



# A competition between slicing and buckling underlies the erratic nature of paper cuts

Sif Fink Arnbjerg-Nielsen, Matthew D. Biviano, and Kaare H. Jensen

Department of Physics, Technical University of Denmark [www.papermachete.org](http://www.papermachete.org)

[khjensen@fysik.dtu.dk](mailto:khjensen@fysik.dtu.dk)

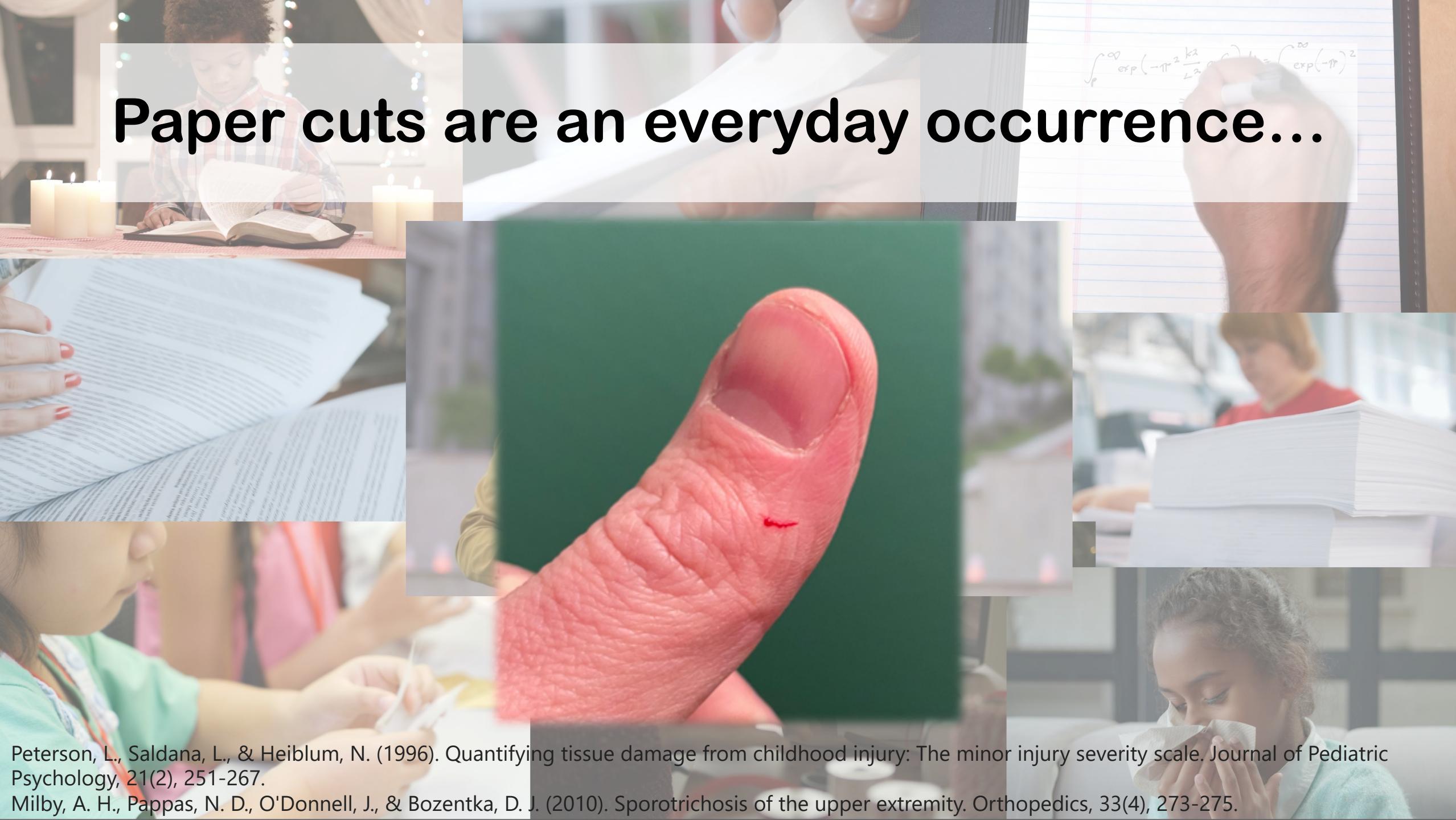
[www.jensen-research.com](http://www.jensen-research.com)



