中央大學物理學系
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Colloquium

Lifting a granular box by a half-buried rod

如何用筷子把米罐拔離桌面
- 顆粒堆的凝固和融解

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Abstract :

We studied an interesting experiment that showed a half-buried chopstick lifting a full bottle of granules off the table. In Janssen's theory, the friction force provided by the container wall helps alleviate the weight of the granules. How can a thin rod with a much less contact area support the full weight plus that of the container? Insights are gained by allowing the friction on the wall to change direction before solving the Janssen equation. We obtained the analytic expression for the critical depth of granules that enables a successful lift-off. If we analogize this feat as the solidification of granules, the spontaneous or stimulated (by vibrations or AC torsions) drop will be equivalent to melting or aging. We established that the stick-slip phenomenon is involved when the bottle falls to the ground and during a failed lift-off by analyzing the frequency of fluctuations in the pull force. Finally, a photo-elasticity experiment was employed to directly visualize the stress field sensitive to the pull force, and verify the directional change of friction force from the wall.