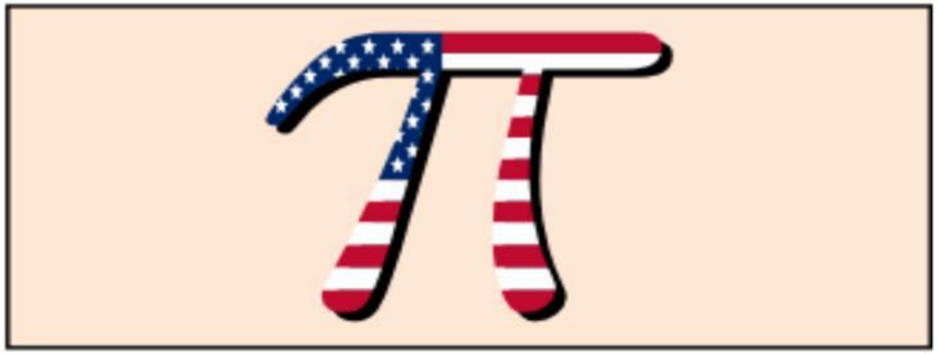
Movie title 1

$$9.80665\ \mathrm{m/s^2}$$

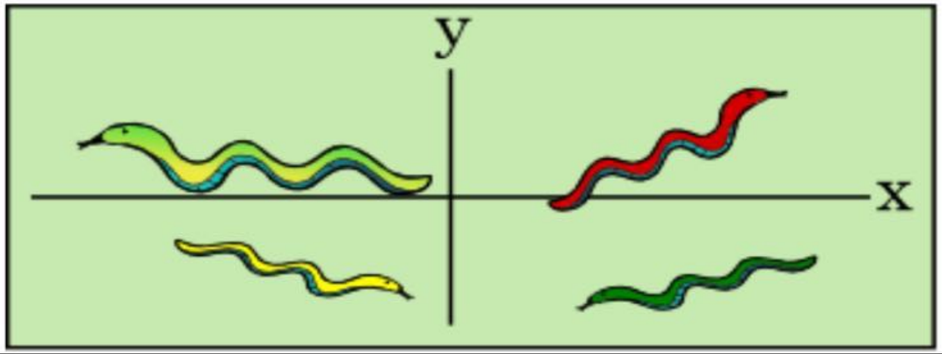
Movie title 2



Movie title 3

$$\left|\frac{ds}{dt}\right|$$

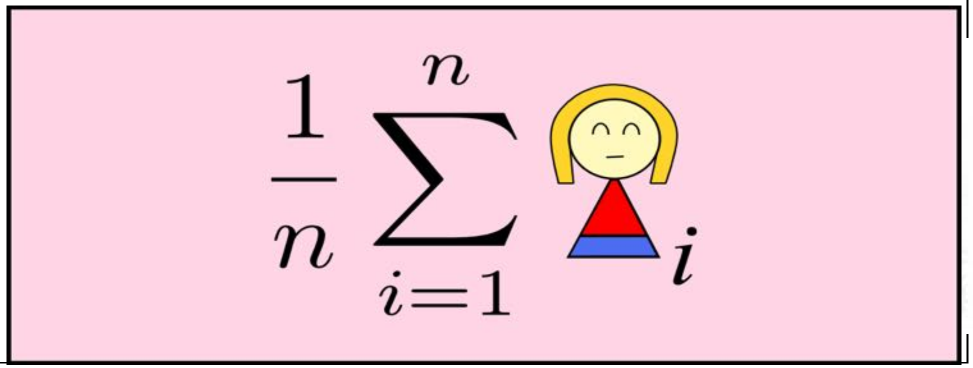
Movie title 4



Movie title 5

1609.344 METRES

Movie title 6



Torsion and the brain

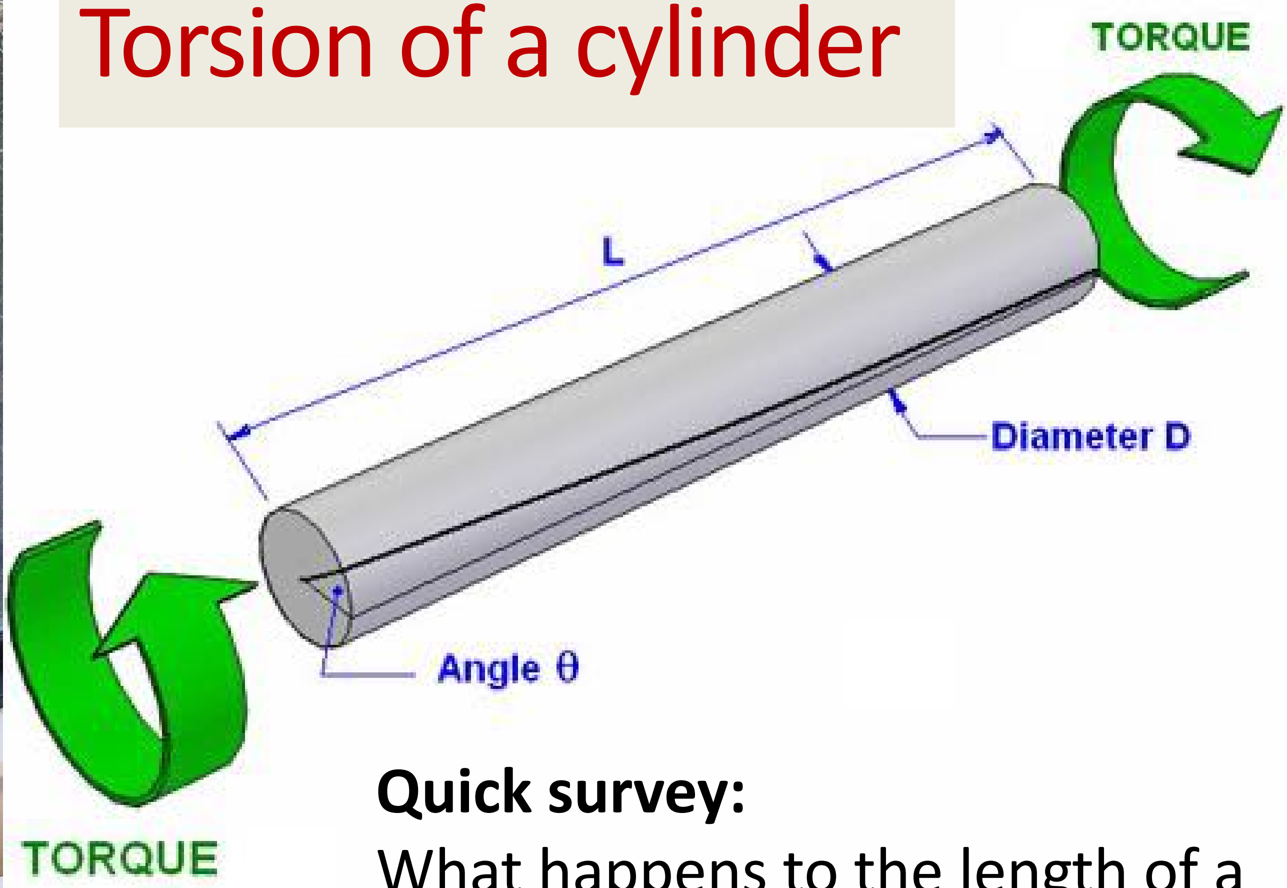
Michel DESTRADE

Chair of Applied Mathematics,

NUI Galway

Adjunct Professor,
University College Dublin,