INDEPENDENT  
RESEARCH FUND  
DENMARK



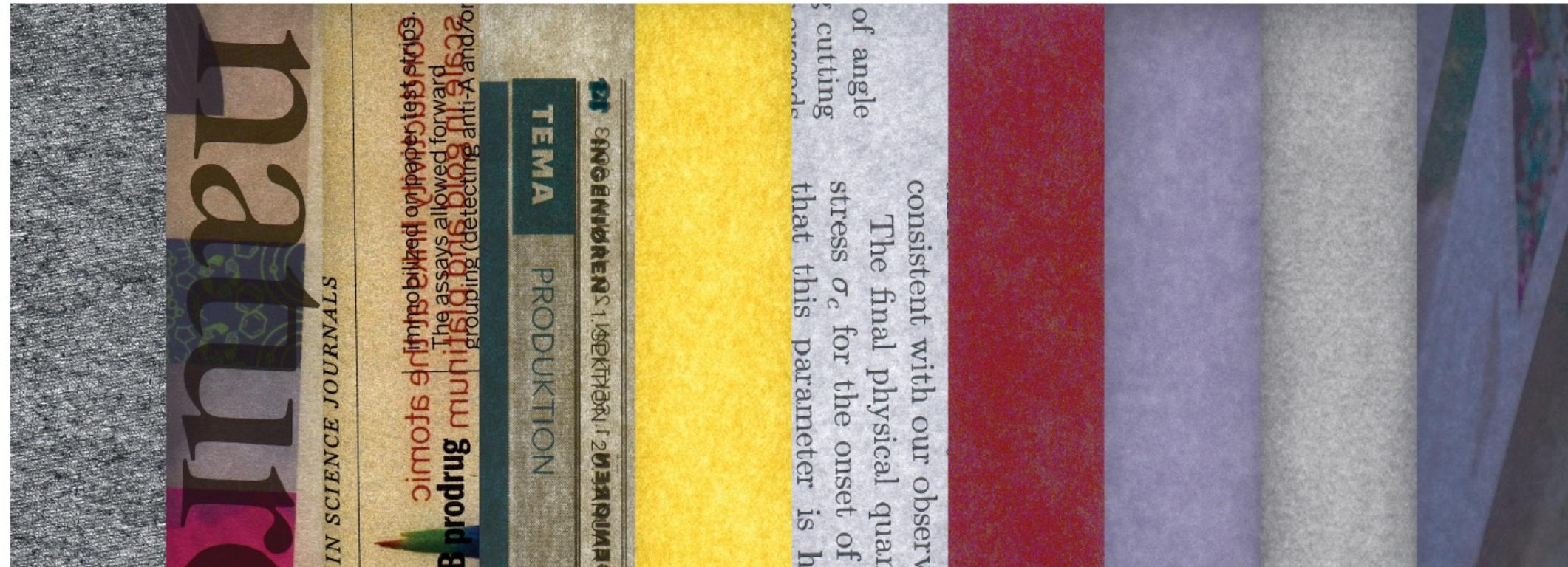
# Paper cuts are an everyday occurrence...



Peterson, L., Saldana, L., & Heiblum, N. (1996). Quantifying tissue damage from childhood injury: The minor injury severity scale. *Journal of Pediatric Psychology*, 21(2), 251-267.

Milby, A. H., Pappas, N. D., O'Donnell, J., & Bozentka, D. J. (2010). Sporotrichosis of the upper extremity. *Orthopedics*, 33(4), 273-275.

