

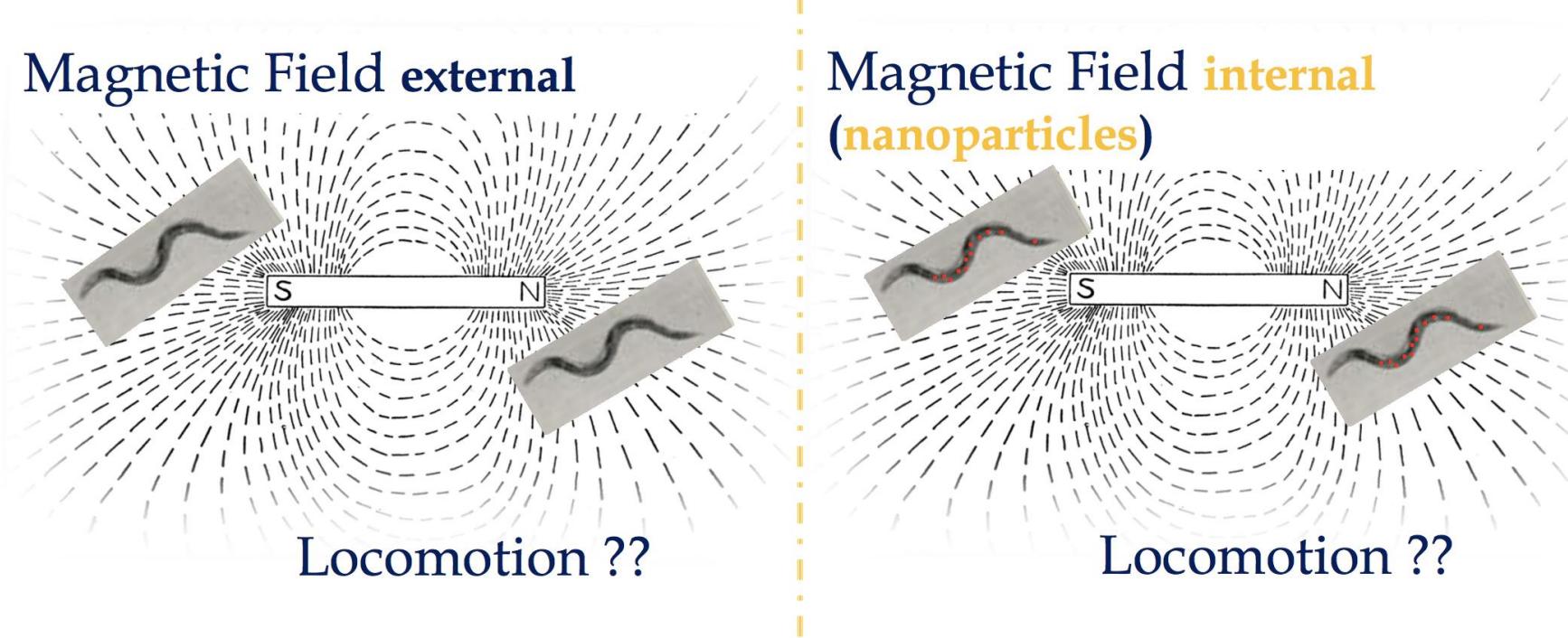
# Internally localized magnetic fields affect *C. elegans* locomotion dynamics

Yang Zhang, Ehsan Mirzakhalili, Bogdan Epureanu, Eleni Gourgou  
College of Engineering, University of Michigan, Ann Arbor

