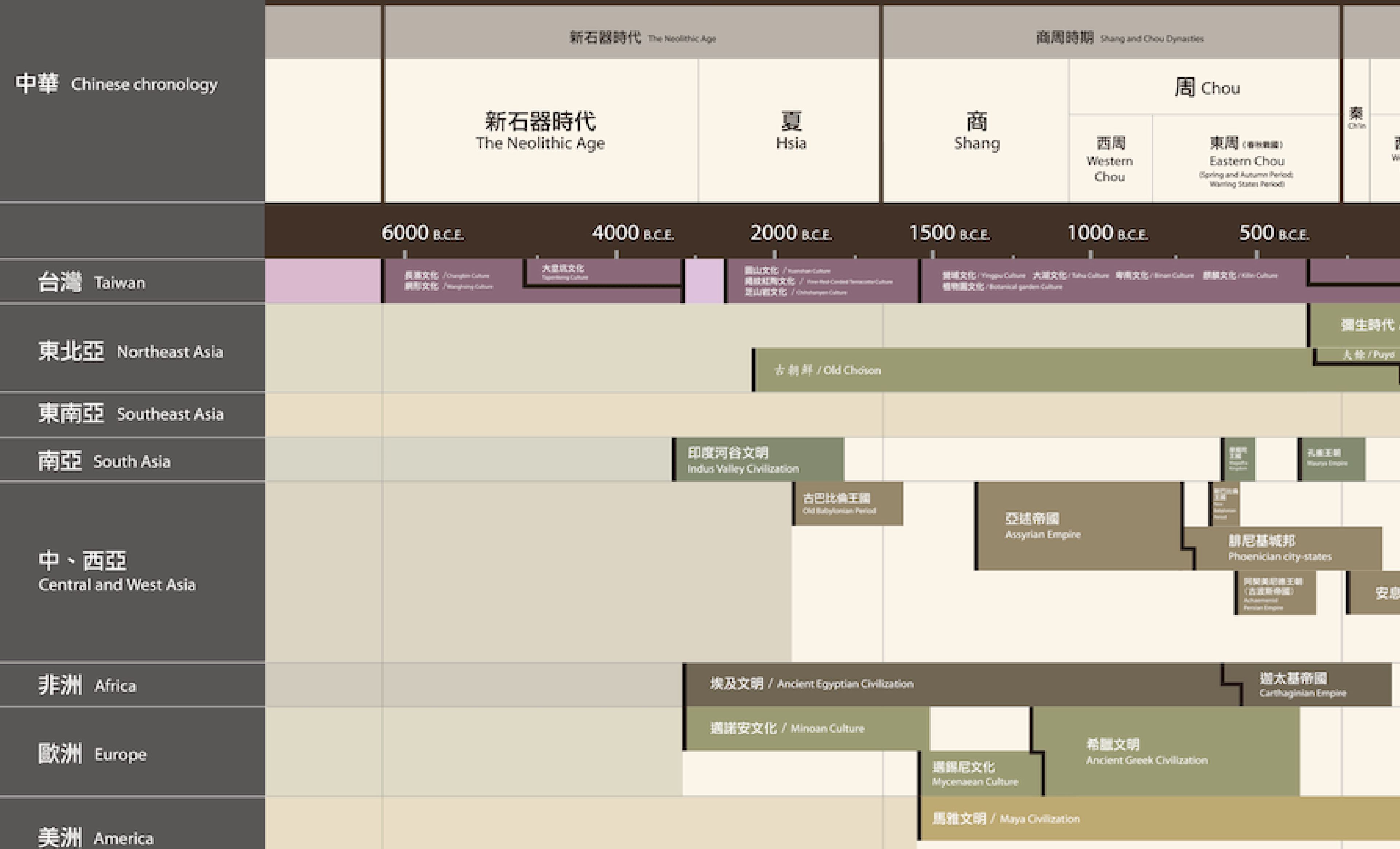
How physicist can find ideas in National Palace Museum?





Tzay-Ming Hong
Physics, National Tsing Hua University
ming@phys.nthu.edu.tw
0928-617-923; (03) 574-2481

東西文化年表 Timeline of World Cultures



Understanding *qi-wa*, the curling of scrolled artwork. In the Chinese and other traditions, paintings are executed on long paper or silk scrolls. On display, those artworks may be plagued by *qi-wa*, a curling up of the side edges that can tear fibers and dislodge pigment. Many analyses to date of *qi-wa* have focused on such factors as environmental humidity or the glue used to affix a painting to its mounting. But a group of Taiwanese physicists and conservationists led by Tzay-Ming Hong of National Tsing Hua University have shown that *qi-wa* can be explained by a physical mechanism put into play when the art is rolled up for storage. Rolling compresses the inner, painted face of the scroll in the long direction and stretches the outer face. When the scroll is removed from storage, the strain relaxes. As a result of the Poisson

SHEN NANPI

PRL 112, 034302 (2014) PHYSICAL REVIEW LETTERS week ending 24 JANUARY 2014

Curling Edges: A Problem that Has Plagued Scrolls for Millennia

Ming-Han Chou,[1] Wei-Chao Shen,[1] Yi-Ping Wang,[1] Sun-Hsin Hung,[2] and Tzay-Ming Hong[1,3,*]
[1]*Department of Physics, National Tsing Hua University, Hsinchu 30013, Taiwan, Republic of China*
[2]*Department of Registration and Conservation, National Palace Museum, Taipei 11143, Taiwan, Republic of China*
[3]*Center for Fundamental Science Research, National Tsing Hua University, Hsinchu 30013, Taiwan, Republic of China*
(Received 25 August 2013; published 23 January 2014)

Qi-Wa refers to the up curl on the lengths of hand scrolls and hanging scrolls, which has troubled Chinese artisans and emperors for as long as the art of painting and calligraphy has existed. This warp is unwelcome not only for aesthetic reasons, but its potential damage to the fiber and ink. Although it is generally treated as a part of the cockling and curling due to moisture, consistency of paste, and defects from the mounting procedures, we demonstrate that the spontaneous extrinsic curvature incurred from the storage is in fact more essential to understanding and curing Qi-Wa. In contrast to the former factors whose effects are less predictable, the plastic deformation and strain distribution on a membrane are a well-defined mechanical problem. We study this phenomenon by experiments, theoretical models, and molecular dynamics simulation, and obtain consistent scaling relations for the Qi-Wa height. This knowledge enables us to propose modifications on the traditional mounting techniques that are tested on real mounted paper to be effective at mitigating Qi-Wa. By experimenting on polymer-based films, we demonstrate the possible relevance of our study to the modern development of flexible electronic paper.

DOI: 10.1103/PhysRevLett.112.034302 PACS numbers: 46.32.+x, 46.70.De

凡煮糊，必去筋，稀緩得所，攪之不停，自然調熟。
————《歷代名畫記》

良工用糊如用水，止在多刷，刷多则漿水沁透纸，凝结如抄成者，不全恃糊力矣 ————《裝潢志》

裱房惡地濕而憚風燥，喜溫潤而愛虛明。裝板須高，利畫堅挺。必安地屏，杜濕上蒸。 ————《裝潢志》

裝潢書畫，秋為上時，春為中時，夏為下時，暑濕及凝寒俱不可裝裱 ————《長物志》

上壁宜潤，貴其濕潤，下壁宜燥，庶平瓦患，燥潤失宜，優劣繫焉。 ————《裝潢志》

Paste, mounting skills, humidity, weather, etc.

Collaborators

Ming-Han Chou（周明翰，清大物理系）
Wei-Chao Shen （沈維昭，清大物理系）
Yi-Ping Wang（汪依平，清大物理系）
Sun-Hsun Hong（洪順興，國立故宮博物院）

Outline

- Introduction（15 min.）
- Curling edges on scrolls, aka Qi-Wa 起瓦（5 min.）
- Background knowledge on mounting（5 min.）
- Experiment, theoretical model, and MD simulation（10 min.）
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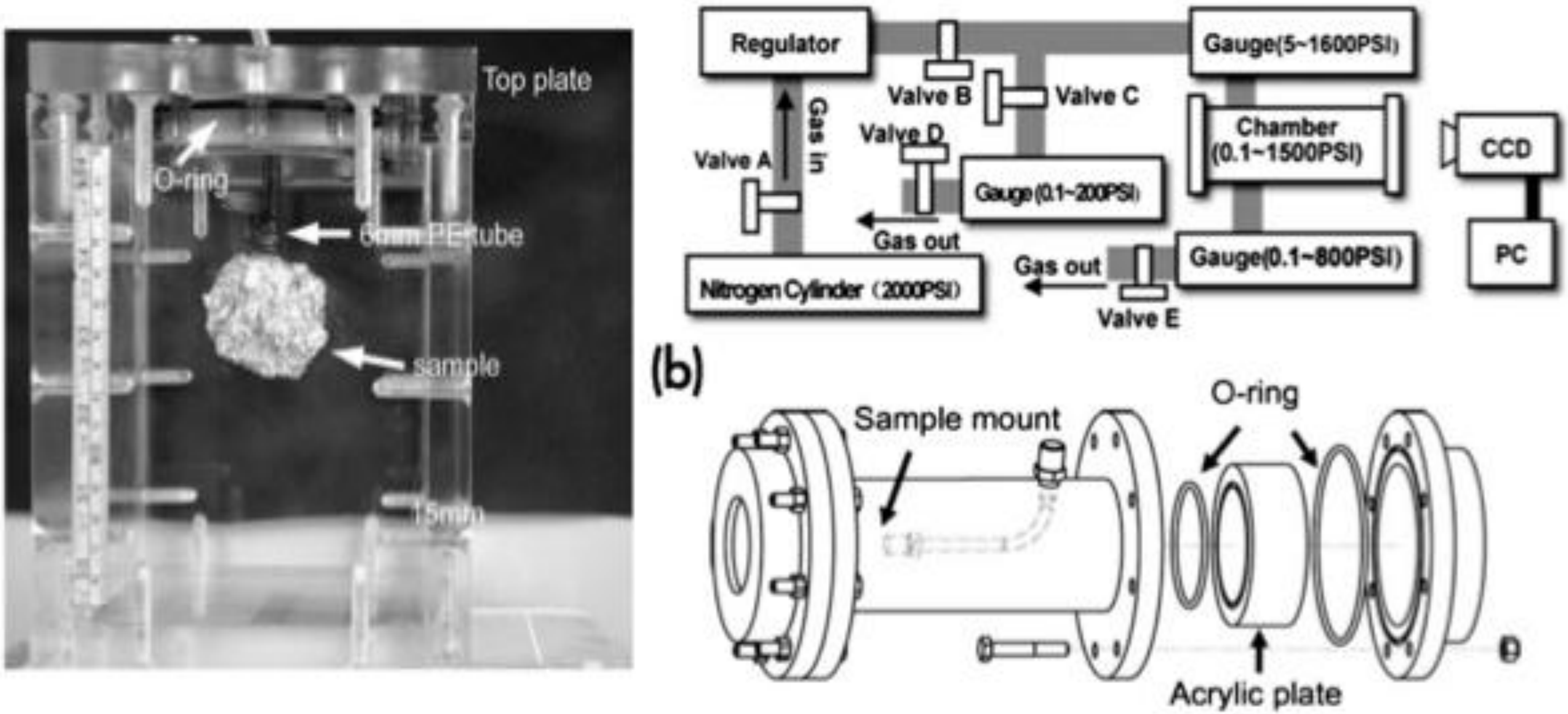
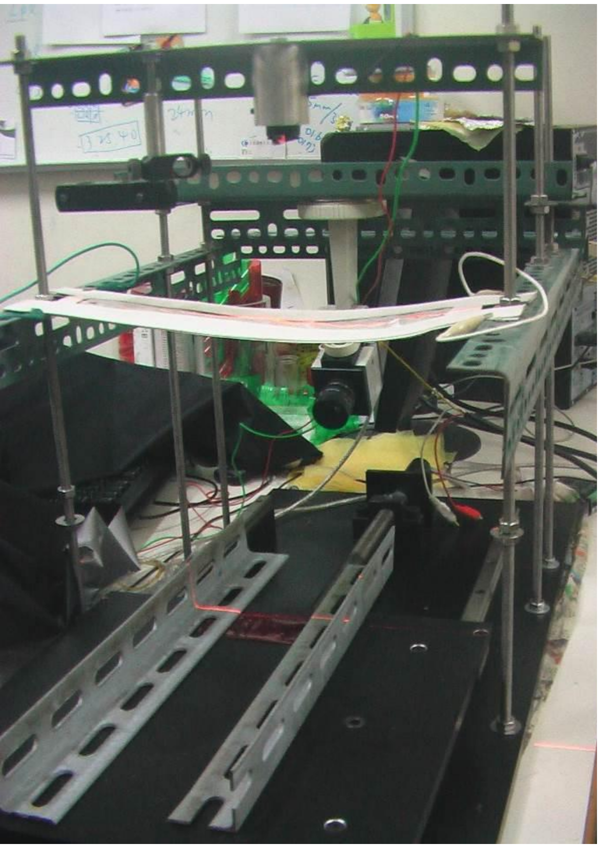
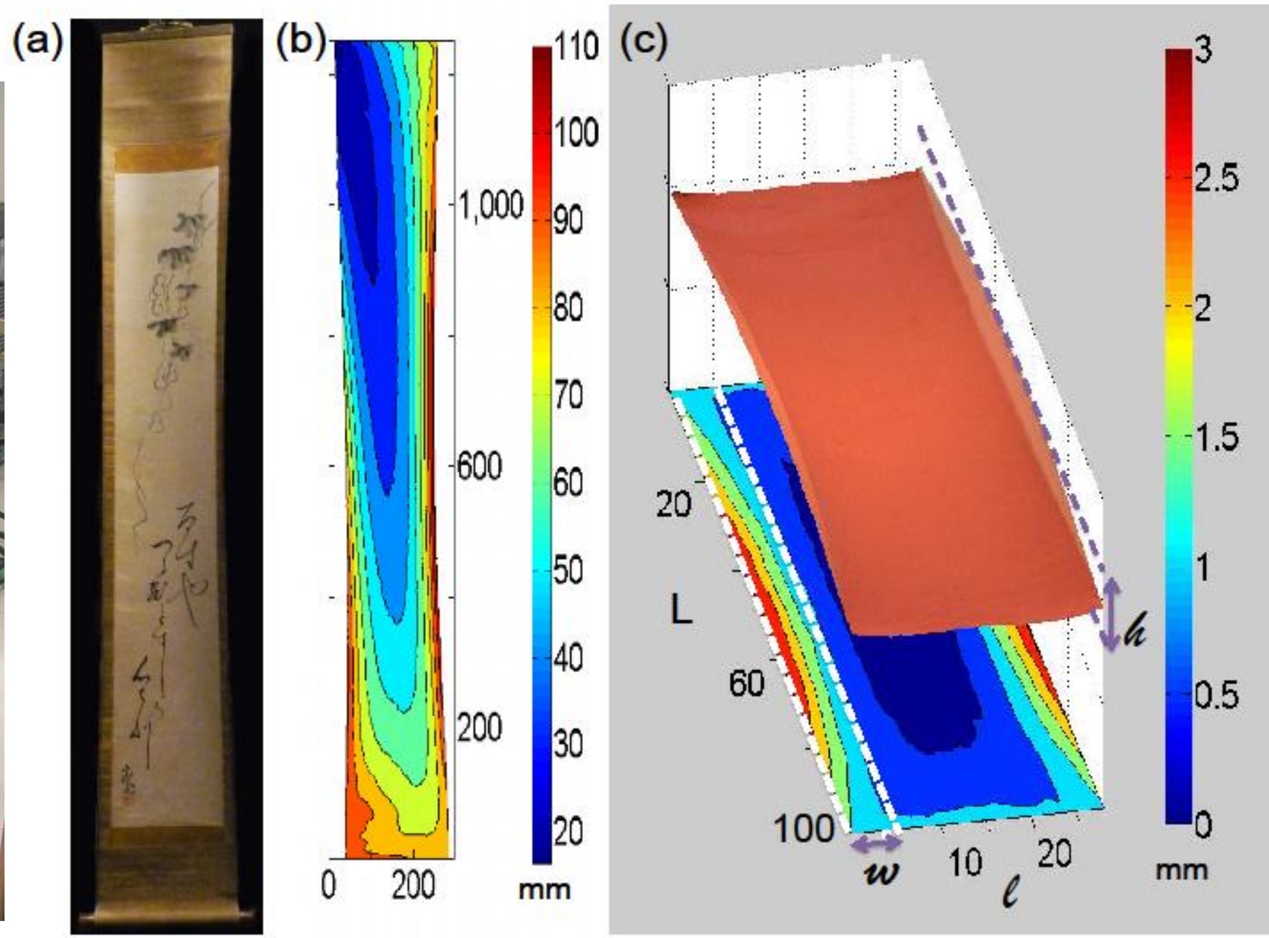