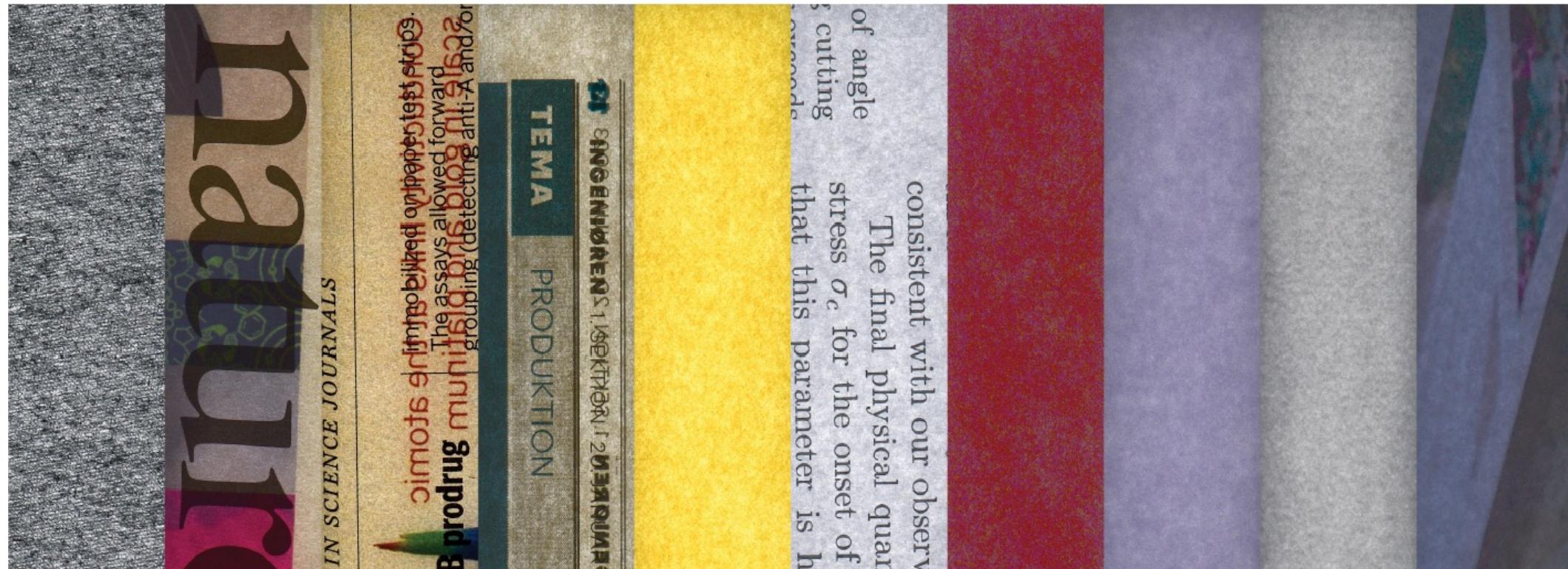
# ... but only for certain types of paper



consistent with our observations  
The final physical quantity in Eq. (1)  
stress  $\sigma_c$  for the onset of cutting  
that this parameter is h