Zhejiang University.

Torsion of a cylinder



Quick survey:

What happens to the length of a cylinder when you twist it?

1. Increases (cylinder lengthens);
2. Decreases (cylinder shortens);
3. Stays the same;
4. I don’t know.

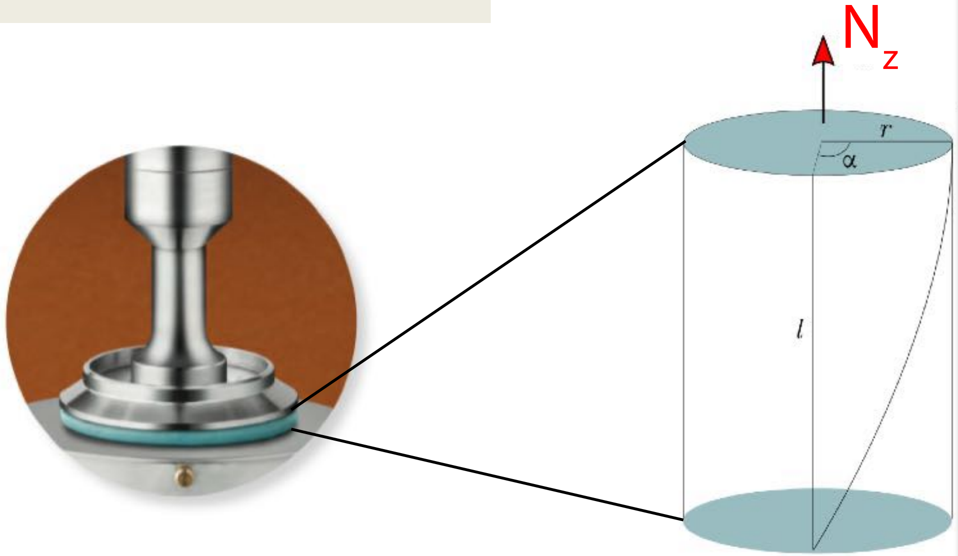
Torsion of a cylinder: The POYNTING effect

Watch the YOUTUBE video at
https://www.youtube.com/watch?v=ugD6PsDaLu4

Zurlo et al. 'The Poynting effect'. *American Journal of Physics* (to appear)

