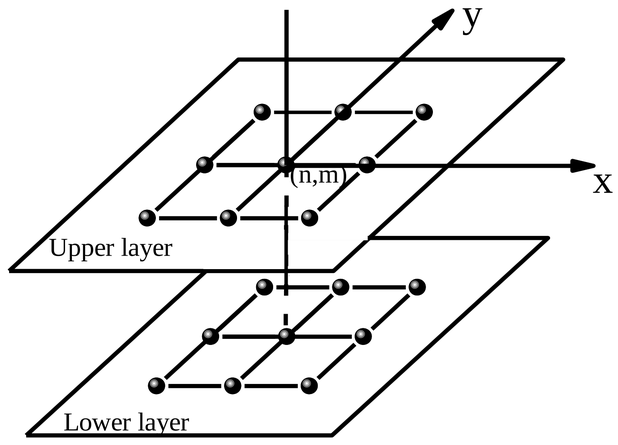
# Friction phenomena in the underdamped two-dimensional Frenkel-Kontorova model

Yang Yang, Wen-Shan Duan, Jian-Min Chen, Lei Yang, Jasmina Tekic, Zhi-Gang Shao, and Cang-Long Wang

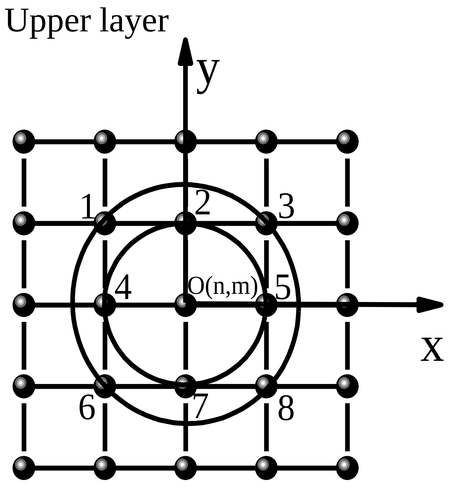
## Introduction

Friction is a common phenmenon which is often observed in our daily lives. One of the current areas of development in understanding the sliding friction is the depinning transition between substrate and slider in static friction.

## Model

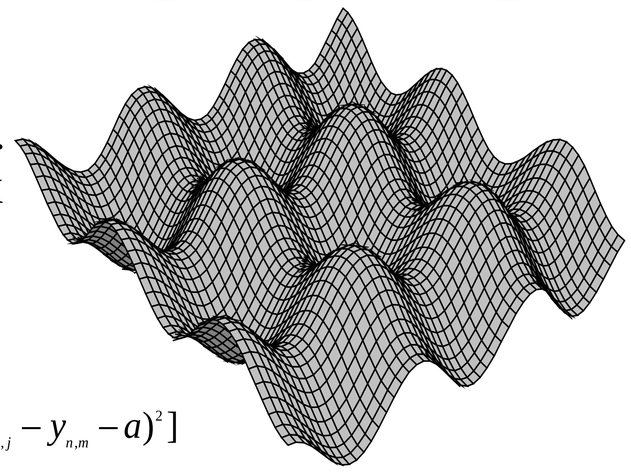



Upper layer




Lower layer

$$V_{sub} = -\frac{f}{2\pi}[\cos(\frac{b}{2\pi}x) + \cos(\frac{b}{2\pi}y)]$$

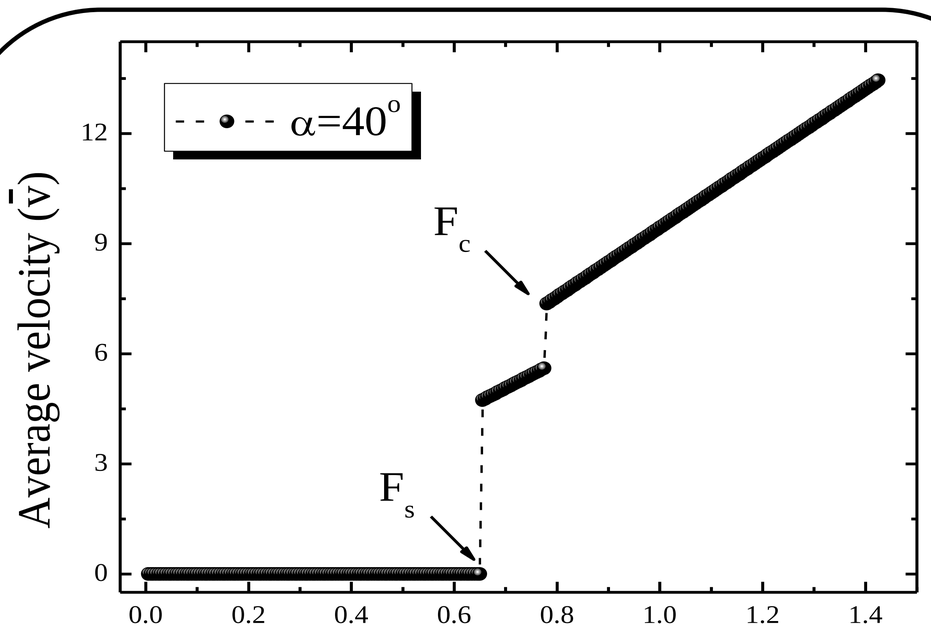


$$V_{int} = \sum_{i,j} \frac{K}{2}[(x_{i,j} - x_{n,m} - a)^2 + (y_{i,j} - y_{n,m} - a)^2]$$