## Background

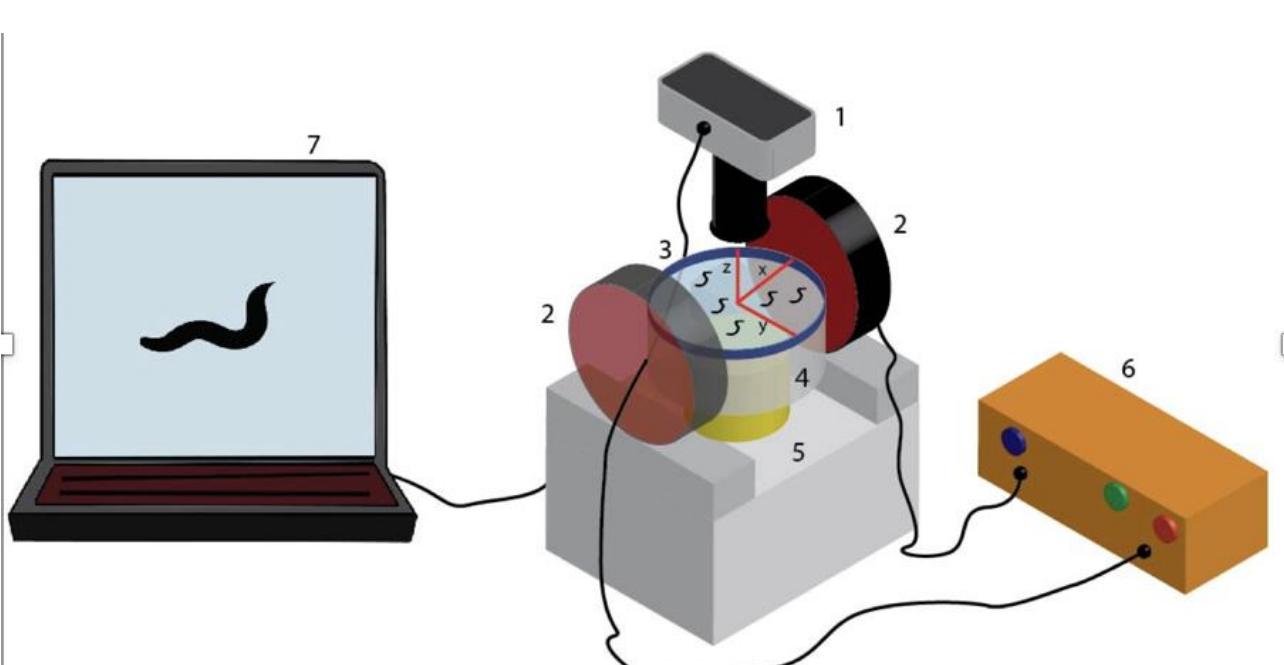
- The effects of magnetic field (MF) on living organisms is associated with activity linked to the modern way of living. (1)
- C. elegans* is a successful resource to study MF effects on various types of cells and tissues. (2)
- Nanoparticles uptake by *C. elegans* worms has been a successful means to evaluate toxicity of materials. (3)
- C. elegans* locomotion can be used to assess impact on behavior (4)

## Objectives



Use locomotion as a quantifiable and revealing behavioral expression to determine the effect of MF gradient on *C. elegans*.