Top plate
O-ring
sample
Regulator
Valve B
Valve C
Gauge(5~1600PSI)
Gas in
Valve D
Valve A
Chamber
(0.1~1500PSI)
CCD
Gauge(0.1~200PSI)
Gas out
Gauge(0.1~800PSI)
PC
Nitrogen Cylinder（2000PSI）
Valve E
(b)
Sample mount
O-ring
Acrylic plate




(a)
(b)
1,000
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200
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80
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(c)
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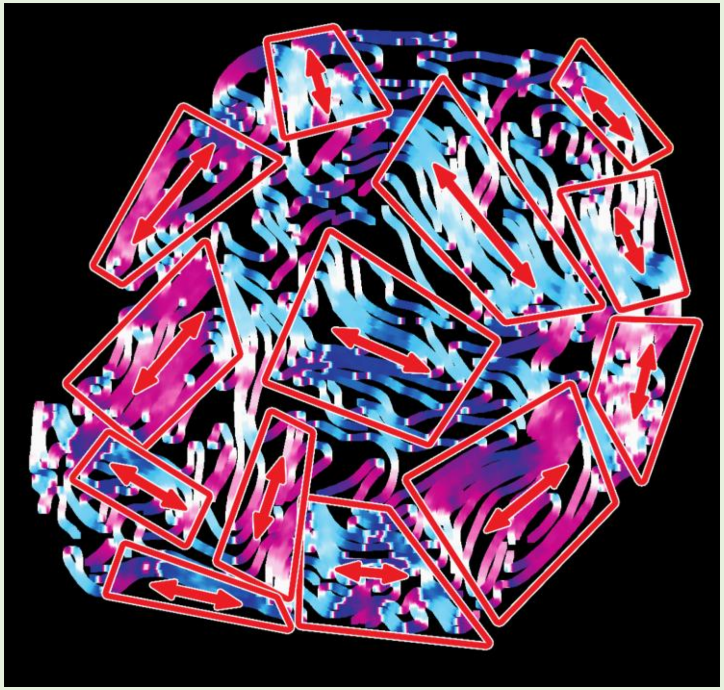
PHYSICAL REVIEW LETTERS

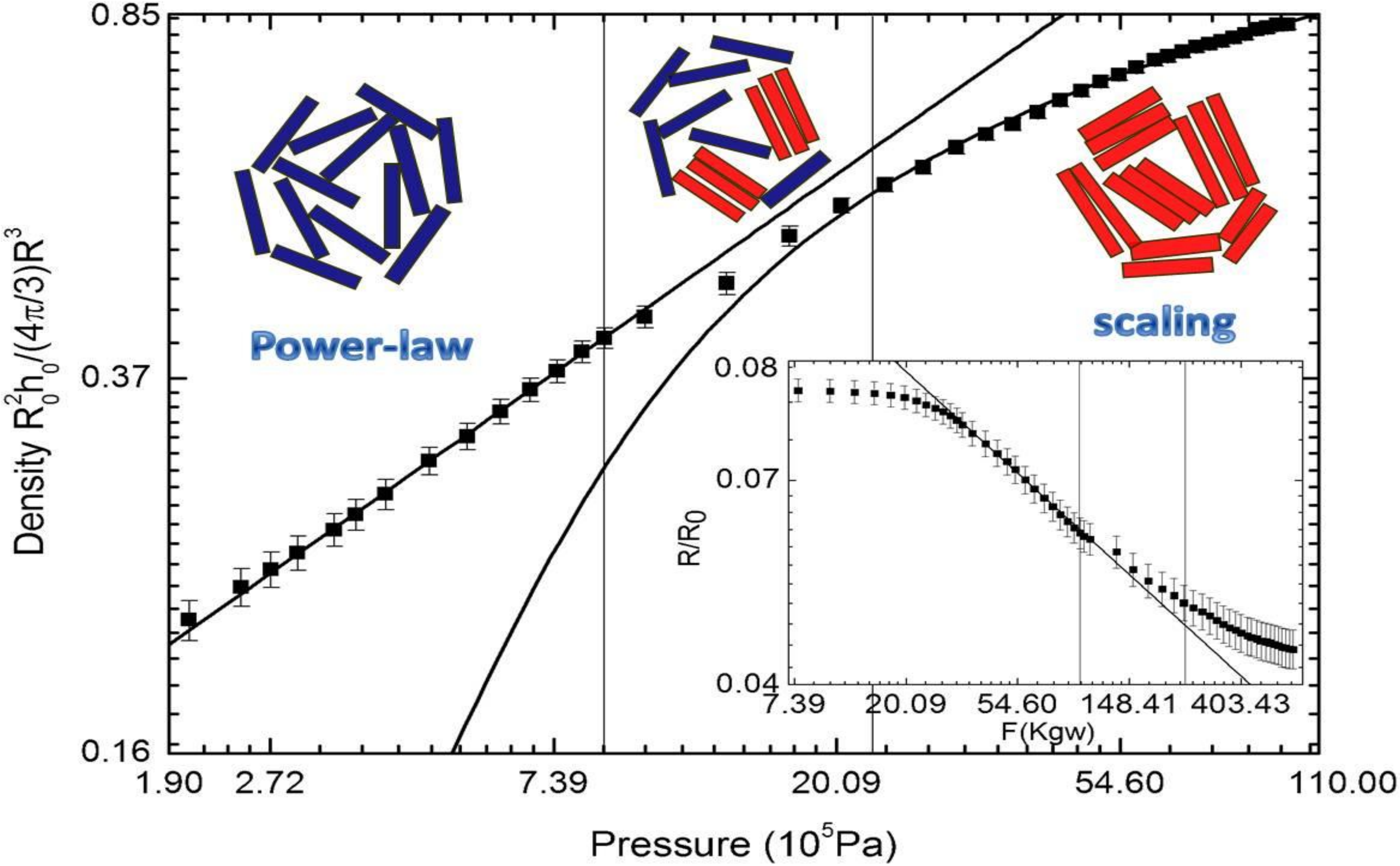
Articles published eight days ending 31 DECEMBER 2009



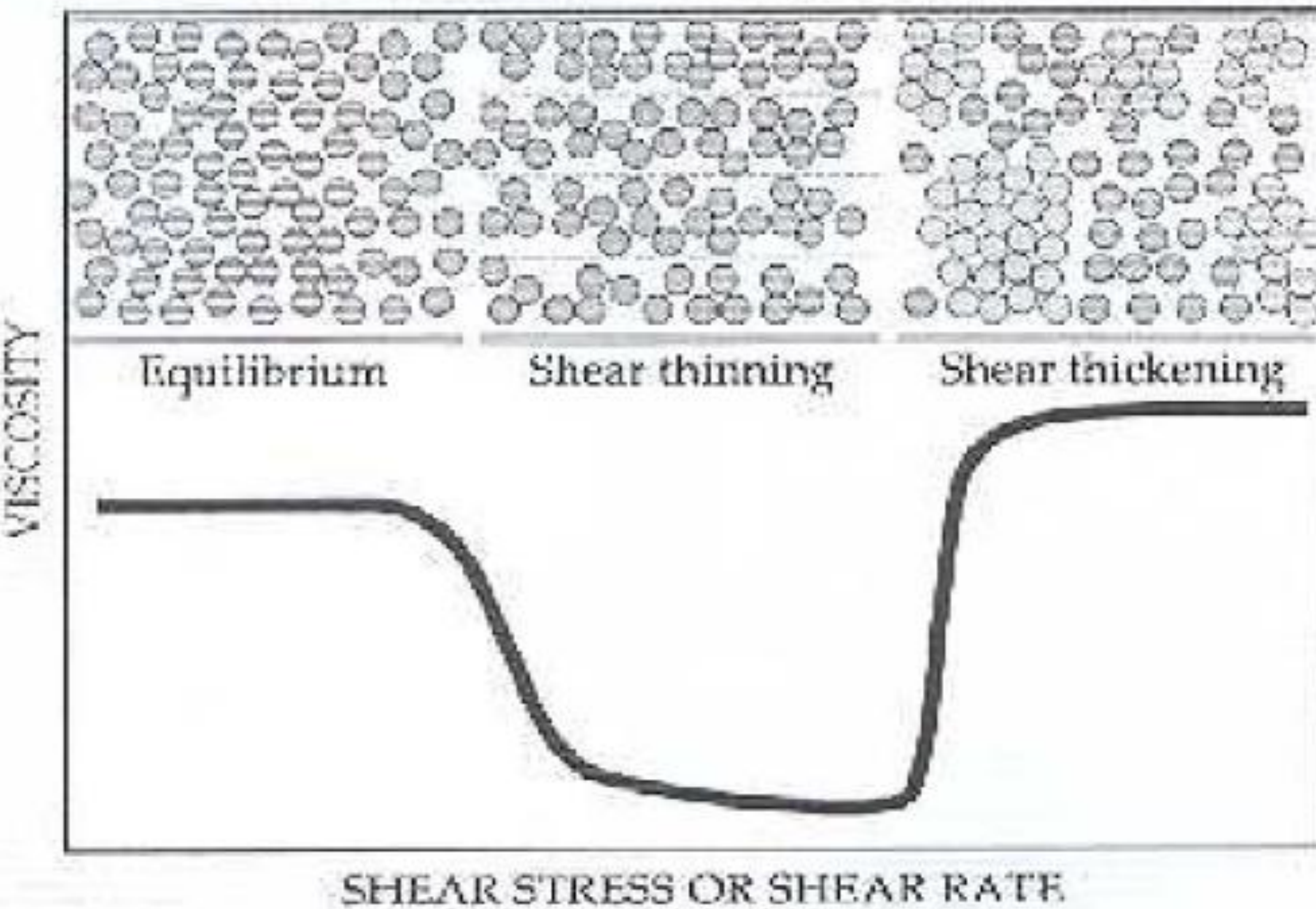
Published by the
American Physical Society