An arbitrary (n,m)th atom of the upper layer satisfies the following equation of motion:

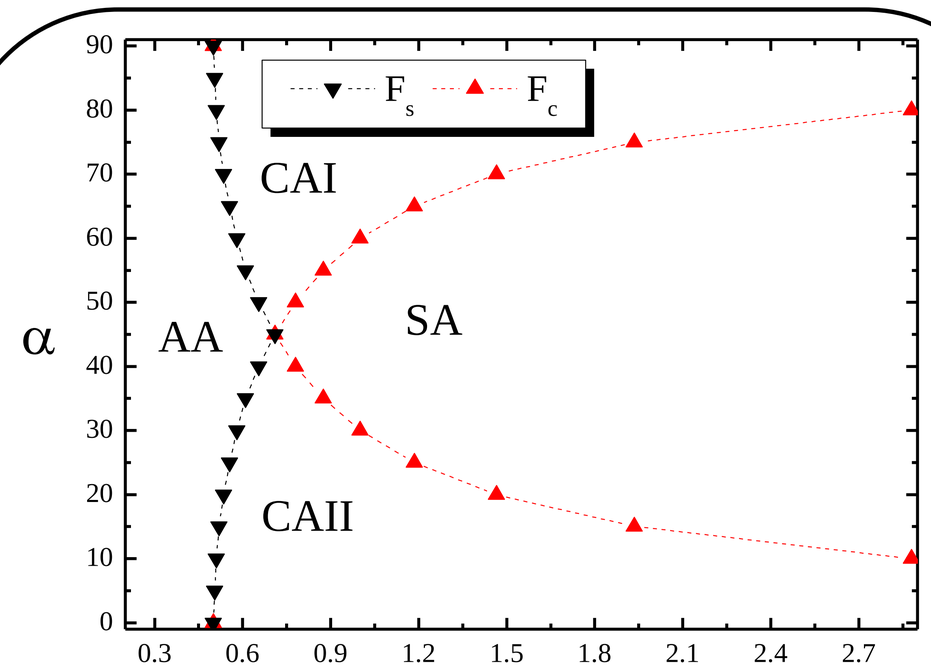
$$M_{n,m}\ddot{r}_{n,m} + \gamma M_{n,m}\dot{r}_{n,m} + \frac{\partial(V_{int} + V_{sub})}{\partial r_{n,m}} = F_{ext}$$

## Numerical Results




Fs is the static friction force at which the upper layer start to move;

Fc is the kinetic friction force at which the upper layer slide in the direction of the external force.




(1) Region AA where $F_{ext} < F_s$ and the average atomic velocity $\bar{v}$.
(2) Region CA where $F_s < F_{ext} < F_c$ and $\beta$ is a constant while $\beta \neq \alpha$.
(3) Region SA where $F_{ext} > F_c$ and $\beta = \alpha$.

## Published Papers

1. Yang Yang, Wen-Shan Duan, Jian-Min Chen, Lei Yang, Jasmina Tekic, Zhi-Gang Shao and Cang-Long Wang. Friction phenomena and phase transition in the underdamped two-dimensional Frenkel-Kontorova model，Phy. Rev. E 82, 051119 (2010).

2. Yang Yang, Wen-Shan Duan, Lei Yang, Jian-Min Chen and Mai-Mai Lin. Rectication and phase locking in overdamped two dimensional Frenkel-Kontorova model. Europhys. Lett. 93, 16001 (2011).

3. Yang Yang, Cang-Long Wang, Wen-Shan Duan and Jian-Min Chen. Resonance and Rectication in a two-dimensional Frenkel-Kontorova model with triangular symmetry. Chin. Phys. Lett. 28(3), 030503 (2011).

## Conclusion

The locked-to-sliding phase transition for certain materials with square lattice symmetry has been studied in the 2D FK model.

These two critical forces, the static friction and the kinetic friction force for which particles move in the direction of driving force have been analyzed for different system parameters. They both depend on the direction and the value of external driving force, the magnitude of adhesive force and the interaction strength between two in the upper layer and especially on the misfit angle $\theta$.

In order to obtain superlubricity between two layers, we will choose the materials with the larger interatomic interaction strength of the upper layer, and the smaller magnitude of adhesive force of the lower layer. This conclusion is similar with that found in 1D case. Meanwhile, the suitable misfit angle had to be chosen in order to obtain smaller friction force.

NORTHWEST NORMAL UNIVERSITY

Name: Yang Yang
Education: Master's degree in physics, Northwest Normal University, 2012
Email: ygygaa@gmail.com
Telephone: 8615095394699