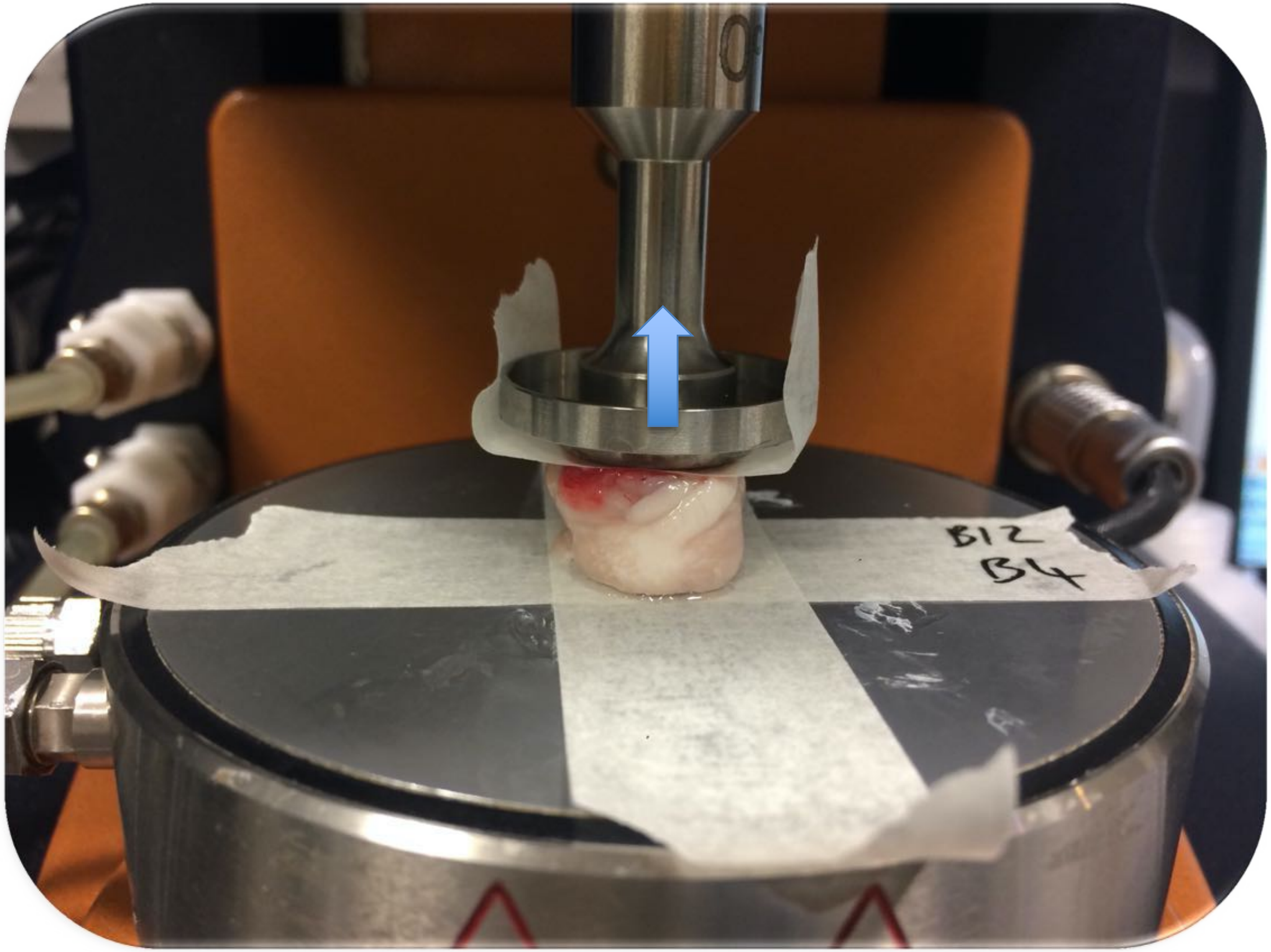
Torsion testing of brain matter

Discovery Hybrid 2 rheometer



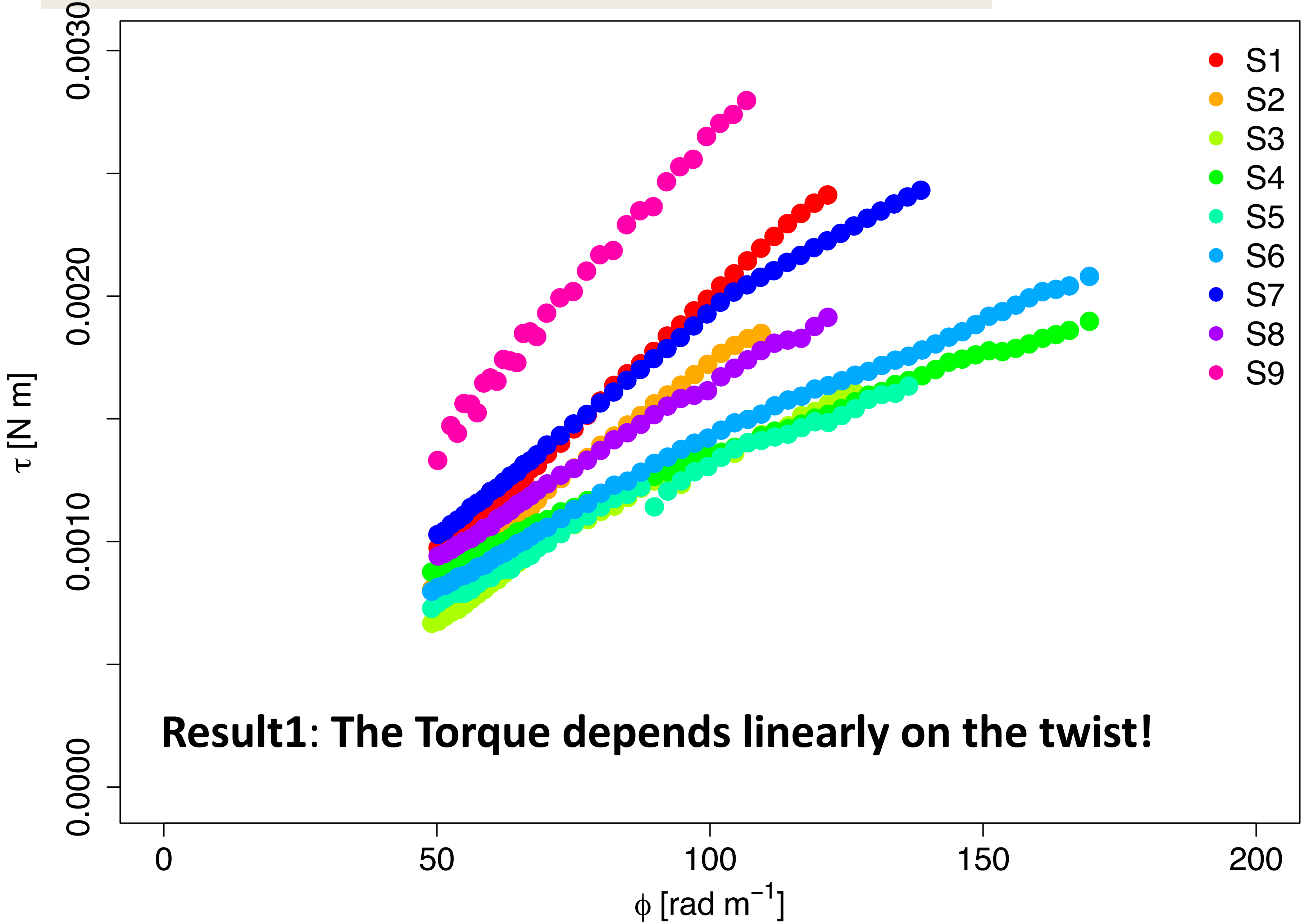
The rheometer measures the torque $\boldsymbol{\tau}$ and normal force $\mathbf{N_z}$ required to twist a cylindrical sample by an angle α.