APS physics

Volume 103, Number 26

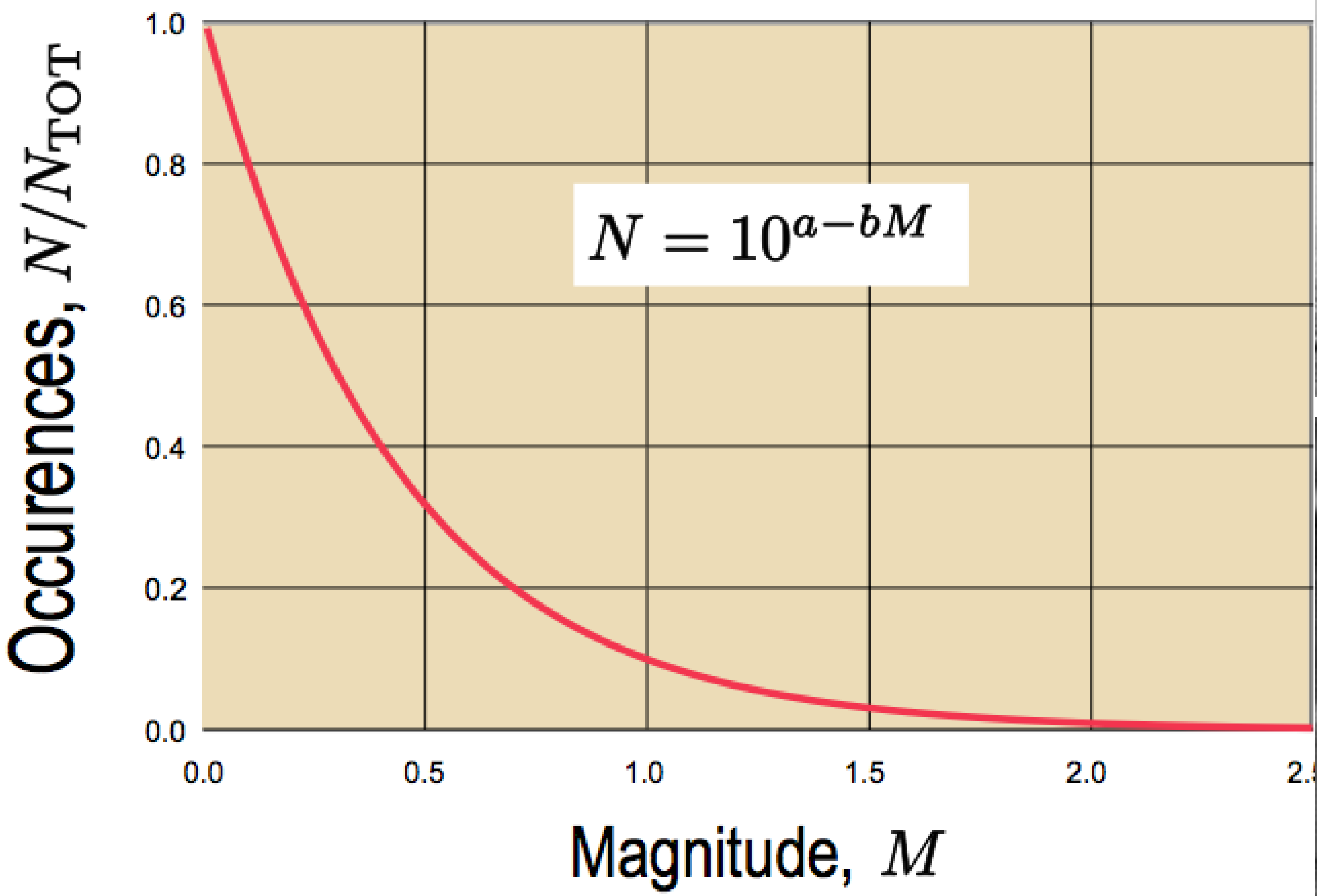


0.85
0.37
0.16
Density $R_0^2 h_0/(4\pi/3)R^3$
1.90
2.72
7.39
20.09
54.60
110.00
Pressure (10^5Pa)
Power-law
scaling
0.08
0.07
0.04
R/R_0
7.39
20.09
54.60
148.41
403.43
F(Kgw)



Equilibrium
Shear thinning
Shear thickening
VISCOSITY
SHEAR STRESS OR SHEAR RATE

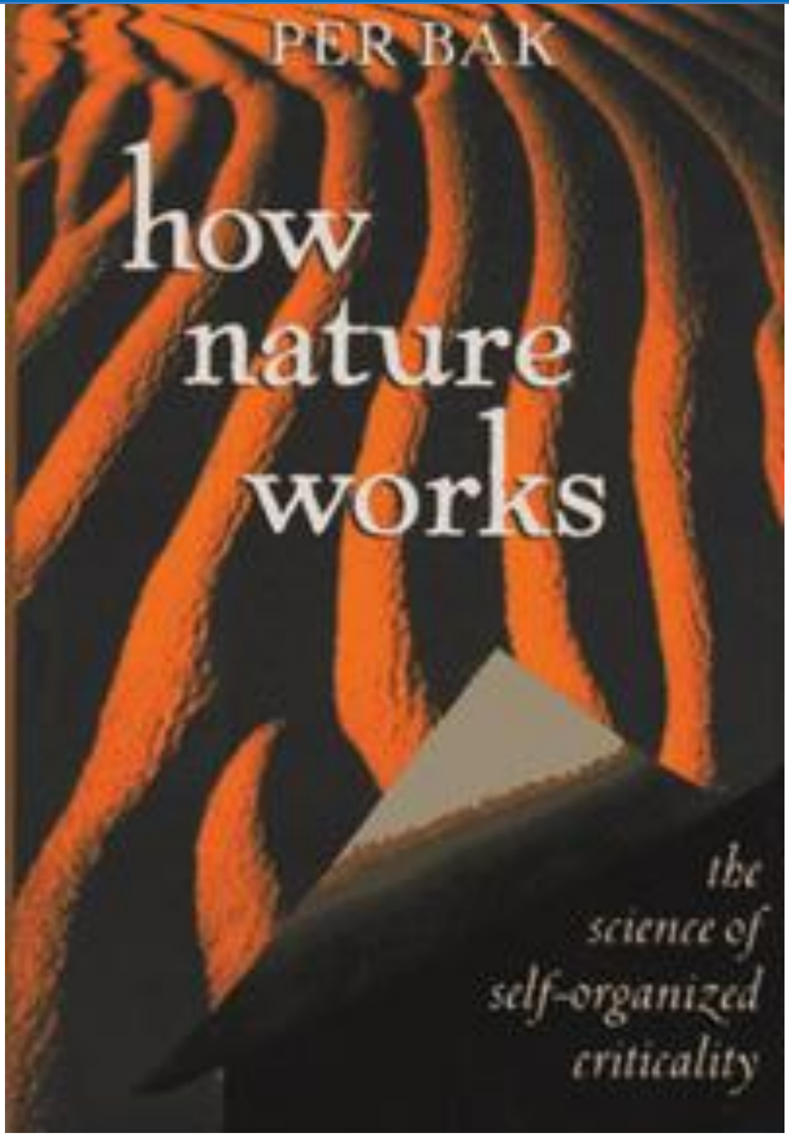
Gutenberg-Richter law



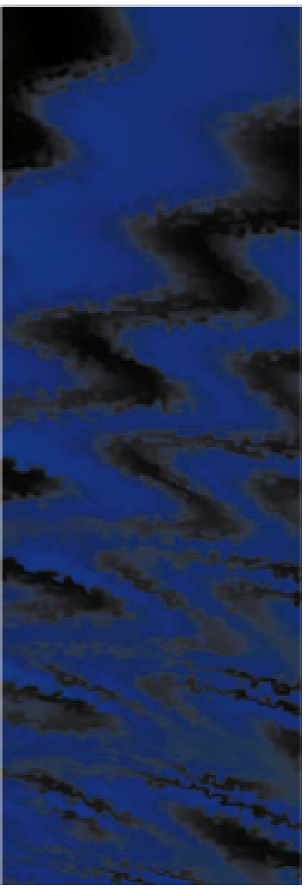
Ubiquity of power law

1. Pareto's law of income distribution, aka 80-20 rule
2. Number of cities having a certain population
3. Sizes of earthquakes
4. Sizes of craters on the moon
5. Sizes of solar flares
6. Foraging pattern of various species
7. Activity patterns of neuronal populations
8. Frequencies of words in most languages
9. Frequencies of family names
10. The species richness in clades of organisms
11. Sizes of power outages
12. Sizes of war
13. Criminal charges per convict

Sand pile explains it all?



Universality from RG?



insight review articles

Crackling noise

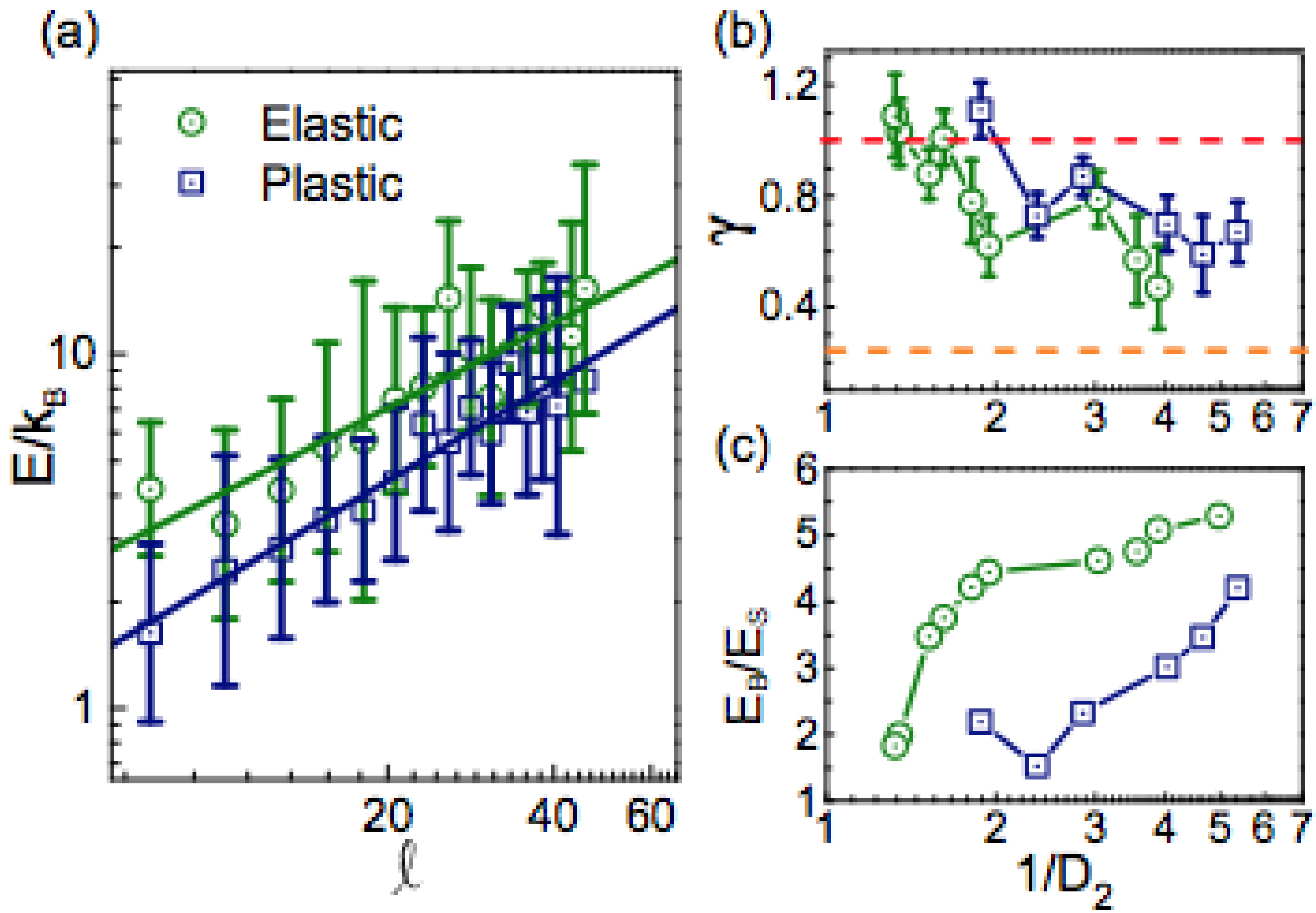
James P. Sethna*, Karin A. Dahmen† & Christopher R. Myers‡

*Laboratory of Atomic and Solid State Physics, Clark Hall, Cornell University, Ithaca, New York 14853-2501, USA (sethna@lassp.cornell.edu)
†Department of Physics, 1110 West Green Street, University of Illinois at Urbana-Champaign, Illinois 61801-3080, USA (dahmen@physics.uiuc.edu)
‡Cornell Theory Center, Frank H. T. Rhodes Hall, Cornell University, Ithaca, New York 14853-3801, USA (myers@tc.cornell.edu)

Crackling noise arises when a system responds to changing external conditions through discrete, impulsive events spanning a broad range of sizes. A wide variety of physical systems exhibiting crackling noise have been studied, from earthquakes on faults to paper crumpling. Because these systems exhibit regular behaviour over a huge range of sizes, their behaviour is likely to be independent of microscopic and macroscopic details, and progress can be made by the use of simple models. The fact that these models and real systems can share the same behaviour on many scales is called universality. We illustrate these ideas by using results for our model of crackling noise in magnets, explaining the use of the renormalization group and scaling collapses, and we highlight some continuing challenges in this still-evolving field.