# ... but only for certain types of paper

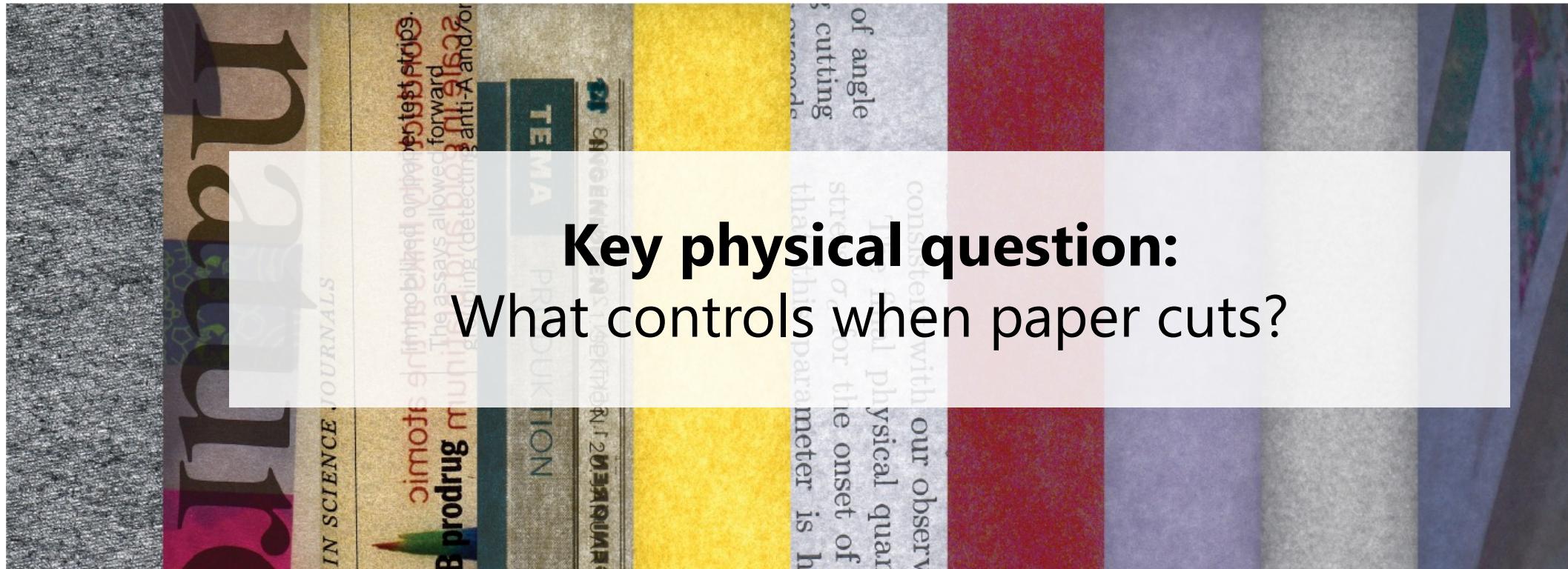


of angle  
cutting  
woods

consistent with our observations in Eq. (1).  
The final physical quantity  
stress  $\sigma_c$  for the onset of cutting  
that this parameter is h



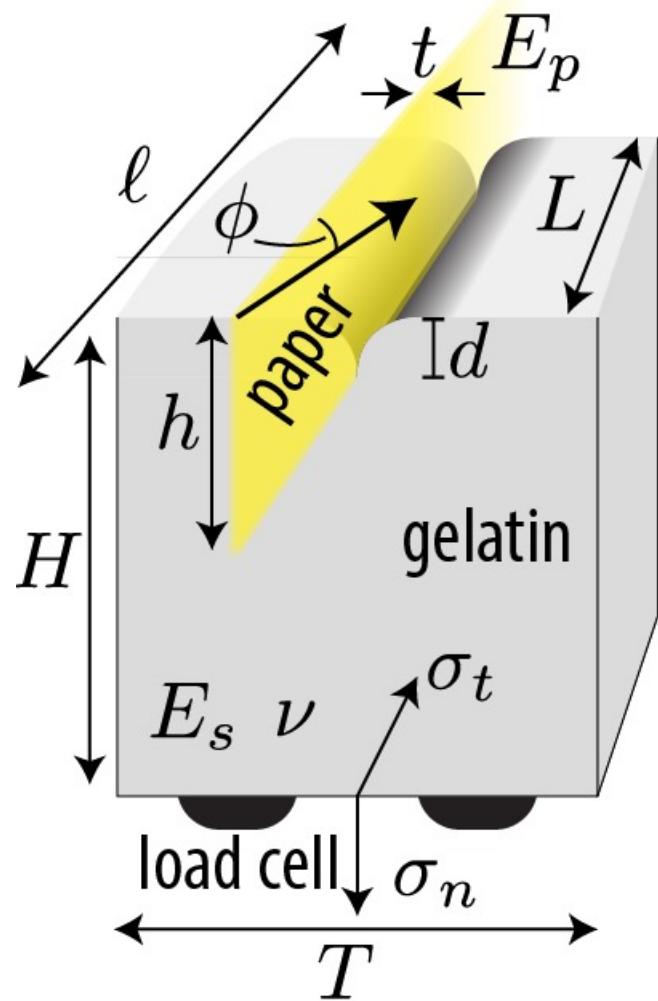
# ... but only for certain types of paper