Poynting effect in torsion



The sample is pushing up against the top plate

Experimental data: Torque



Result1: The Torque depends linearly on the twist!

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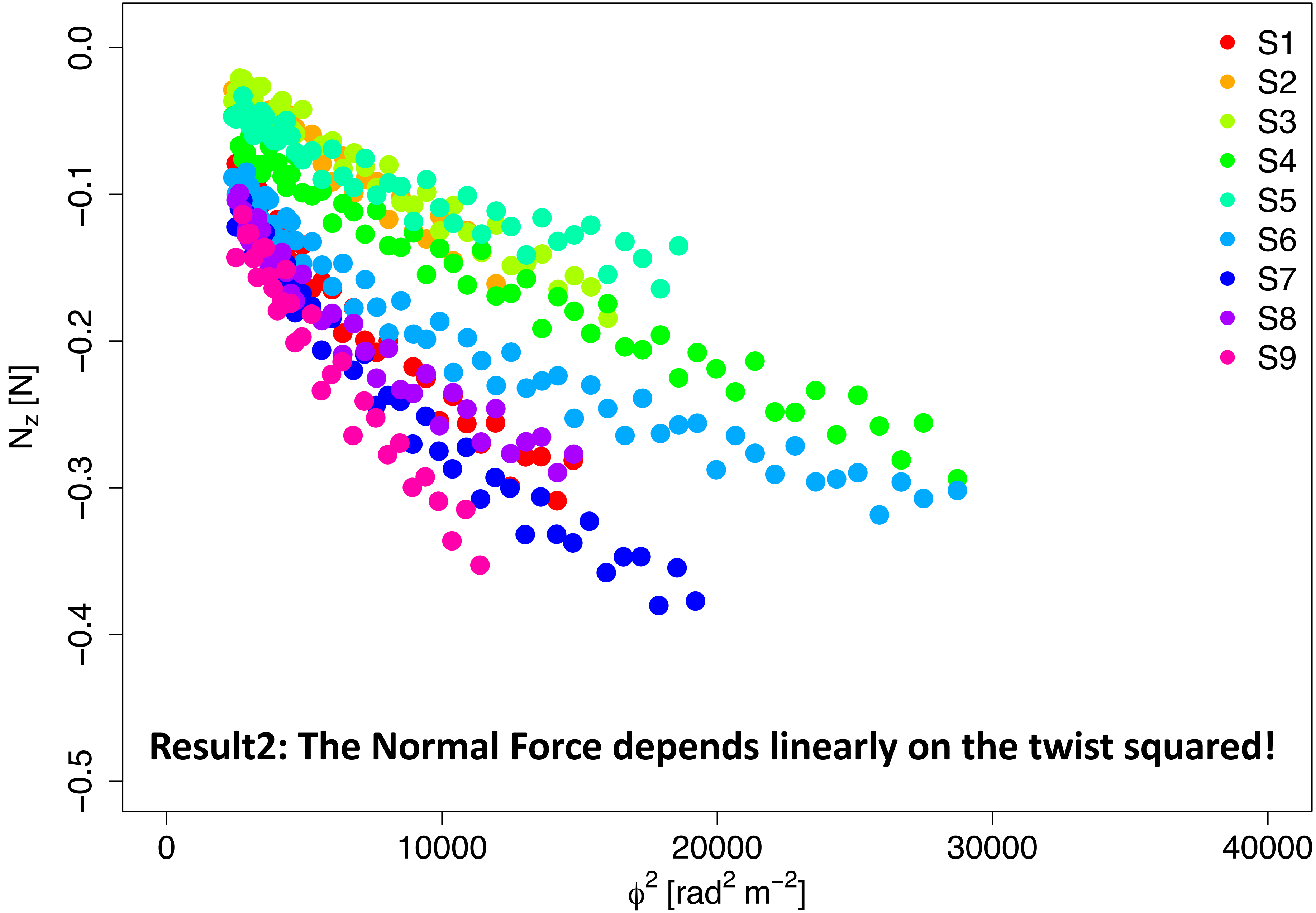
Experimental data: Normal force



Result2: The Normal Force depends linearly on the twist squared!