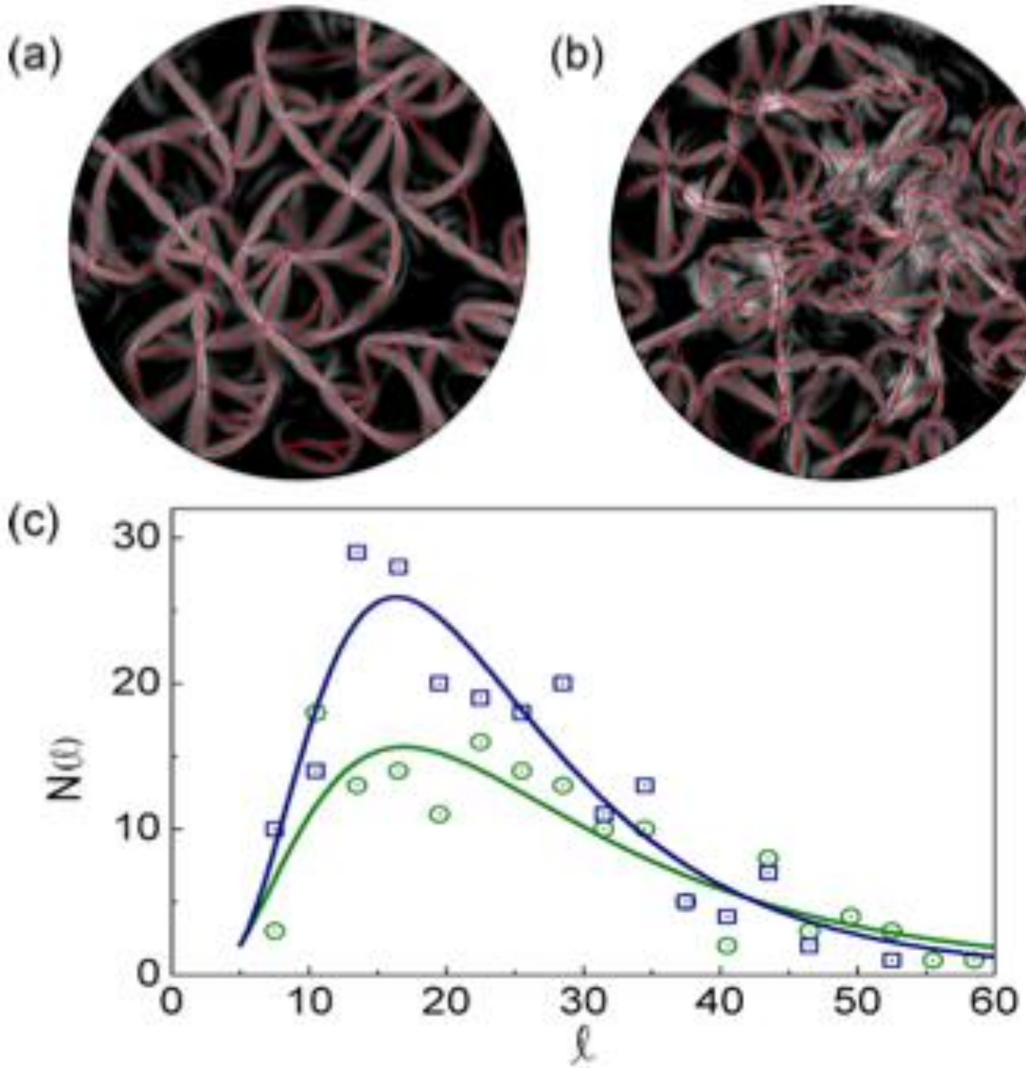
NATURE | VOL 410 | 8 MARCH 2001 | www.nature.com