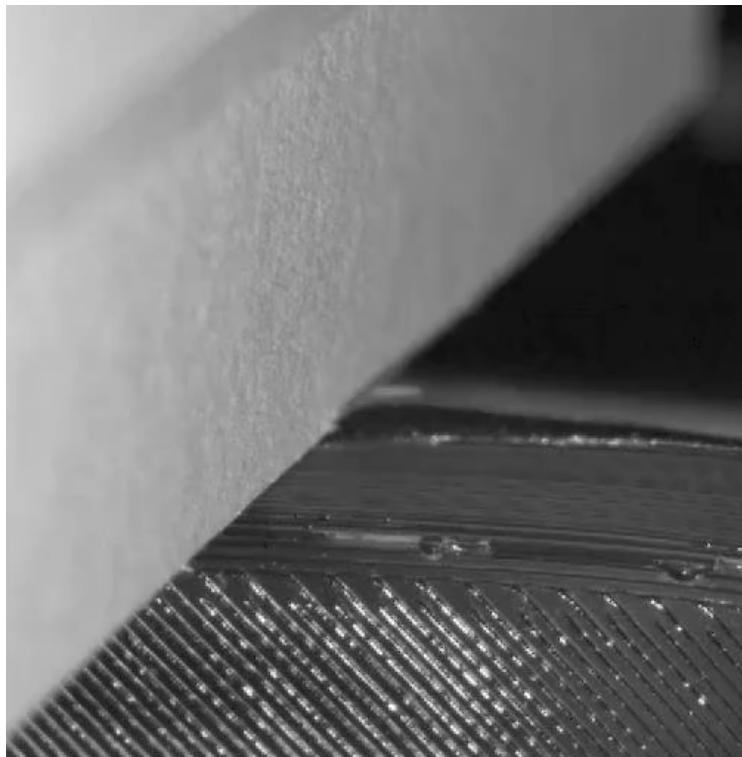
**Key physical question:**  
What controls when paper cuts?