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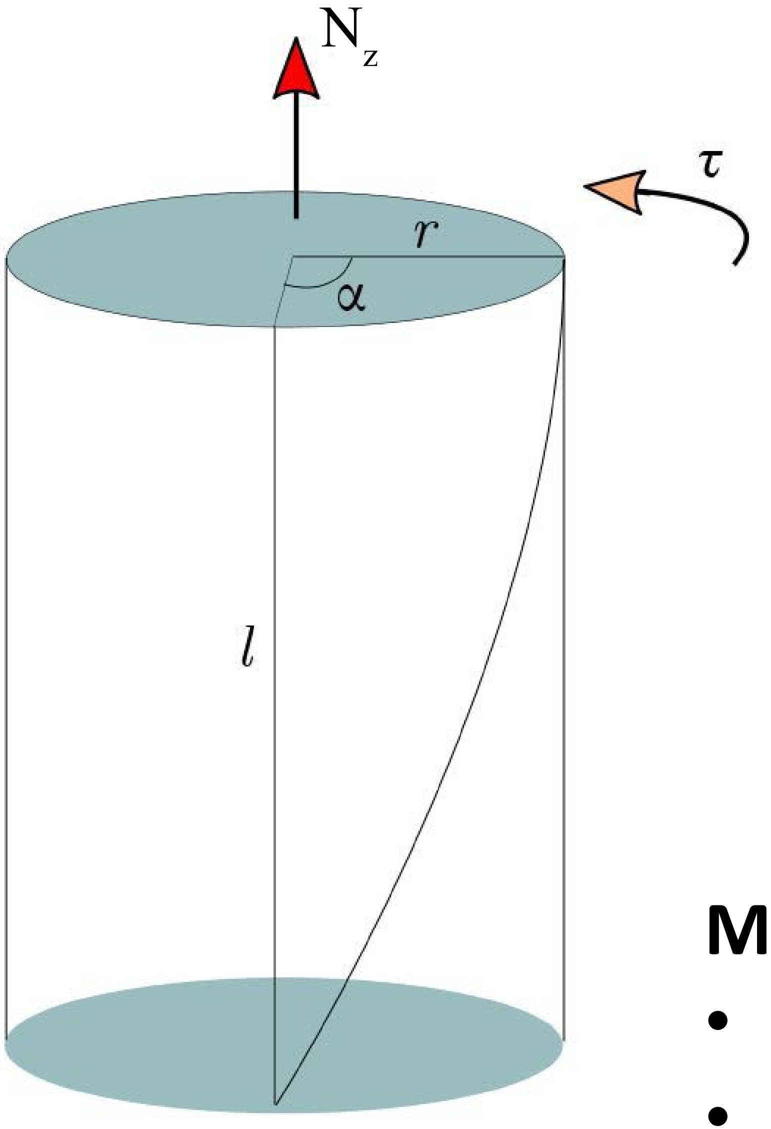
Modelling the torsion



Deformation:

$$\begin{cases} r &= \frac{1}{\sqrt{\lambda}} R \\ \theta &= \Theta + \phi \lambda Z \\ z &= \lambda Z \end{cases}$$