Power laws for energetics



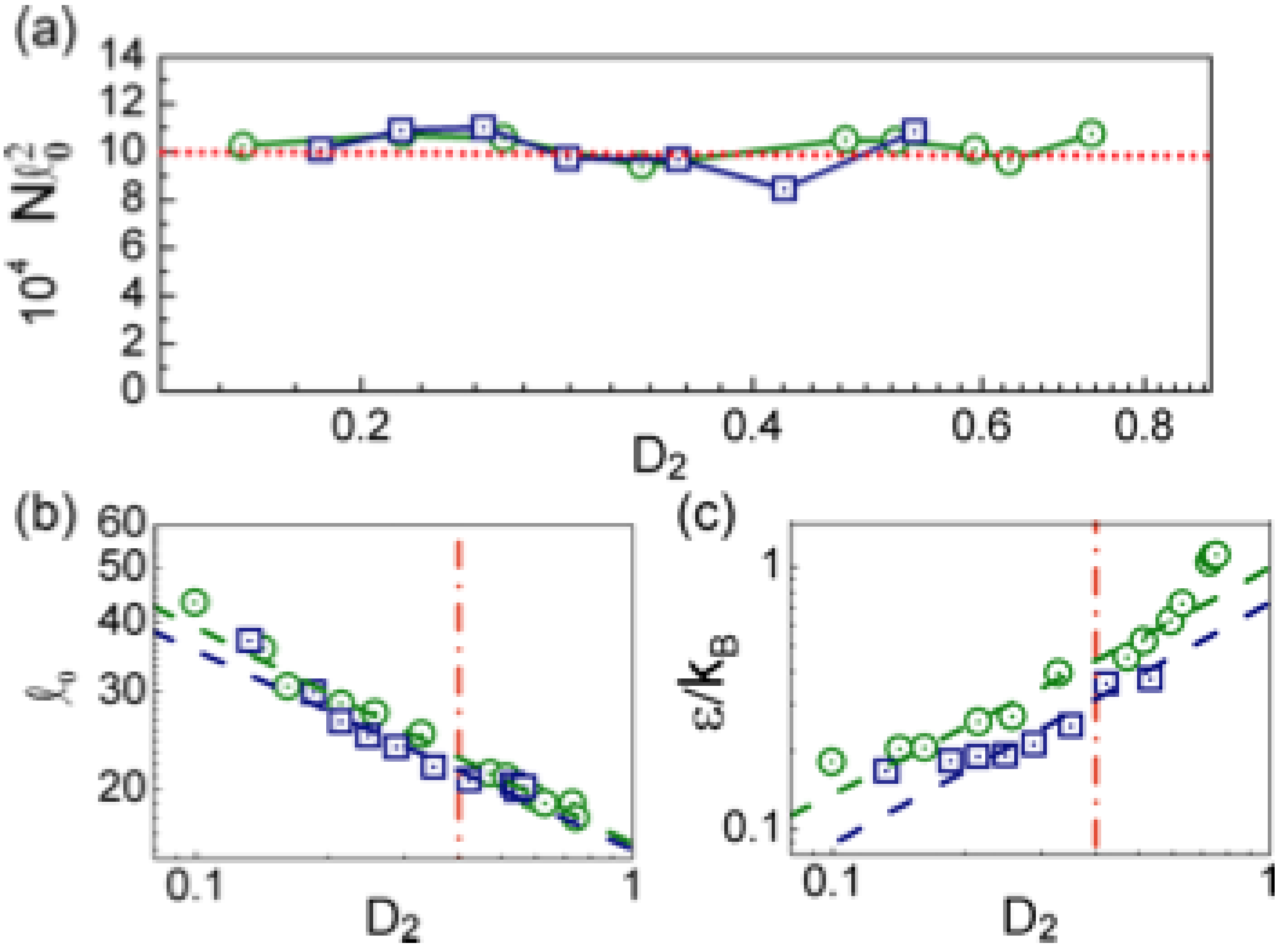
Tom Witten, Chicago

Ridge length distribution

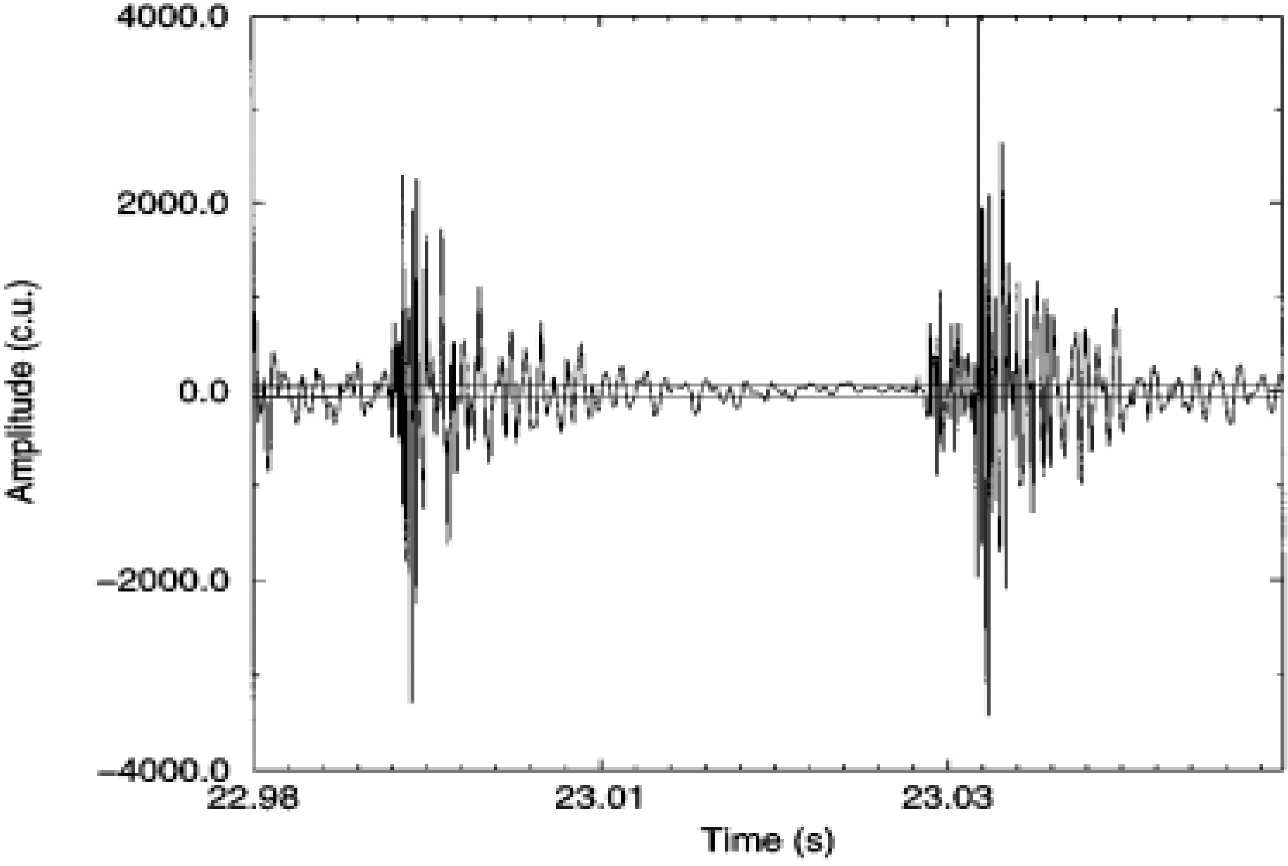


$$\frac{1}{x\sqrt{2\pi}\sigma}\, e^{-\frac{(\ln x-\mu)^2}{2\sigma^2}}$$

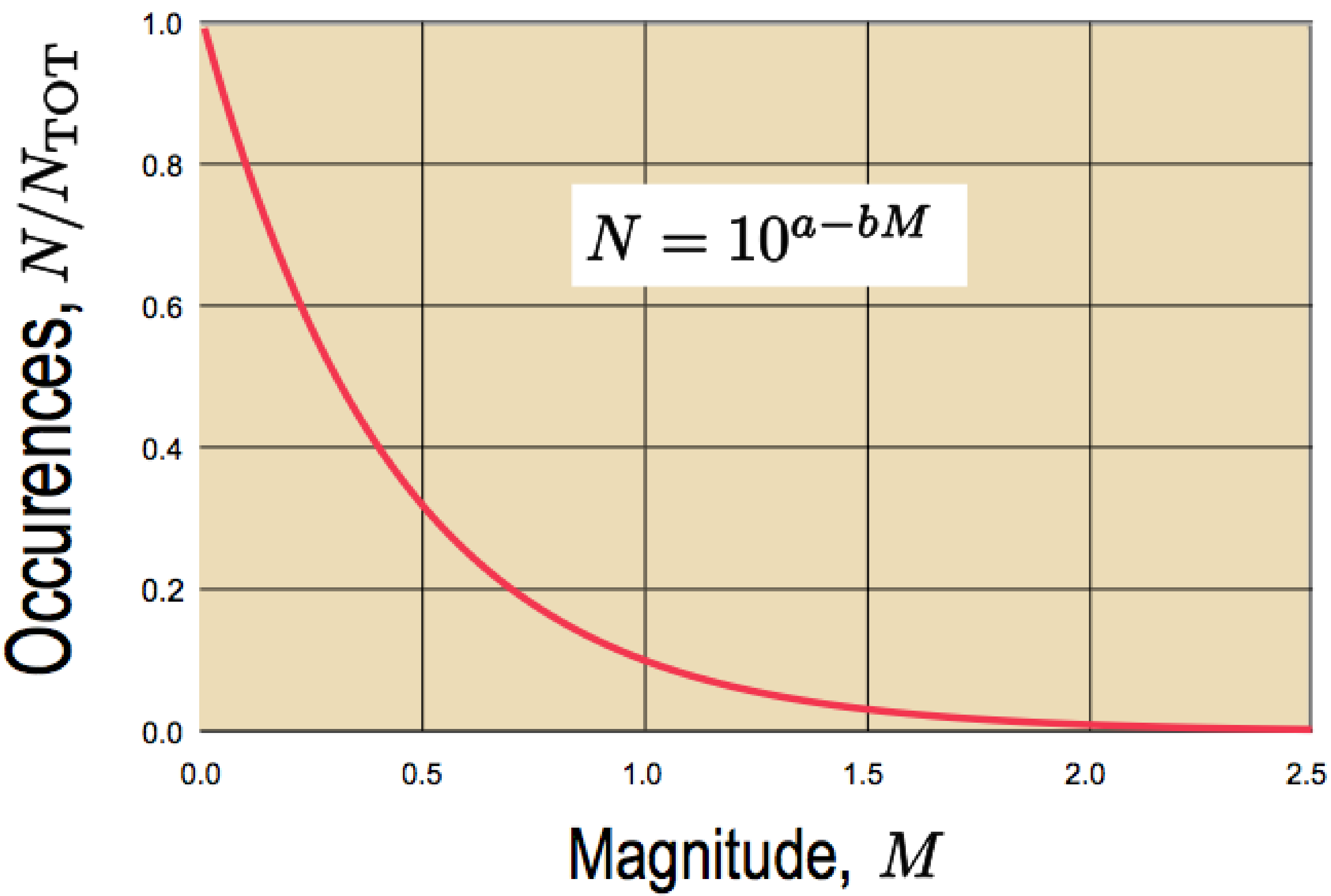
Average ridge length and number

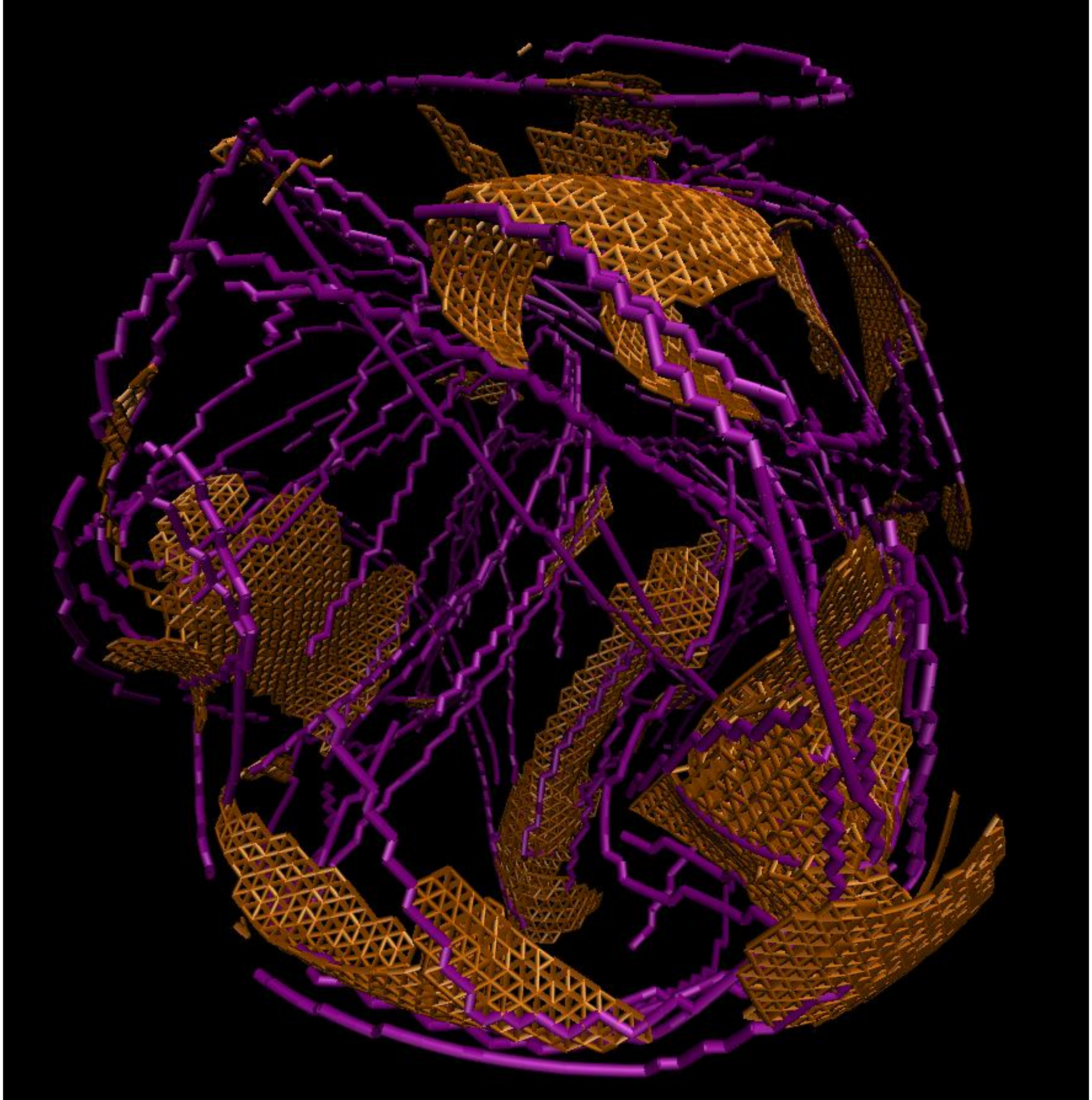


Crumpling noises



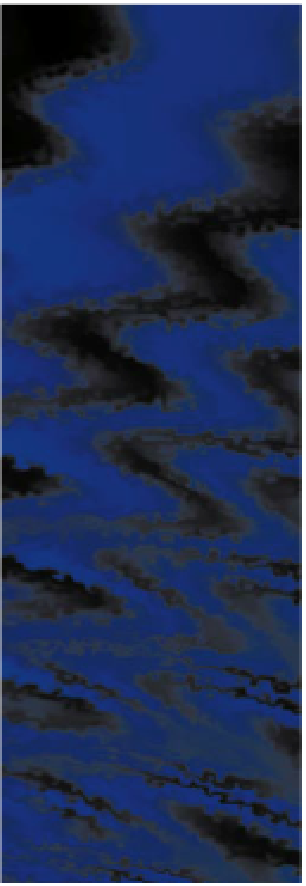
Gutenberg-Richter law





Co-crumpling

Universality?



insight **review articles**

Crackling noise

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* *Laboratory of Atomic and Solid State Physics, Clark Hall, Cornell University, Ithaca, New York 14853-2501, USA (sethna@lassp.cornell.edu)*
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Collection of scrolls in National Palace Museum, Taipei dated back to the Six Dynasties (222-589)

女史箴圖 顧愷之(345-406)

Ancient Chinese literature on Qi-Wa

凡煮糊，必去筋，稀緩得所，攪之不停，自然調熟。
———《歷代名畫記，唐 張彥遠》

良工用糊如用水，止在多刷，刷多则漿水沁透纸，凝结如抄成者，不全恃糊力矣…上壁宜潤，貴其滋潤，下壁宜燥，庶乎瓦患，燥潤失宜，優劣繫焉…裱房惡地濕而憚風燥，喜溫潤而愛虛明。裝板須高，利畫堅挺。必安地屏，杜濕上蒸。
——《裝潢志，明 周嘉胄》

裝潢書畫，秋為上時，春為中時，夏為下時，暑濕及凝寒俱不可裝裱。
——《長物志，明 文震亨》

Traditionally Qi-Wa is treated as a part of cockling and curling due to moisture, consistency of paste, and defects from mounting procedures

We demonstrate that spontaneous extrinsic curvature incurred from storage is more essential

In contrast to conventional factors whose effects are less predictable, plastic deformations due to spontaneous curvature are a well-defined mechanical problem

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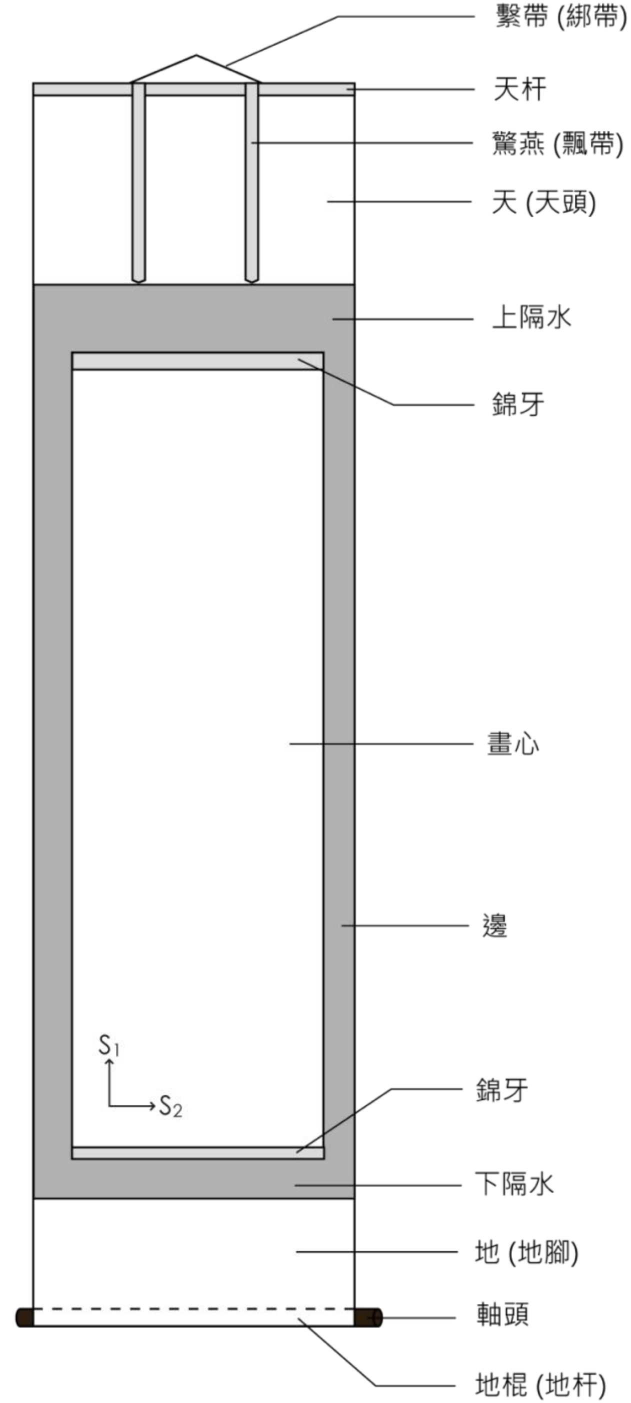
Mounting is an old trade with strict traditions and aesthetic standards (and tons of jargons)