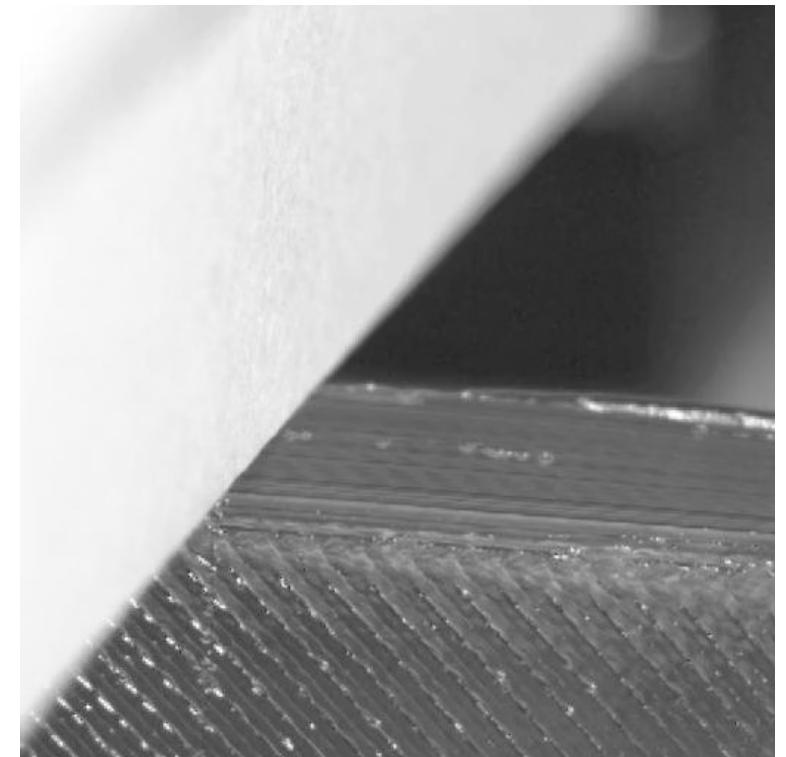
# We built a paper cutting machine



$$\phi = 5^\circ$$



$$\phi = 90^\circ$$



2 mm

# We observe three different regimes

$t = 30 \mu\text{m}$

$t = 65 \mu\text{m}$

$t = 155 \mu\text{m}$

$t = 220 \mu\text{m}$

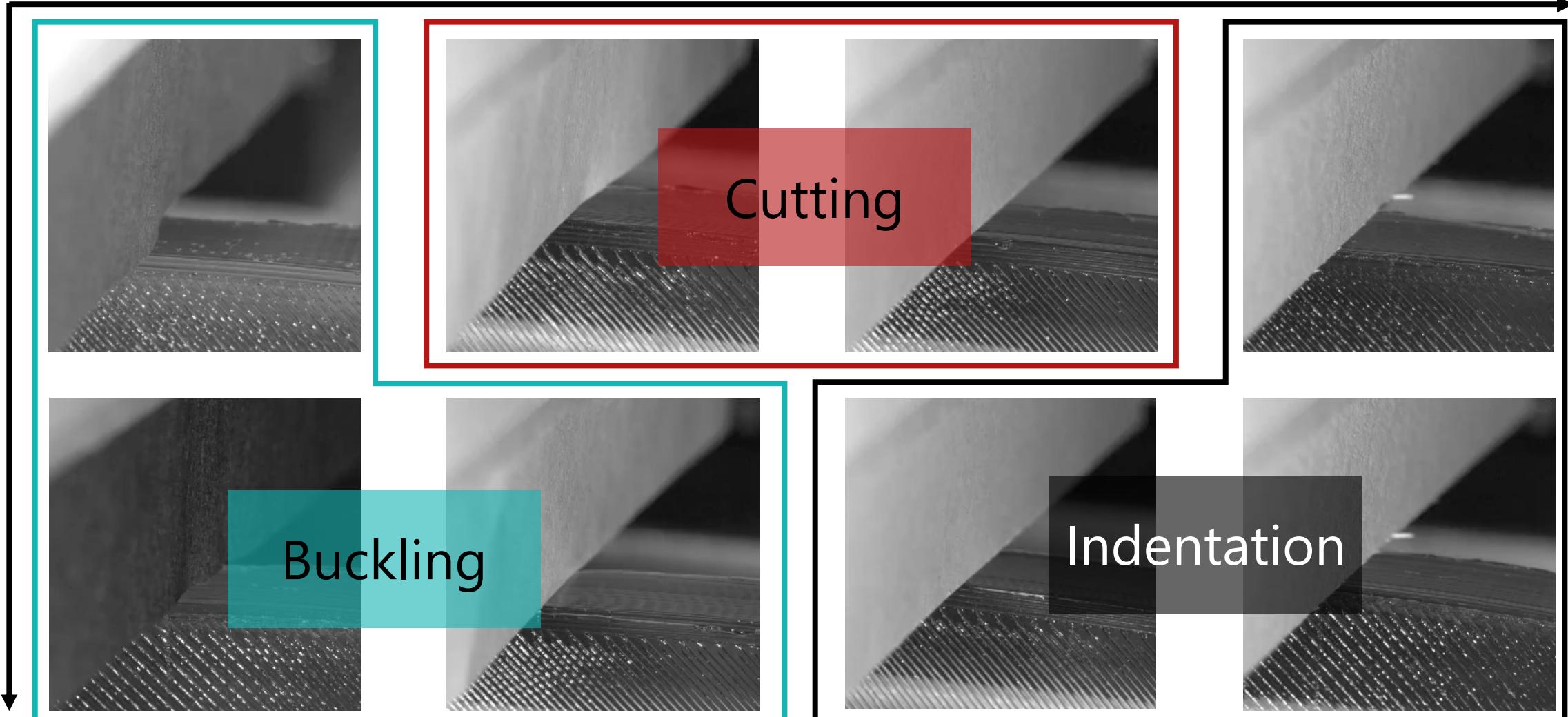
$\phi = 15^\circ$

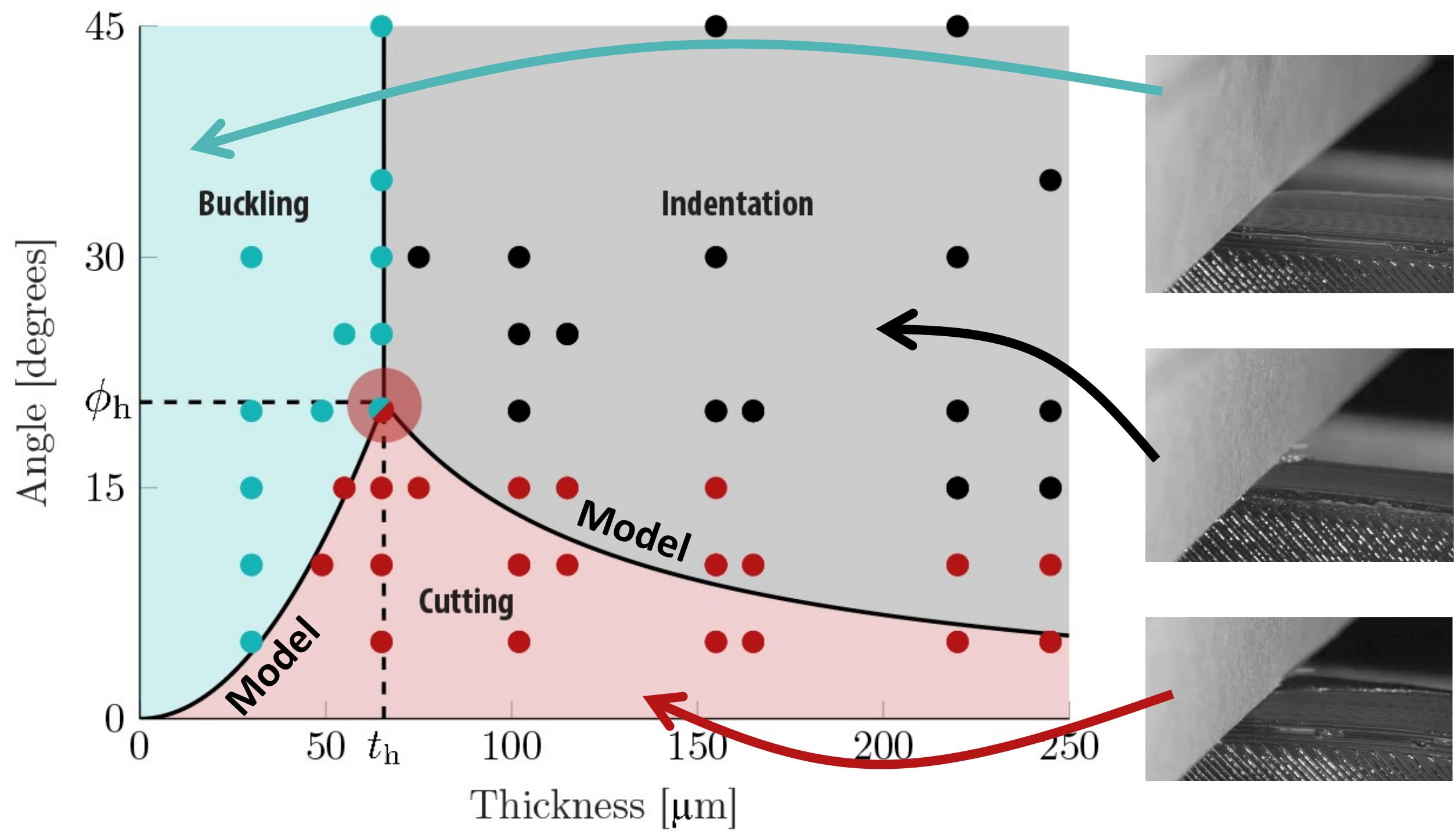
$\phi = 30^\circ$

Cutting

Buckling

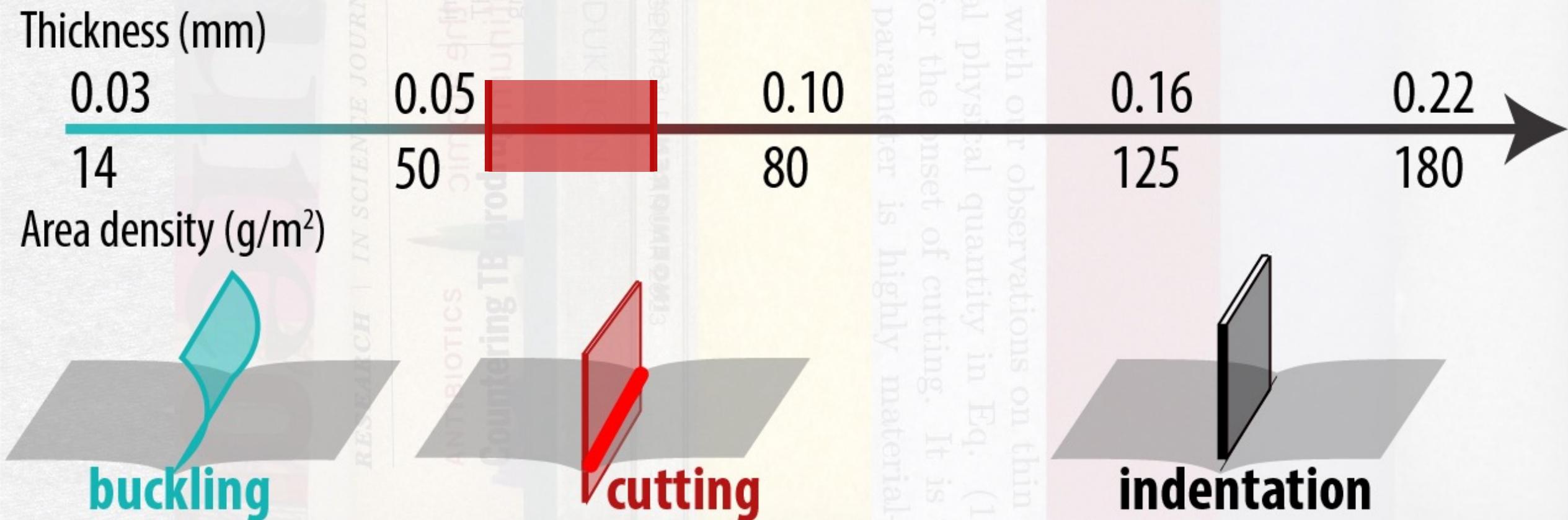
Indentation





# A competition between slicing and buckling underlies the erratic nature of paper cuts

of angular cutting  
stress  $\sigma_c$  for the  
inset of cutting. It is  
consistent with our  
observations on thin  
paper.



*Science*  
 $t \approx 55 \mu\text{m}$

2



$t \approx 65 \mu\text{m}$

1

*nature*  
 $t \approx 50 \mu\text{m}$

3

# THE PAPERMACHETTE



# THE PAPERMACHETTE



papermachete v2



# A competition between slicing and buckling underlies the erratic nature of paper cuts

Sif Fink Arnbjerg-Nielsen, Matthew D. Biviano, and Kaare H. Jensen

Department of Physics, Technical University of Denmark [www.papermachete.org](http://www.papermachete.org)

[khjensen@fysik.dtu.dk](mailto:khjensen@fysik.dtu.dk)

[www.jensen-research.com](http://www.jensen-research.com)



INDEPENDENT  
RESEARCH FUND  
DENMARK