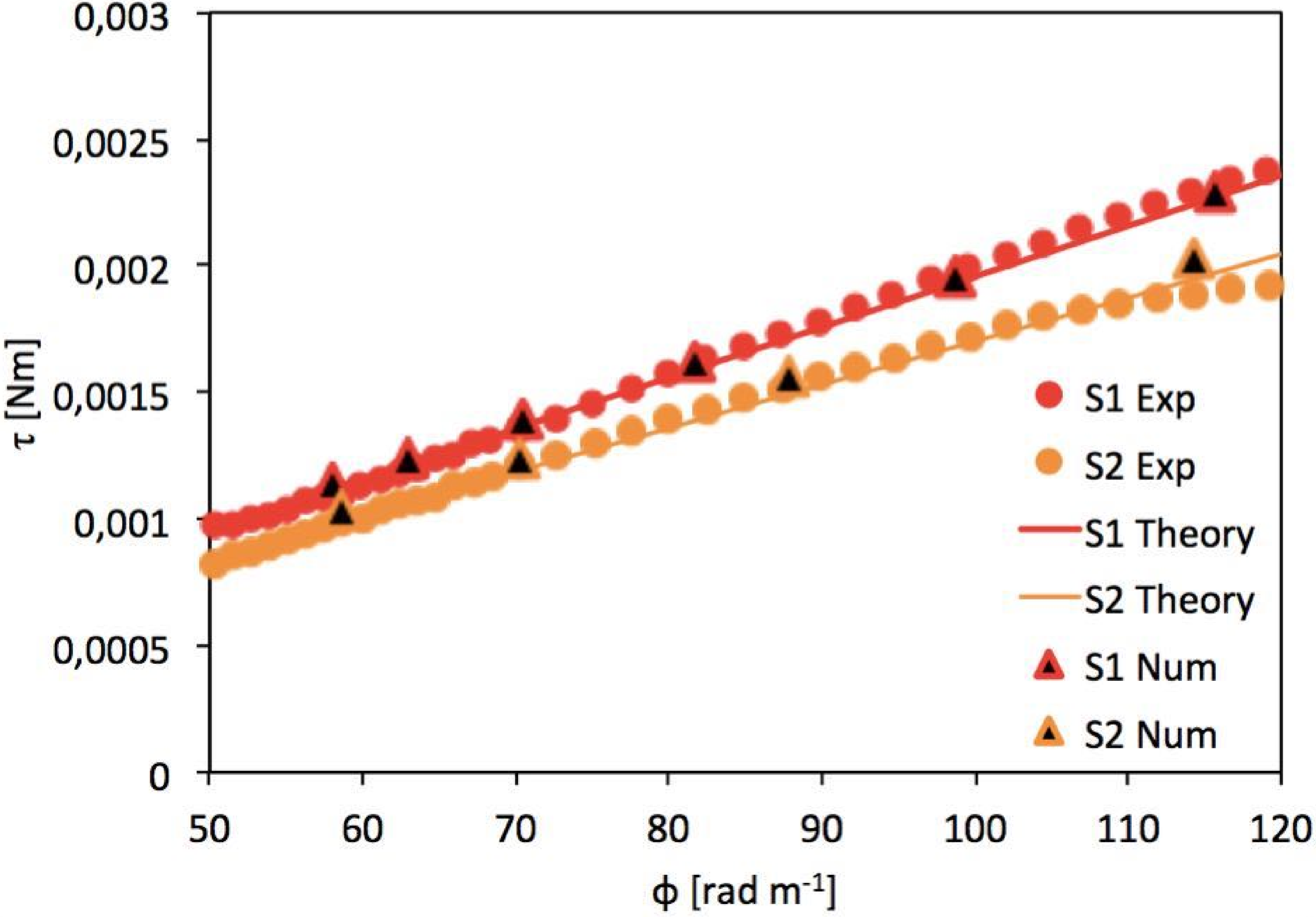
Twist: $\phi = \alpha / l$

Longitudinal stretch: λ

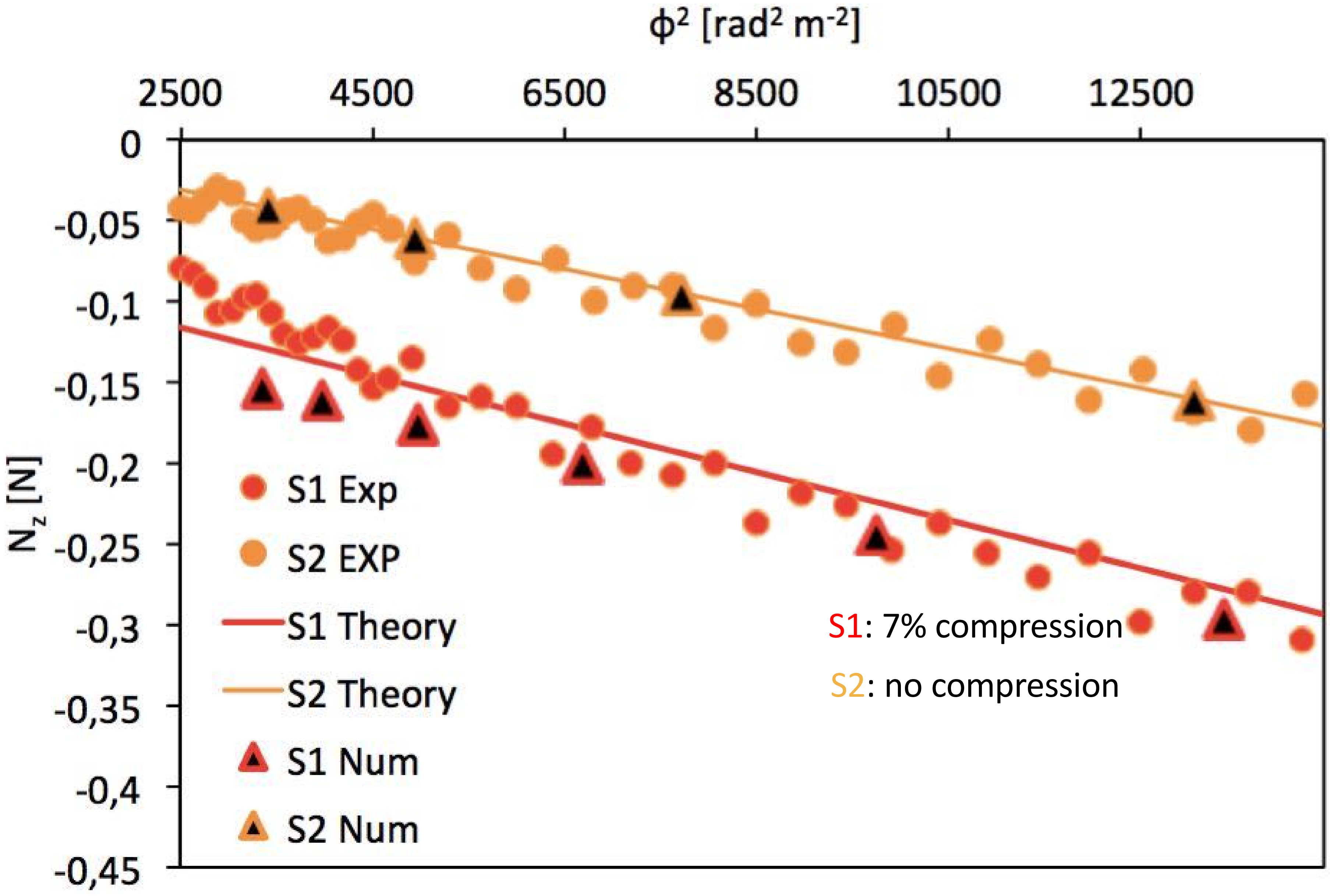
Mooney-Rivlin model predicts

- Torque ∝ ϕ
- Normal force ∝ ϕ^2

Torsion in Abaqus: Torque



Torsion in Abaqus: Normal force



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Conclusions

sample	μ [Pa]	c_2 [Pa]	R^2_τ	$R^2_{N_z}$
S_1	1232.50	294.45	0.999	0.946
S_2	1092.31	235.84	0.998	0.939
S_3	766.95	310.60	0.988	0.966
S_4	491.14	201.22	0.996	0.958
S_5	656.96	59.68	0.988	0.87
S_6	644.59	113.75	0.994	0.92
S_7	952.36	347.26	0.993	0.947
S_8	803.12	401.41	0.997	0.925
S_9	1460.17	710.29	0.995	0.962
mean±SD	900±312	297±189		