Chinese v.s. Japanese mounting

- 裱件組成：四紙三漿

- 中式裝裱和日式裝裱比較

	覆背紙材	纖維長度	纖維方向性	接紙方式	接紙貼法	裏打
中式	宣紙	短	有	邊緣重疊	不規則	無
日式	楮皮紙	長	有	毛邊接合	規則	有


(a)
(b)
(c)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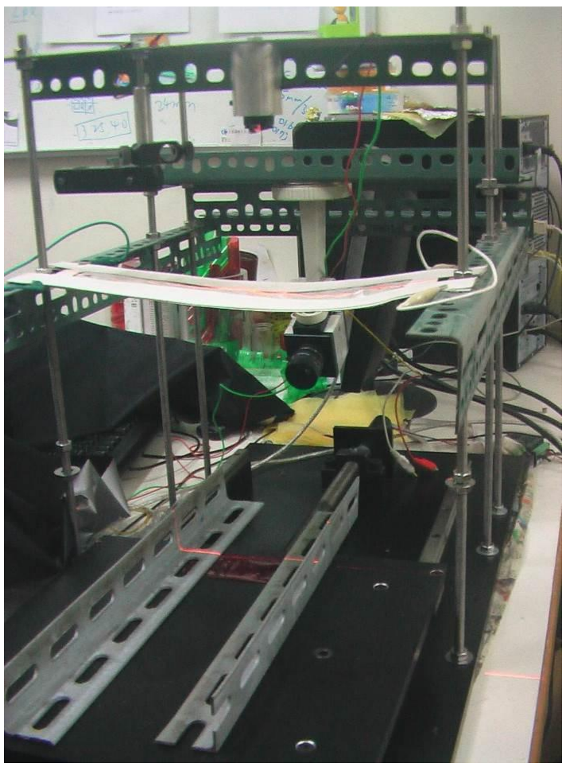
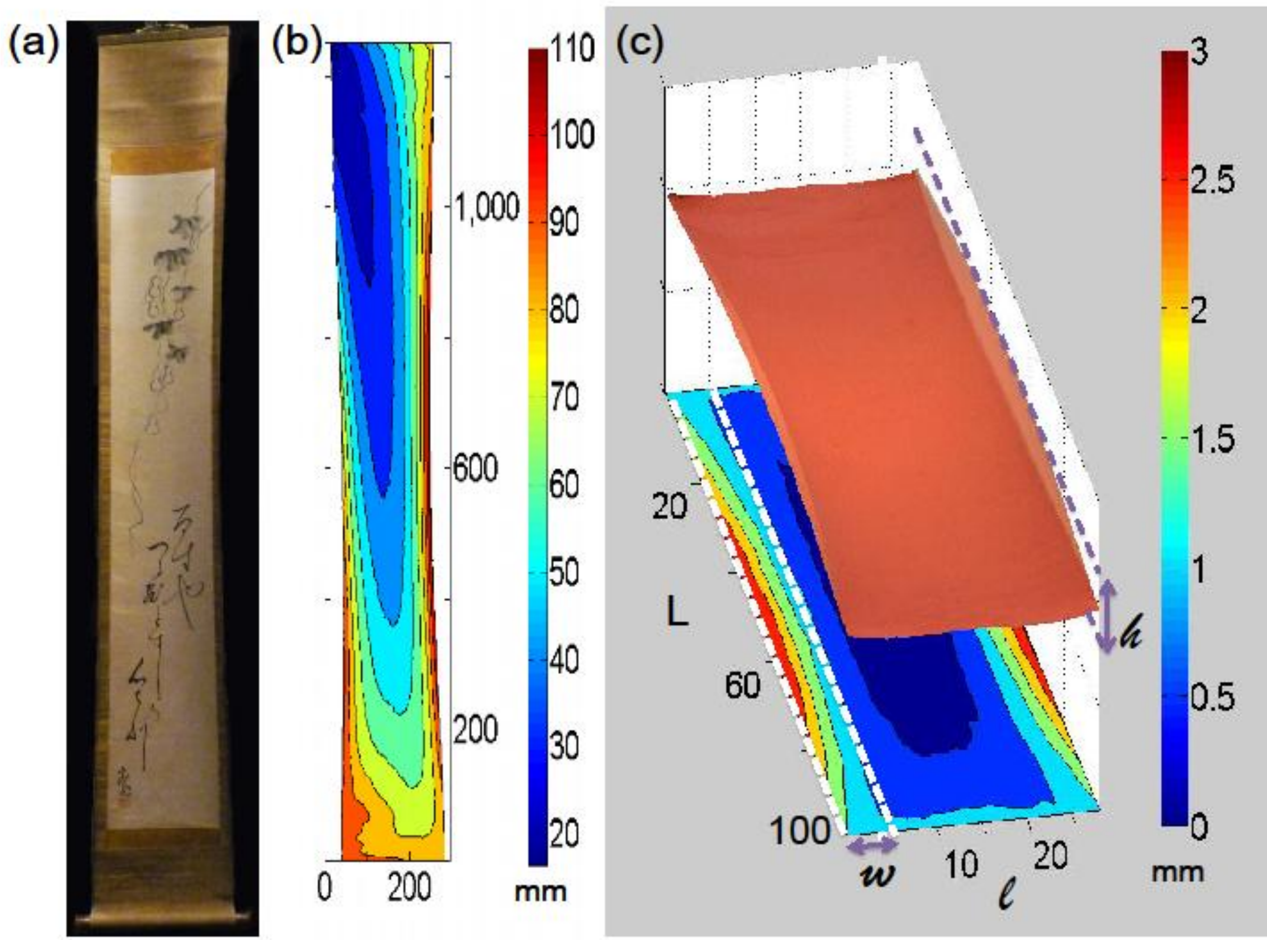
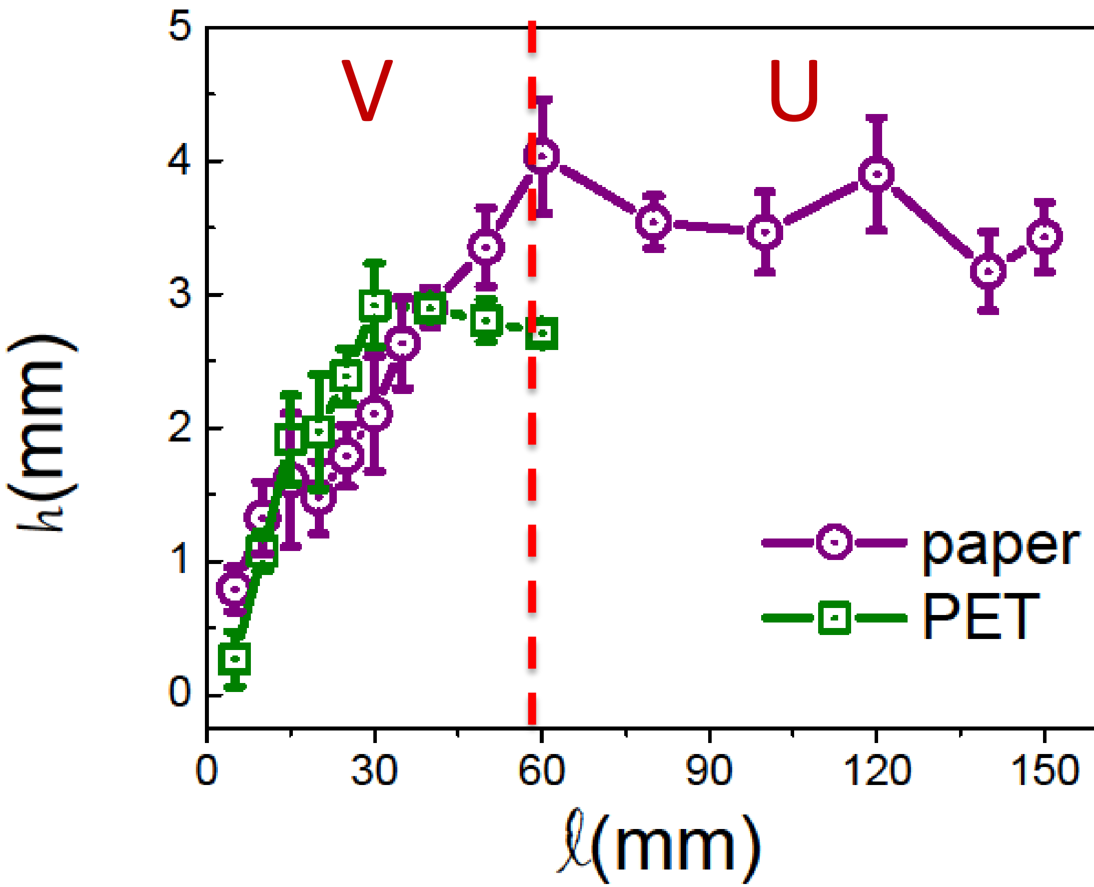
Home-built profilometer

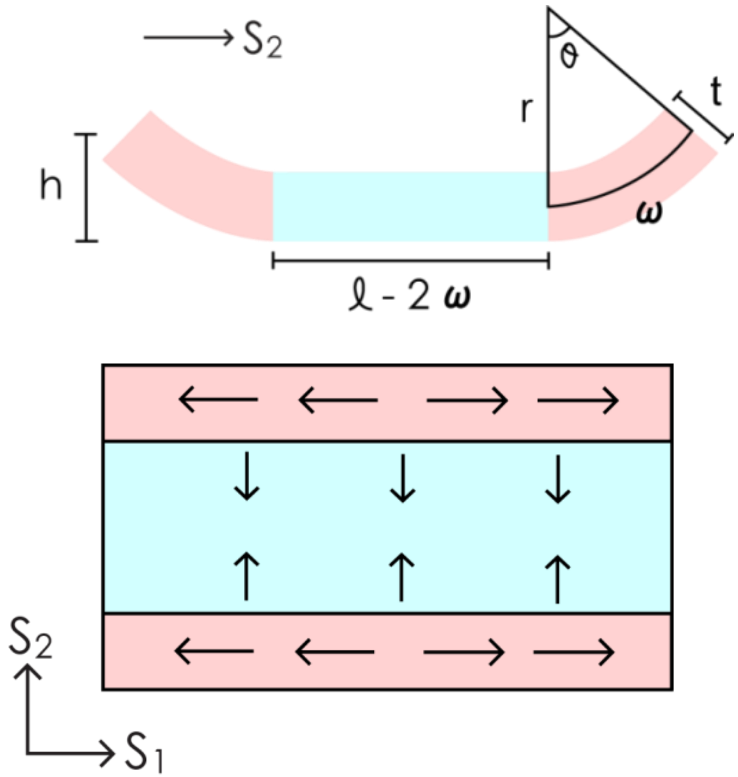




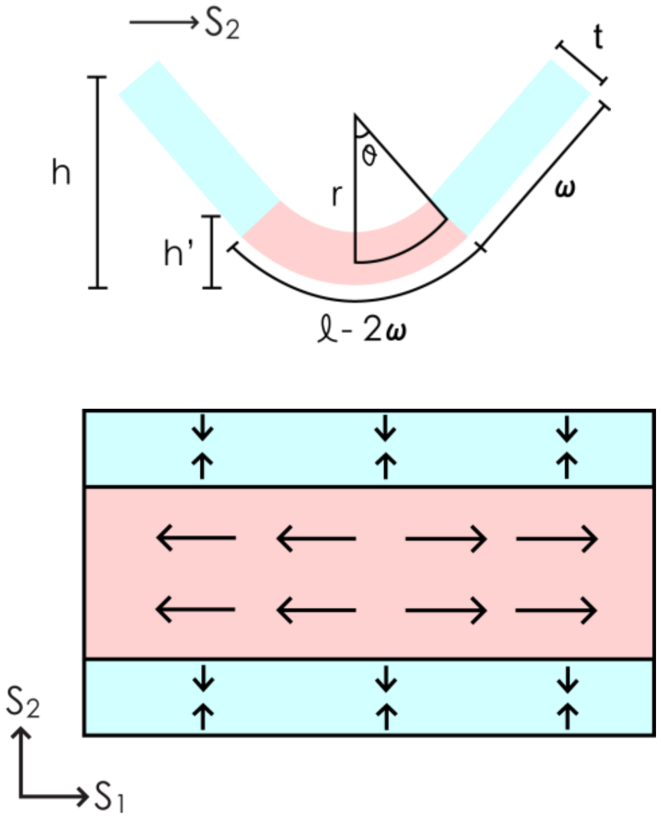
Qi-Wa height v.s. width of scroll



Theoretical models



$$h \sim \left(\frac{K_{\perp}^{c}}{K_{\parallel}^{m}}\right)^{1/4} L\sqrt{\nu\phi t}$$

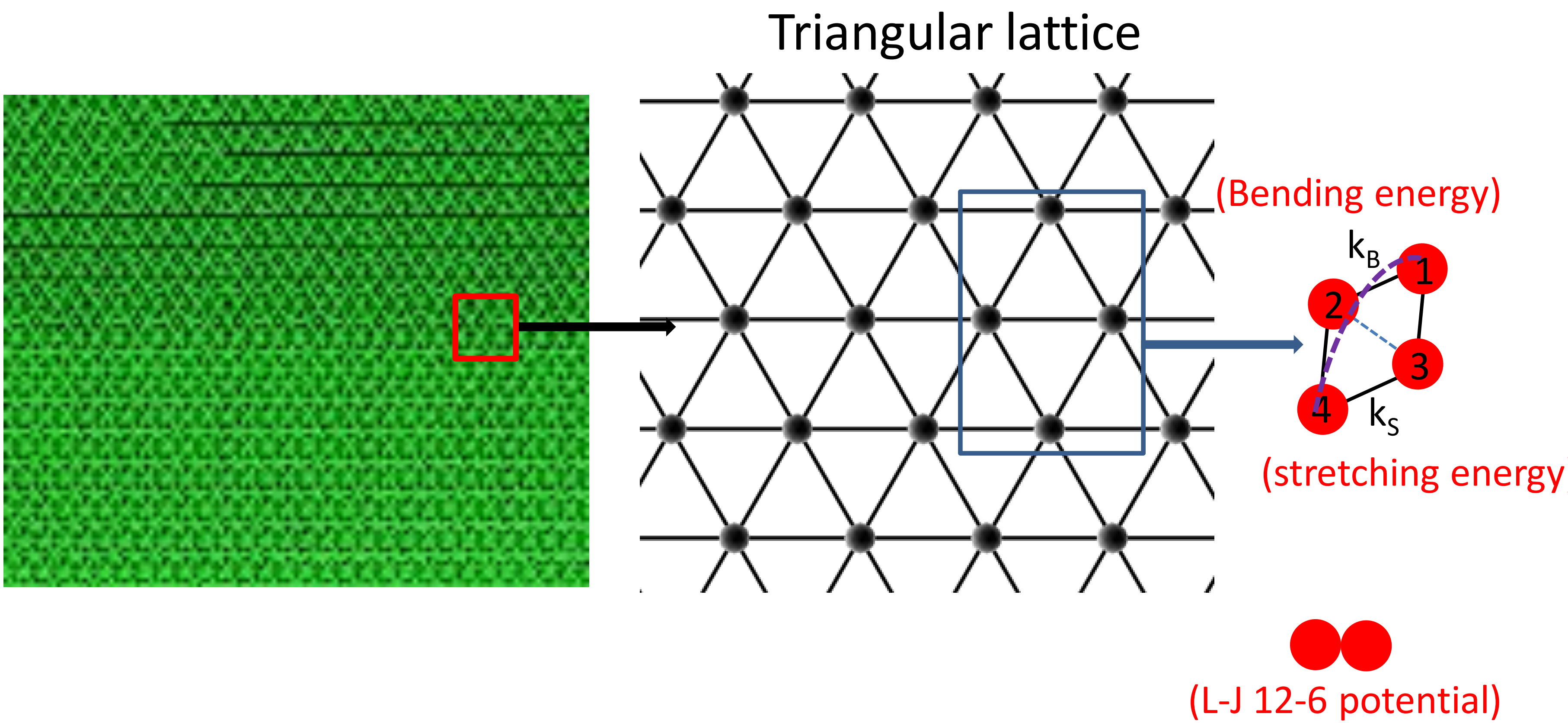


$$h \sim \left(\frac{K_{\perp}^{m}}{K_{\parallel}^{c}}\right)^{1/8} \sqrt{L}\,(\nu\phi)^{3/4}\, t^{1/4}\, l$$

