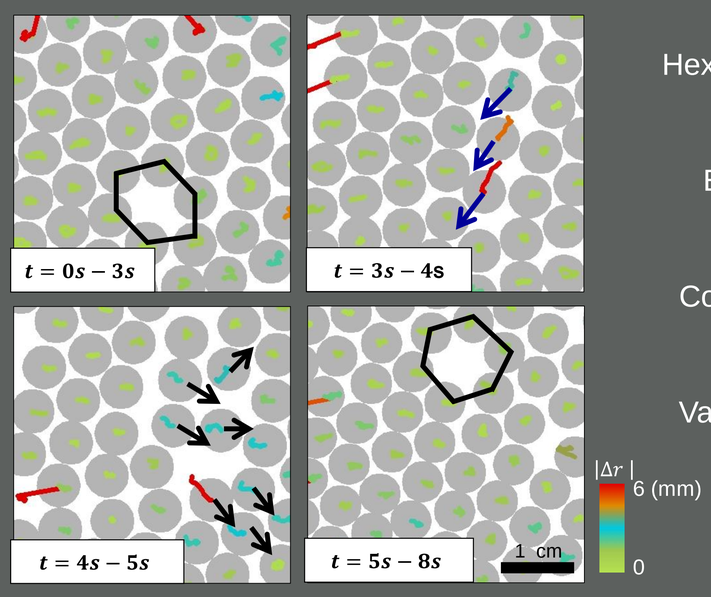
Periodic force and a circle boundary → Vortex

Vacancy formation



Domains rotate　Vacancy appears

Vacancy transfer



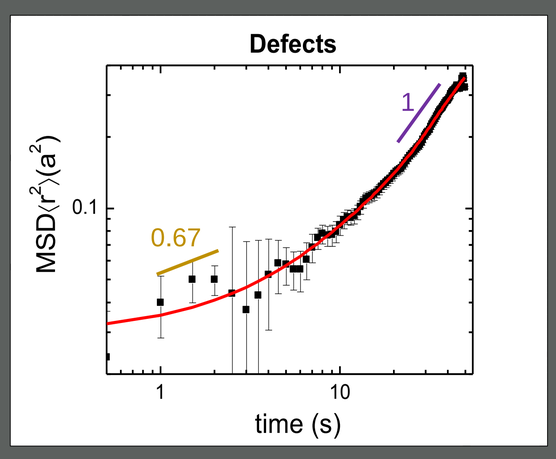
Hexagonal vacancy

Empty space

Collective motion

Vacancy transfer

Mean square displacement (MSD)



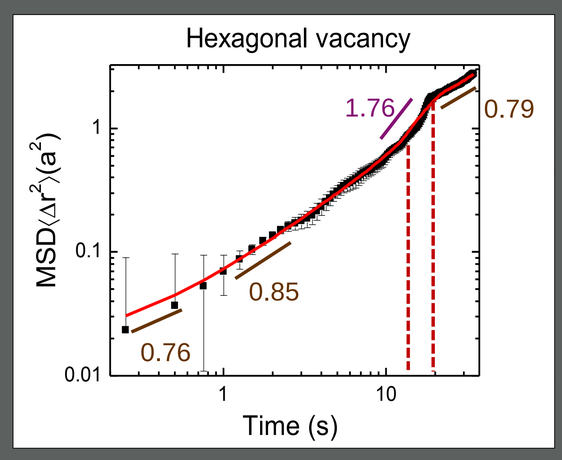
Caged oscillation

Random motion

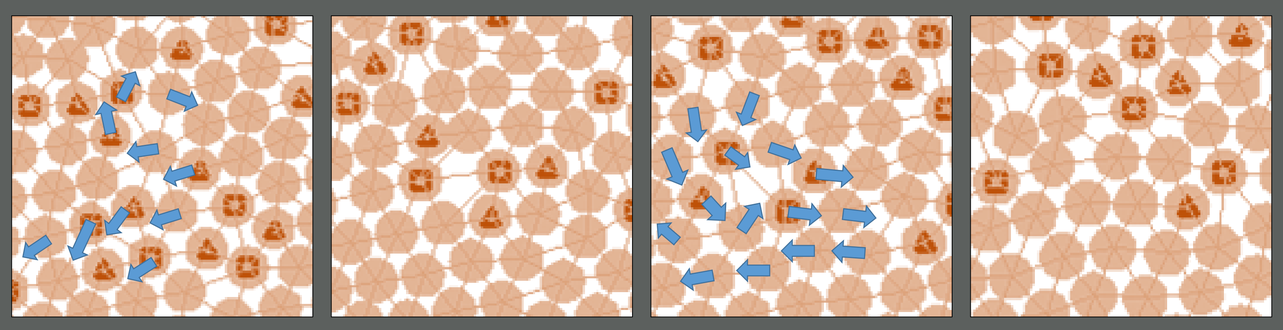
Stable Hexagonal vacancy

Cooperative hopping

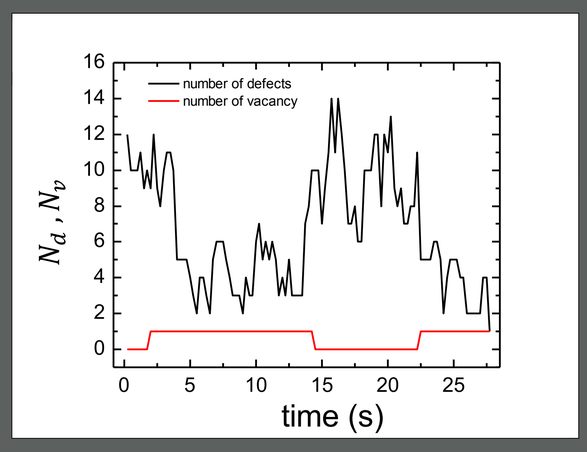
vacancy escape



Local structure rearrangement with vacancy



Vortex of two domains
↓
Vacancy produced
↓
Number of Defect decreasing
↓
Vortex of two domains
↓
Vacancy vanishing
↓
Number of Defect increasing



Conclusion

We find that there are hexagonal vacancies. These vacancies can exist for a long time and they will transmit. We find that the defects are correlated to the hexagonal vacancy. The vacancy appears as the defects decreases that the structure rearranges into an order state. The vacancy disintegrates that leads to defect increasing.

Reference

1. Chi Yang, Wen Wang, and Lin I, Phys. Rev. E 93, 013202 (2016)

2. Meng-Chun Chen, Chi Yang, and Lin I, Phys. Rev. E 90, 050401(R) (2014)