Estimated elastic parameters:
shear modulus $\mu=2(c_1+c_2)$,
Mooney-Rivlin parameter c_2 and
the two coefficients of determination for the torque (R^2_τ) and the normal force (R^2_{Nz}) data fits.

1. Brain displays the classical **Positive Poynting Effect** in torsion

2. Brain **behaves as a Mooney-Rivlin material** in torsion

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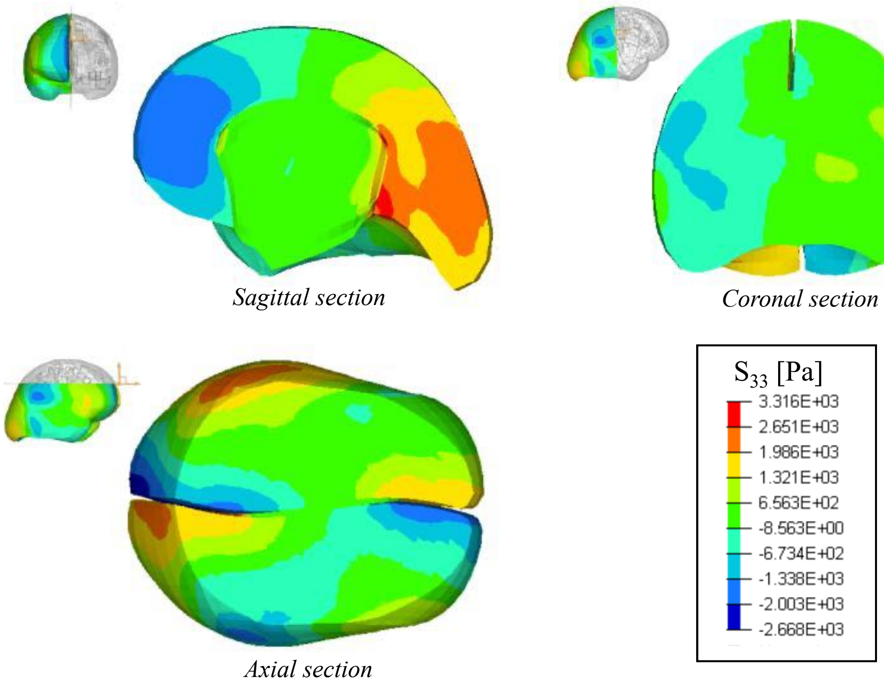
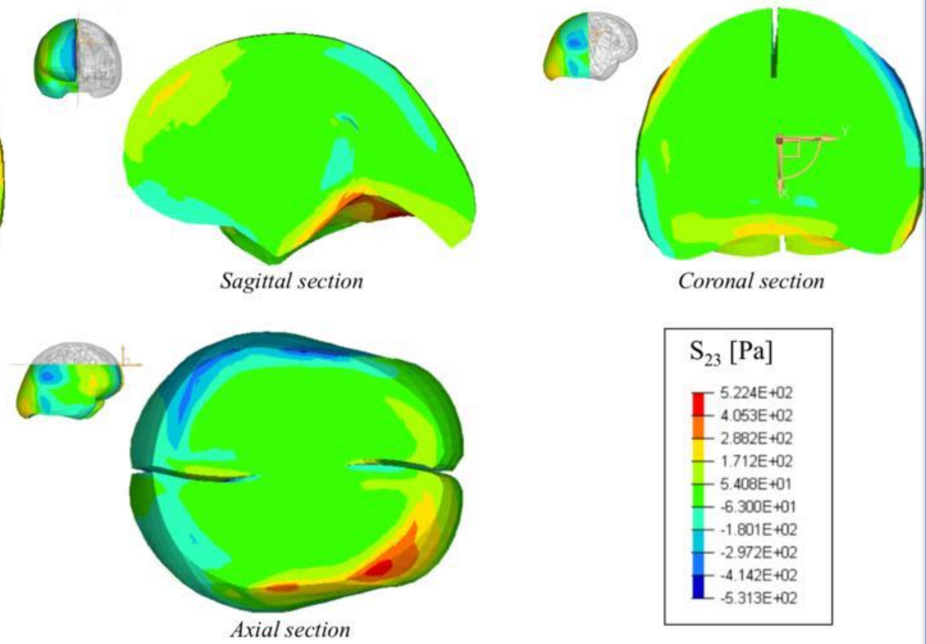
Simulation: Rotational head impact





Normal component **Shear component**

Peak acceleration: 2,170 rad s^{-2} (thresholds for mild DAI are >5,000 rad s^{-2})

Normal and shear stress are of the same order of magnitude (kPa) as thresholds for DAI (Deck & Willinger, 2008)

[*Soft Matter*, 2019]