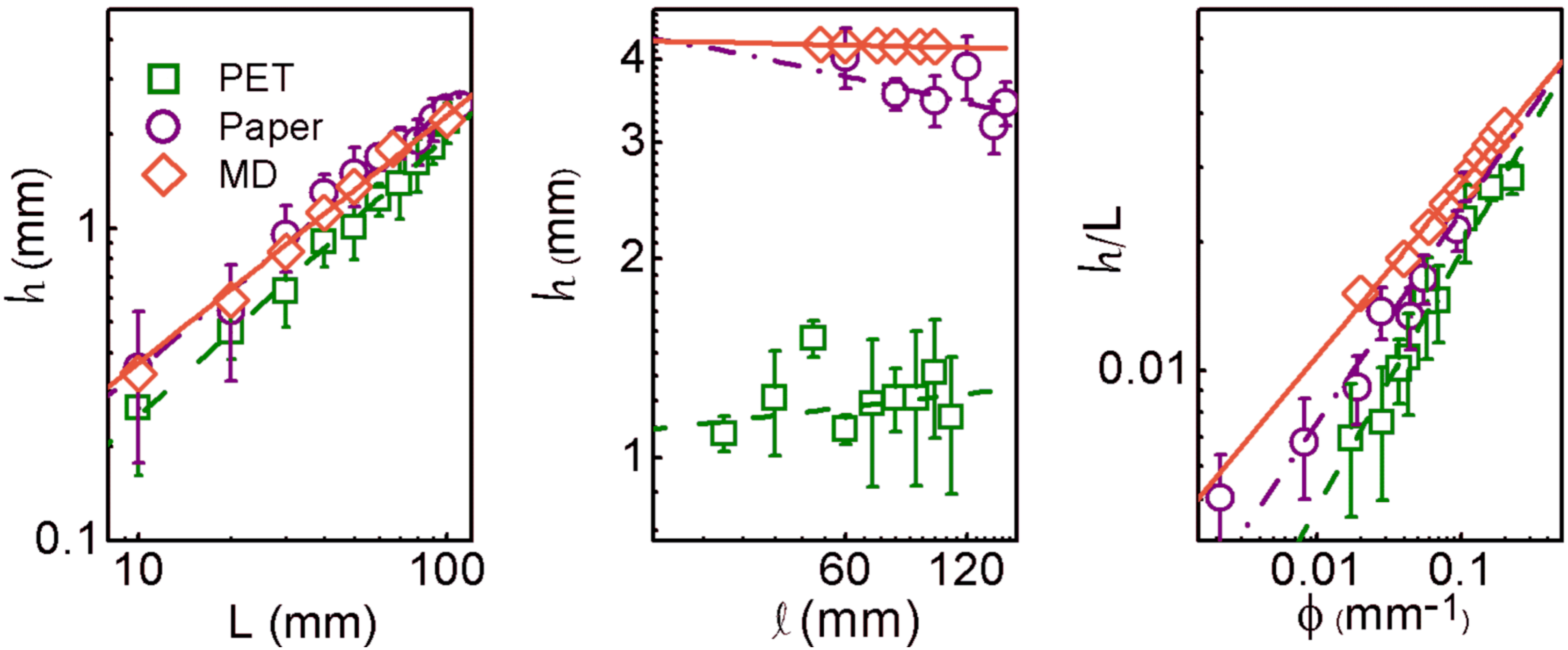
Phase diagram

無法顯示圖像。您的電腦可能沒有足夠的記憶體來開啟圖像，或圖像可能已毀損。請重新啟動您的電腦，並再次開啟檔案。如果仍然出現紅色 x，您可能必須刪除圖像，然後再次插入圖像。

Molecular Dynamics simulations



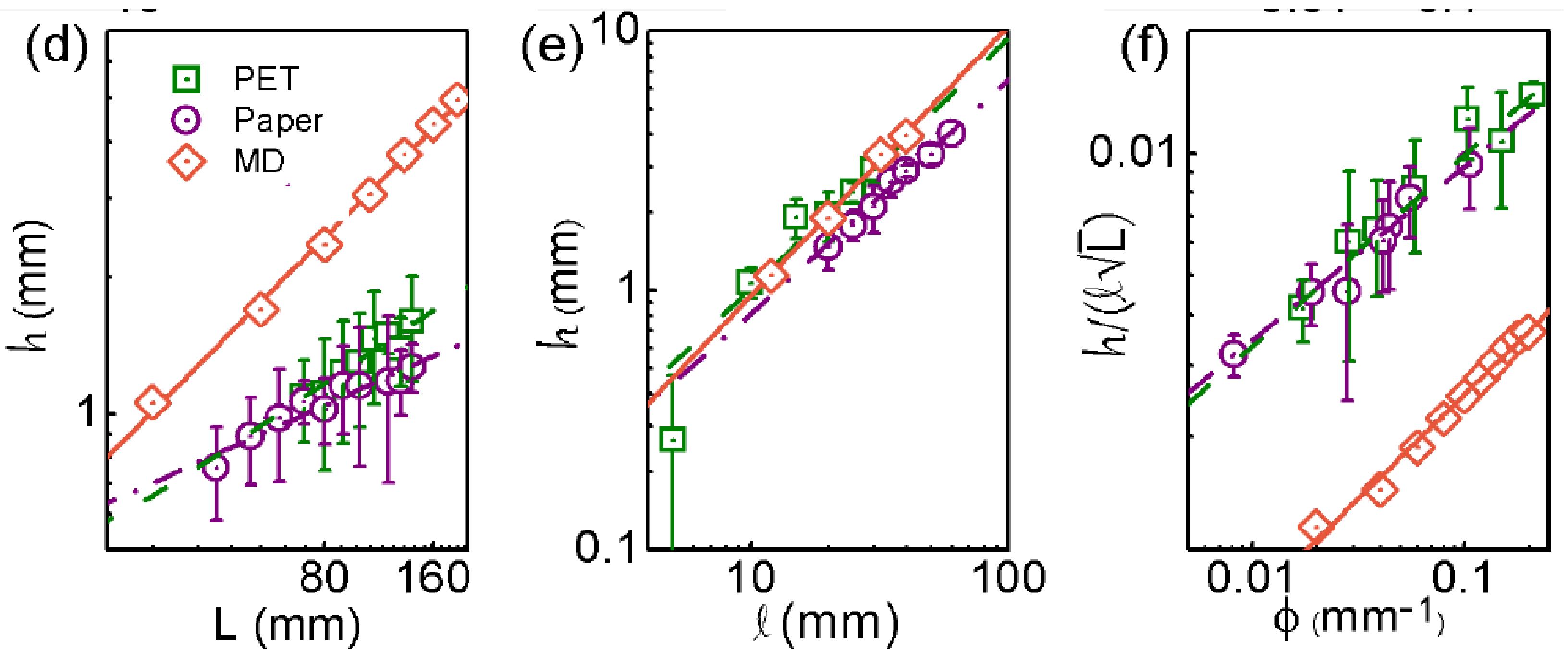
U-shaped scroll



$$h \approx \left(\frac{K_{S2\perp}}{K_{S1\parallel}}\right)^{1/4} \left(\nu \phi t\right)^{1/2} \cdot L$$

U-shape	L	l	∅
PET	0.9	0.069	0.6
Paper	0.85	-0.133	0.5
M.D	0.8	-0.013	0.4

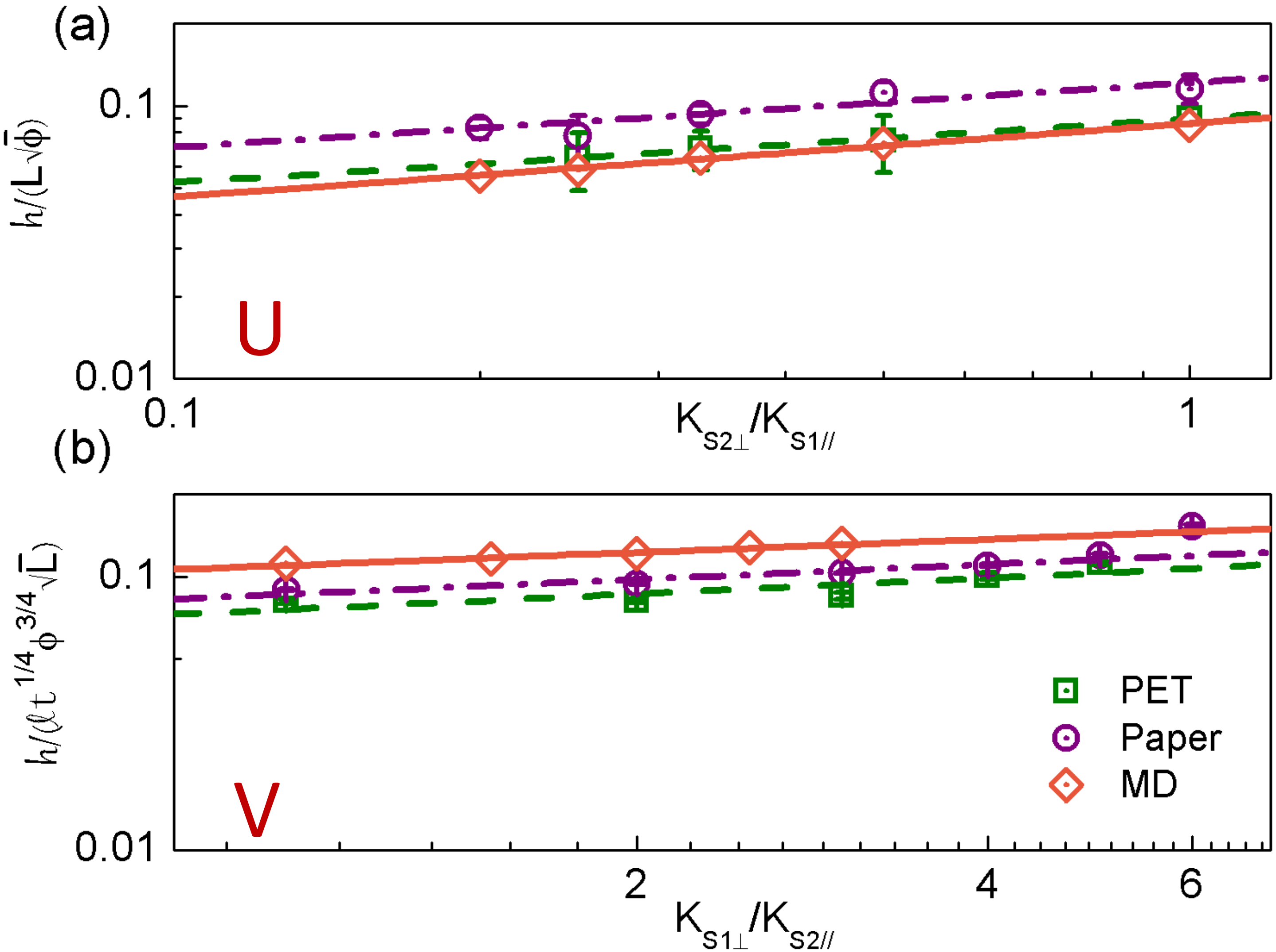
V-shaped scroll



$$h \approx \left(\frac{K_{S1\perp}}{K_{S2\parallel}}\right)^{1/8} L^{1/2} (\nu\phi)^{3/4} t^{1/4} \ell$$

V-shape	L	l	Ø
PET	0.53	0.96	0.47
Paper	0.36	0.9	0.43
M.D	0.8	1.04	0.51

Check the K-dependence



$$h \approx \left(\frac{K_{S2\perp}}{K_{S1\parallel}}\right)^{1/4}$$

$$h \approx \left(\frac{K_{S1\perp}}{K_{S2\parallel}}\right)^{1/8}$$

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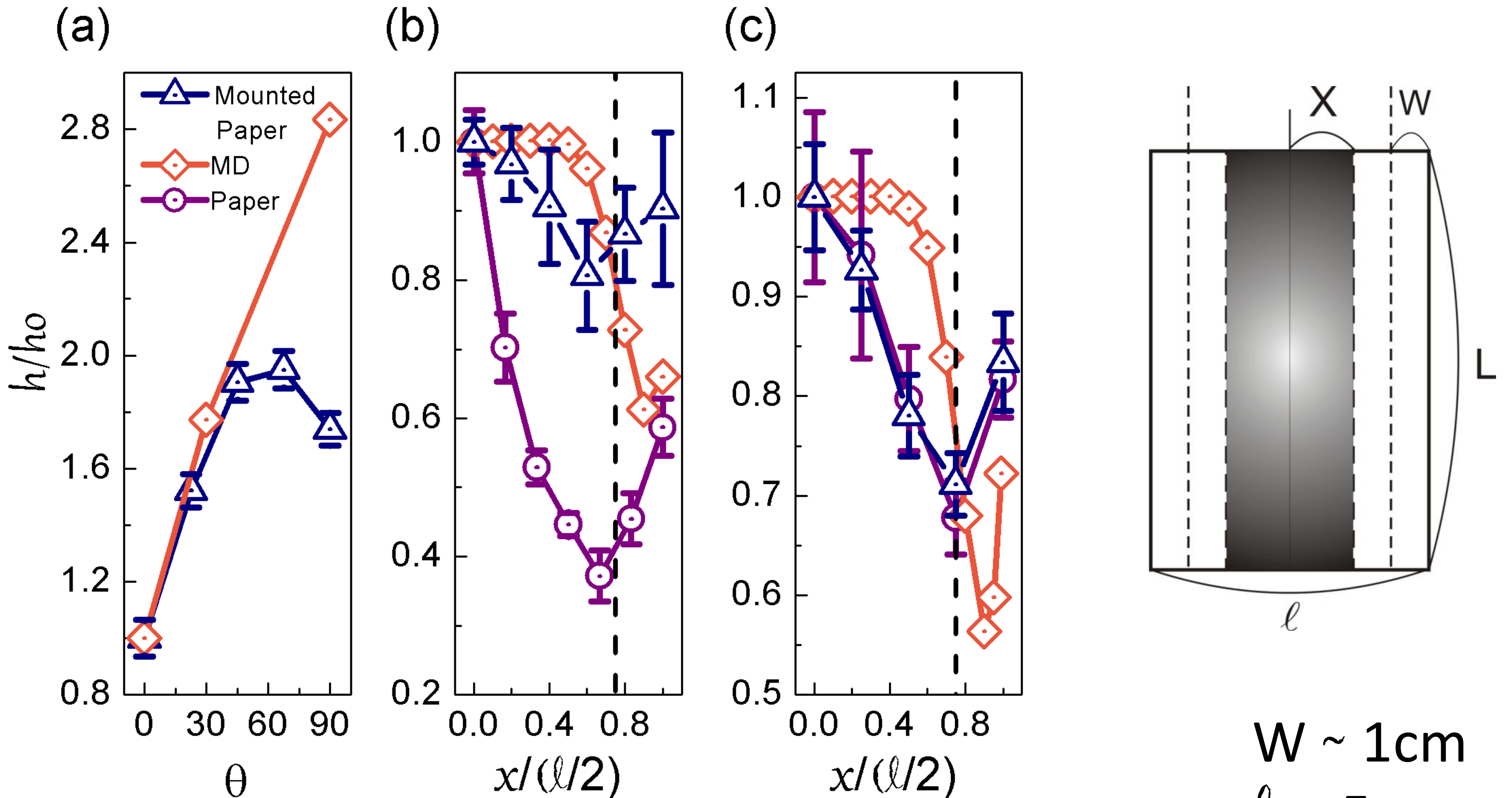
Remedies to mitigate Qi-Wa

