

当纸被揉成团时发生了什么？

作者：writer 来源：科学网

本文原地址：<https://www.iikx.com/news/progress/2951.html>

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论文标题：A state variable for crumpled thin sheets

期刊：Communications Physics

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发表时间：2018/11/08

数字识别码：10.1038/s42005-018-0072-x

原文链接：[https://www.nature.com/articles/s42005-018-0072-x?utm_source=otherutm_medium=otherutm_content=nullutm_](https://www.nature.com/articles/s42005-018-0072-x?utm_source=otherutm_medium=otherutm_content=nullutm_campaign=JRCN_2_RL_sciencenet_article_10.1038_s42005-018-0072-x)

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本周《通讯-物理》在线发表的一篇论文A state variable for crumpled thin sheets报道了聚酯薄膜起皱的动力学机制。这一发现有助于我们准确理解纸张如何起皱变成一个纸球。



图源：Pixabay

当纸被揉成团时发生了什么？把一张纸揉成一个纸球很简单，但是其背后的动力学机制却很复杂。纸张起皱时会形成一个错综复杂的折痕网。虽然纸张会优先沿着已有折痕弯曲，但是除非折叠顺序和之前一模一样，否则纸张每一次起皱时都会形成新的折痕。目前尚不清楚是否有可能预测一张平滑的纸起皱形成纸球的方式。

美国哈佛大学的Omer Gottesman、Shmuel Rubinstein及同事反复地搓揉预先已被卷成圆柱体的单层聚酯薄膜，再把它们摊平，然后分析折痕模式的变化。他们发现所有折痕的总长度不会随机变化，而是以一种取决于某特定瞬间的折痕长度的方式发生变化——无论该聚酯薄膜已被揉过多少次或者已有的折痕模式结构如何。因此作者得以定义一个可以表征一张聚酯薄膜皱度的量。

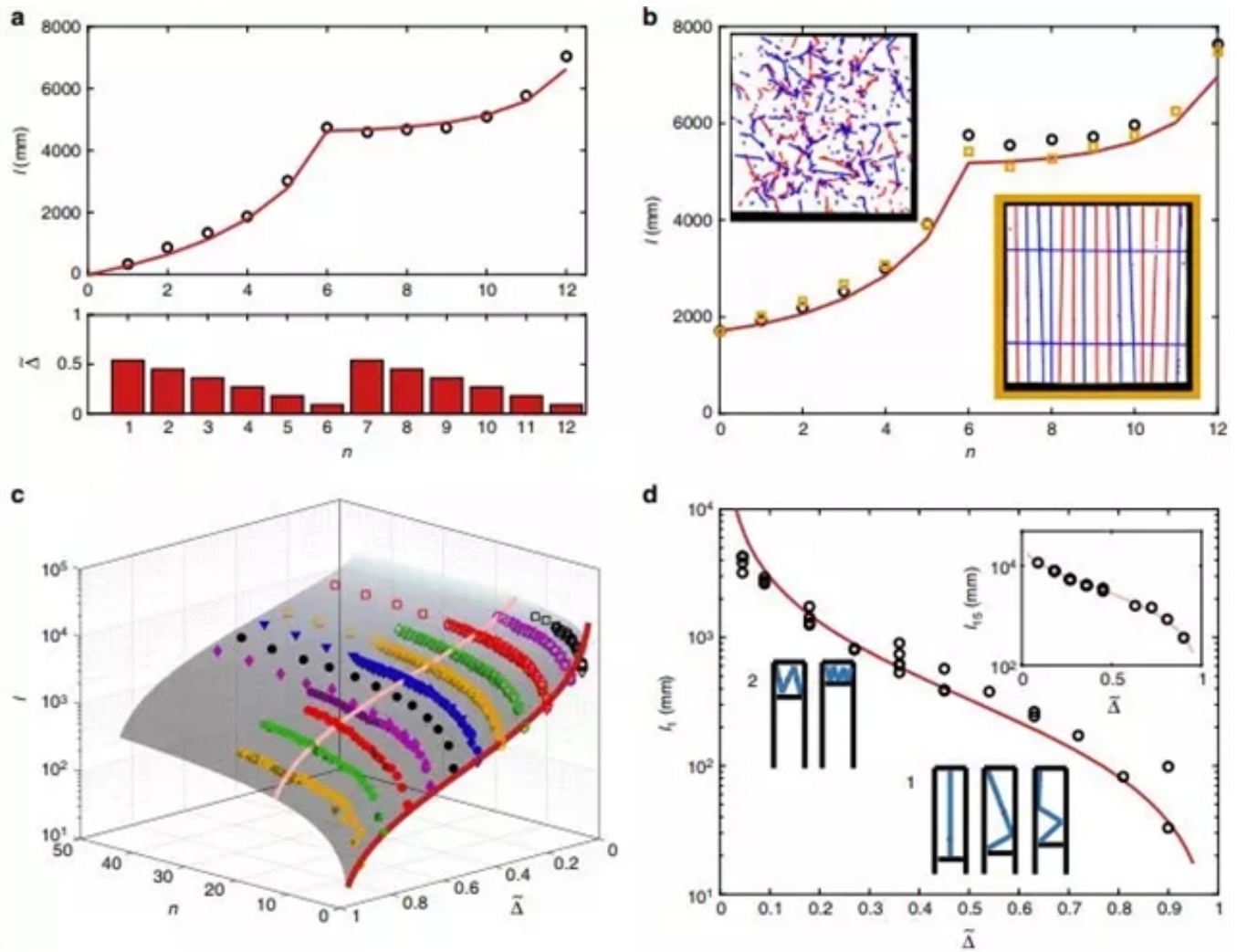


图2：起皱的动力学机制。图源：Gottesman等

作者认为这项发现或可以提供一种模型，用以表征其它受几何和机械约束的系统的动力学特征，这些系统包括蛋白质的折叠以及可导致地震的地质断层系统。

摘要： Despite the apparent ease with which sheets of paper are crumpled and tossed away, crumpling dynamics are often considered a paradigm of complexity. This arises from the infinite number of configurations that disordered, crumpled sheets can take. Here we experimentally show that key aspects of axially confined crumpled Mylar sheets have a very simple description; evolution of damage in crumpling dynamics can largely be described by a single global quantity—the total length of creases. We follow the evolution of the damage network in repetitively crumpled elastoplastic sheets, and show that the dynamics are deterministic, depending only on the instantaneous state of the crease network and not on the crumpling history. We also show that this global quantity captures the crumpling dynamics of a sheet crumpled for the first time. This leads to a remarkable reduction in complexity, allowing a description of a highly disordered system by a single state parameter.

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