The destructive brain team

V. Balbi (UL)

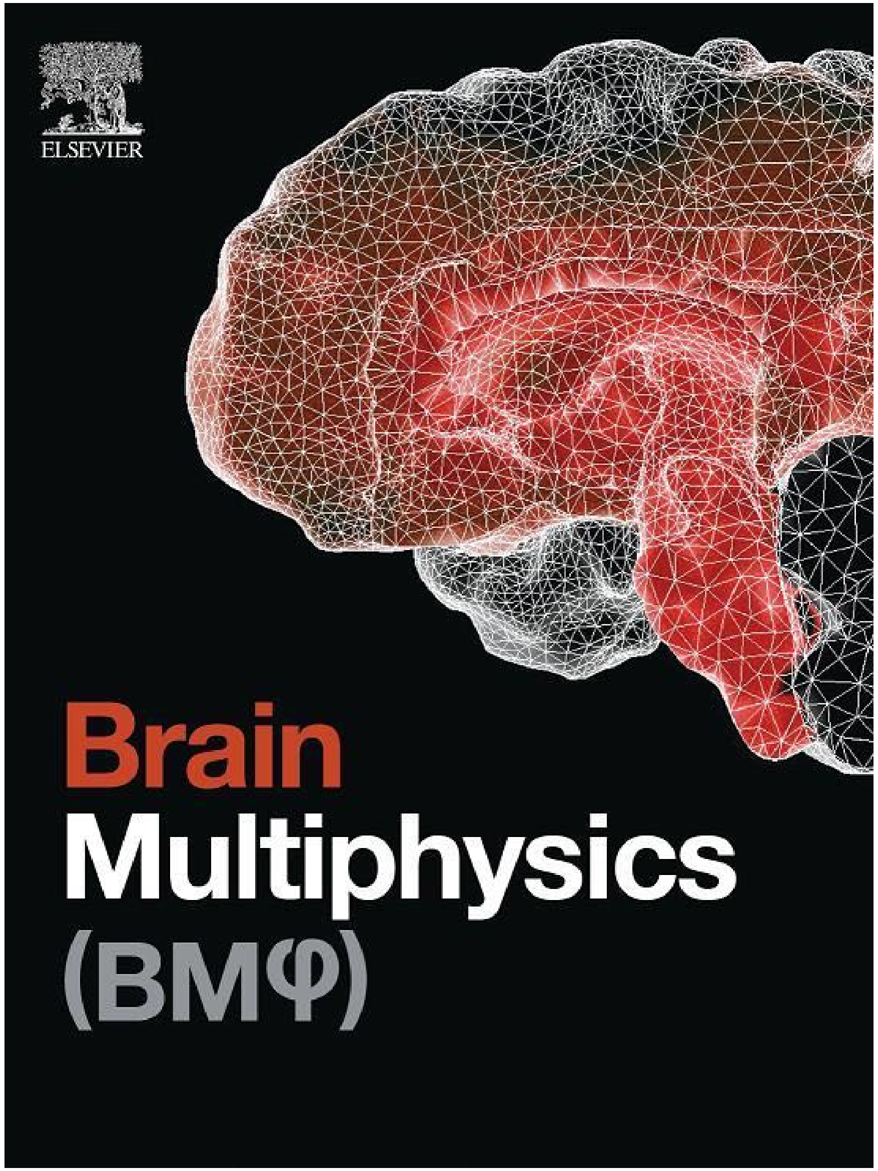
A. Ní Annaidh and A. Trotta (UCD)

Conclusion

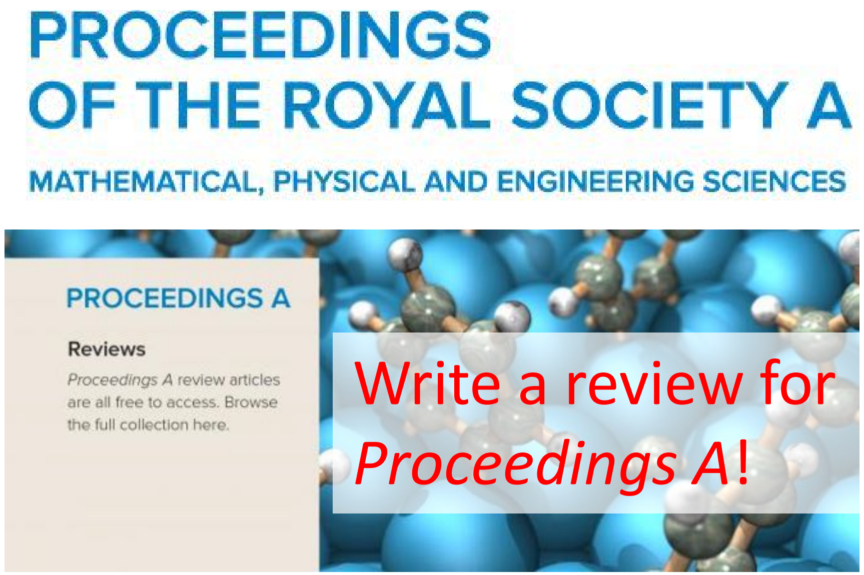
Come visit me in beautiful Galway!

- as a student
- as a postdoc
- as an academic

Advertisements



Propose a Special Issue to *NLM*!



Write a review for *Proceedings A*!

NUI Galway
OÉ Gaillimh

ESMC 2022

11th European Solid Mechanics Conference
National University of Ireland Galway
Ireland, July 2022

Under the auspices of EUROMECH

Chair: Professor Peter McHugh