1. Reorient main fiber direction to parallel the length
2. Increase border thickness
3. Perforate backing paper with a stiff brush
4. Change patching pattern
5. Increase roller radius

U-shaped scroll



W ~ 1cm

ℓ ~ 5 cm

(a) Align fiber directions (b) Adding layers of width ℓ/2 – x to side borders (c) Poking

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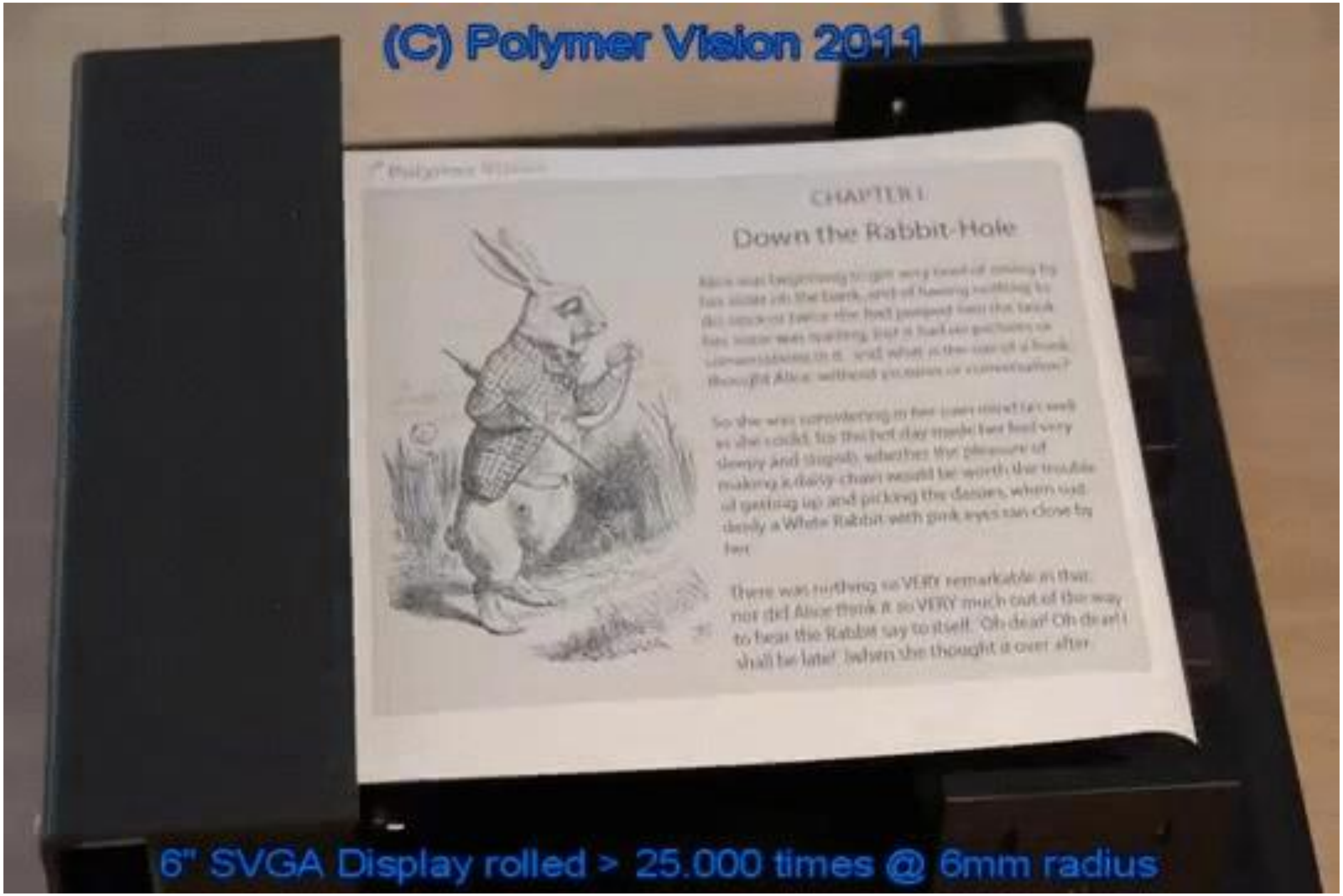
Conclusions

1. Moisture, paste, and mounting techniques are important to prevent cockling, but spontaneous curvature is more essential to causing Qi-Wa.
2. Instead of relying on experience and luck, we propose a scientific method to treat Qi-Wa.
3. Our model for curling edges is general and can be applied to flexible electronic paper.


(C) Polymer Vision 2011
CHAPTER I
Down the Rabbit-Hole
6" SVGA Display rolled > 25.000 times @ 6mm radius

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Synopsis: Modern Recipe for Preserving Ancient Chinese Scrolls

Sun-Hsin Hung/National Palace Museum, Taipei

Curling Edges: A Problem that Has Plagued Scrolls for Millennia

Ming-Han Chou, Wei-Chao Shen, Yi-Ping Wang, Sun-Hsin Hung, and Tzay-Ming Hong

Phys. Rev. Lett. **112**, 034302 (2014)

Published January 23, 2014

As art conservators know, long-term storage of rolled up scrolls—such as ancient Chinese paintings and calligraphy—can cause the long edges of the paper to curl outwards, with potentially damaging effects. Ming-Han Chou and researchers at National Tsing Hua University in Taiwan, now have a theory for what causes this curling, known in Chinese as Qi Wa (起瓦). Their model, presented in *Physical Review Letters*, could help conservators find better ways to prepare and store the artworks, and it may be applicable to biological membranes or other flexible materials.

Curling Edges: A Problem that Has Plagued Scrolls for Millennia

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[3]*Center for Fundamental Science Research, National Tsing Hua University, Hsinchu 30013, Taiwan, Republic of China*
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Chinese painting [1–4] has a long history of tradition and styles in arranging human figures, animals, landscape, and plants into one or multiple themes as in symphonies. The collections of painting scrolls in the National Palace Museum in Taipei, Taiwan can be dated back to the Six Dynasties (222–589). The modes of landscape painting started in the Five Dynasties period (907–960) and have enjoyed many variations through the years. For instance, emphasis was shifted in the Song Dynasty (960–1279) from grand mountains and waterfalls to more intimate depictions as a result of the political and cultural shift to south China. Catering to the tastes of emperors, painters also adjusted their focus on observing nature infused with poetic sentiments to expressing inner feelings. This focus on poetic sentiment led to the combination of painting, poetry, and calligraphy in the same work by the Southern Song (1127–1279). Subsequent movements include the literati [5] painting in the Yuan Dynasty (1279–1368), and concentration on personal cultivations and the establishment of separate local schools in the Ming (1368–1644) and Qing (1644–1911) Dynasties.

THOMAS SUMNER Thomas is a news intern at *Science*.
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*Science*Shot: How to Save Your Scroll

30 January 2014 12:45 pm | 0 Comments

Understanding *qi-wa*, the curling of scrolled artwork. In the Chinese and other traditions, paintings are executed on long paper or silk scrolls. On display, those artworks may be plagued by *qi-wa*, a curling up of the side edges that can tear fibers and dislodge pigment. Many analyses to date of *qi-wa* have focused on such factors as environmental humidity or the glue used to affix a painting to its mounting. But a group of Taiwanese physicists and conservationists led by Tzay-Ming Hong of National Tsing Hua University have shown that *qi-wa* can be explained by a physical mechanism put into play when the art is rolled up for storage. Rolling compresses the inner, painted face of the scroll in the long direction and stretches the outer face. When the scroll is removed from storage, the strain relaxes. As a result of the Poisson

SHEN NANPI

Save ancient Chinese scrolls with anti-curl weapons

19:10 28 January 2014 by Jacob Aron

Ancient Chinese scrolls may solve a dilemma for futuristic electronics: how to avoid curling. Hanging scrolls traditionally used in Chinese paintings are normally stored rolled up to protect their delicate artwork. But when unrolled, the long sides will curl, potentially causing damage.

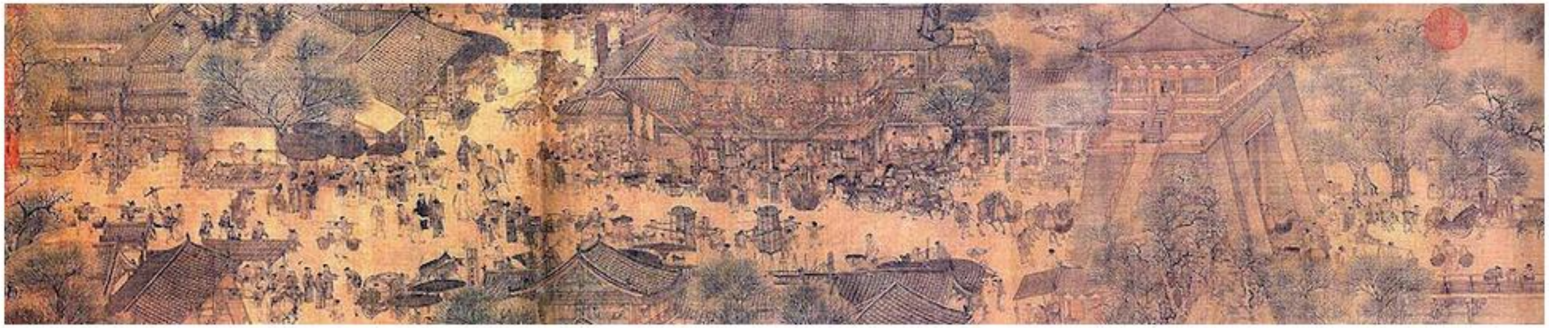
Rolled scrolls protect, but often at the cost of

Tzay-Ming Hong at the National Tsing Hua University in Taiwan and his colleagues decided to investigate curling scrolls after a trip to the National Palace Museum in Taipei, where they talked to art conservationists about ways to use physics to protect hanging scrolls. "Like the mounting masters before them, over the span of more than 2000 years, they did not think this problem was at all solvable," says Hong.

The team modelled the problem on computers and with real paper and plastic films. They found that rolling causes the back layer of a scroll to stretch along its length. This means the paper shrinks back when the scroll is laid out flat, causing it to expand along its width and curl.

The BULLETIN

WHAT ANCIENT CHINESE SCROLLS CAN TEACH US ABOUT FLEXIBLE ELECTRONICS



Posters, panoramic high school photos, ancient scrolls… they're all plagued by the same problem. Curling edges. I usually just roll it up from the opposite side, but that leaves its own unsightly creases.

Now, physicists from Taiwan have found a way to save paper from this unwelcomed warping. And they think their method could help with the development of flexible electronics.

CURLING EDGES: A PROBLEM THAT HAS PLAGUED SCROLLS FOR MILLENNIA

GENERAL ENGINEERING

Limits on fundamental limits to

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Scaling relation for a compact crumpled thin sheet

Wubin Bai, Yen-Chih Lin, Tzon-Kun Hou, and Tzay-Ming Hong
Department of Physics, National Tsing Hua University, Hsinchu 300, Taiwan, Republic of China
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A high-pressure chamber was designed to study crumpling beyond the power-law regime. Preceded by a smooth transition, the crumpled ball that characterizes the high-pressure state contains less than 50% air and exhibits separate ordered domains. All data for different sheet thicknesses, sizes, and numbers were found to collapse to a master line when using volume ratio and pressure as the plotting parameters, which suggests the existence of a scaling relation. Based on these findings, we deduced a bundled-layer model that could consistently explain six outstanding properties at both low and high pressures. This successful union of theory and experiment has strong bearings on other soft-matter systems where similar changes in mechanical response are also linked to reorganization of structure.

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the sample with an isotropic force. The thin film adopted is latex, which is commonly used to produce condoms and ideal for preventing leakage of fluids. To monitor the leakage