## Experimental Setup

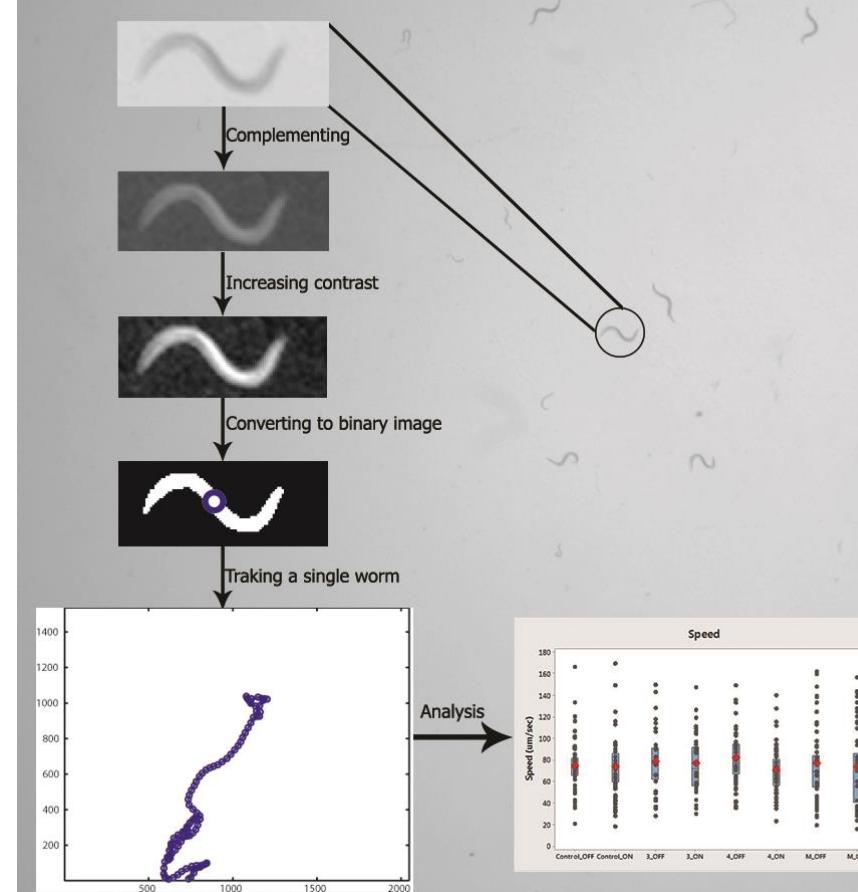


1: Objective lens and camera; 2: Electromagnets; 3: NGM plate with *C. elegans*, with schematic of plate orientation; 4: Auxiliary base; 5: Bright light source; 6: Power supply; 7: Computer and software.

Group	Particle Size	Coating	Magnetic properties	Fluorescence
Group C	-	-	-	-
Group 1	1 $\mu$ m	Streptavidin	Superparamagnetic, iron core	No
Group 100	100 nm	No	Magnetic, dextran iron oxide composite	Rhodamine
Group 40	40 nm	-COOH	Magnetic, iron oxide (magnetite)	No

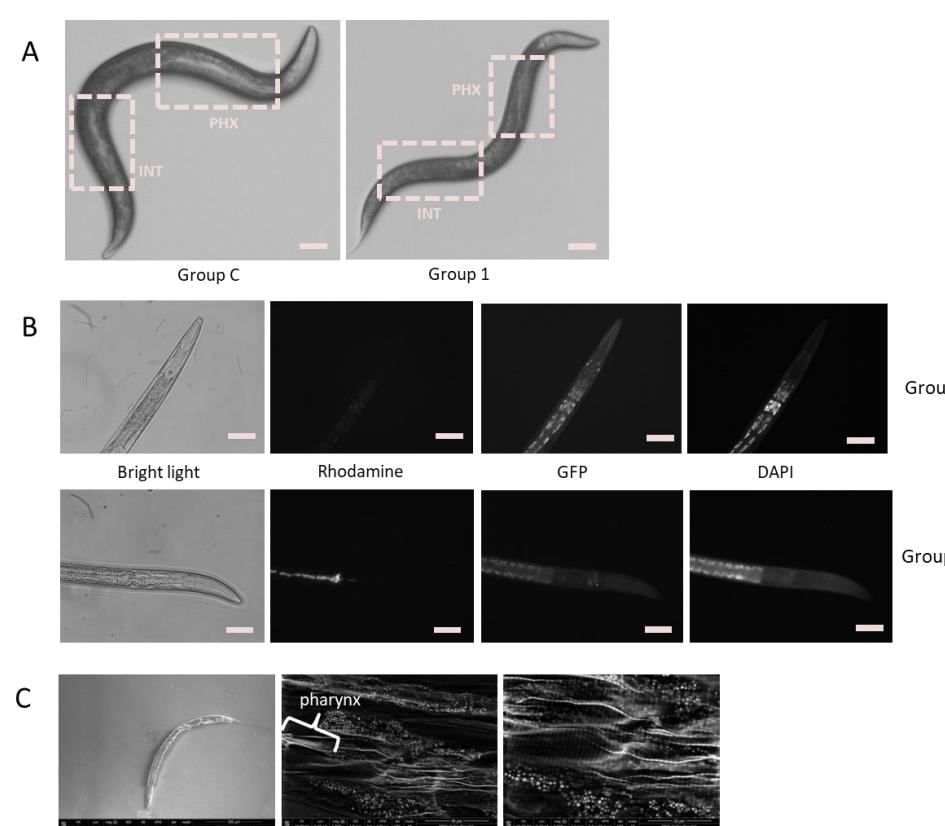
## Methods

### Worms recording and tracking



### Locomotion Features Analysis (5)

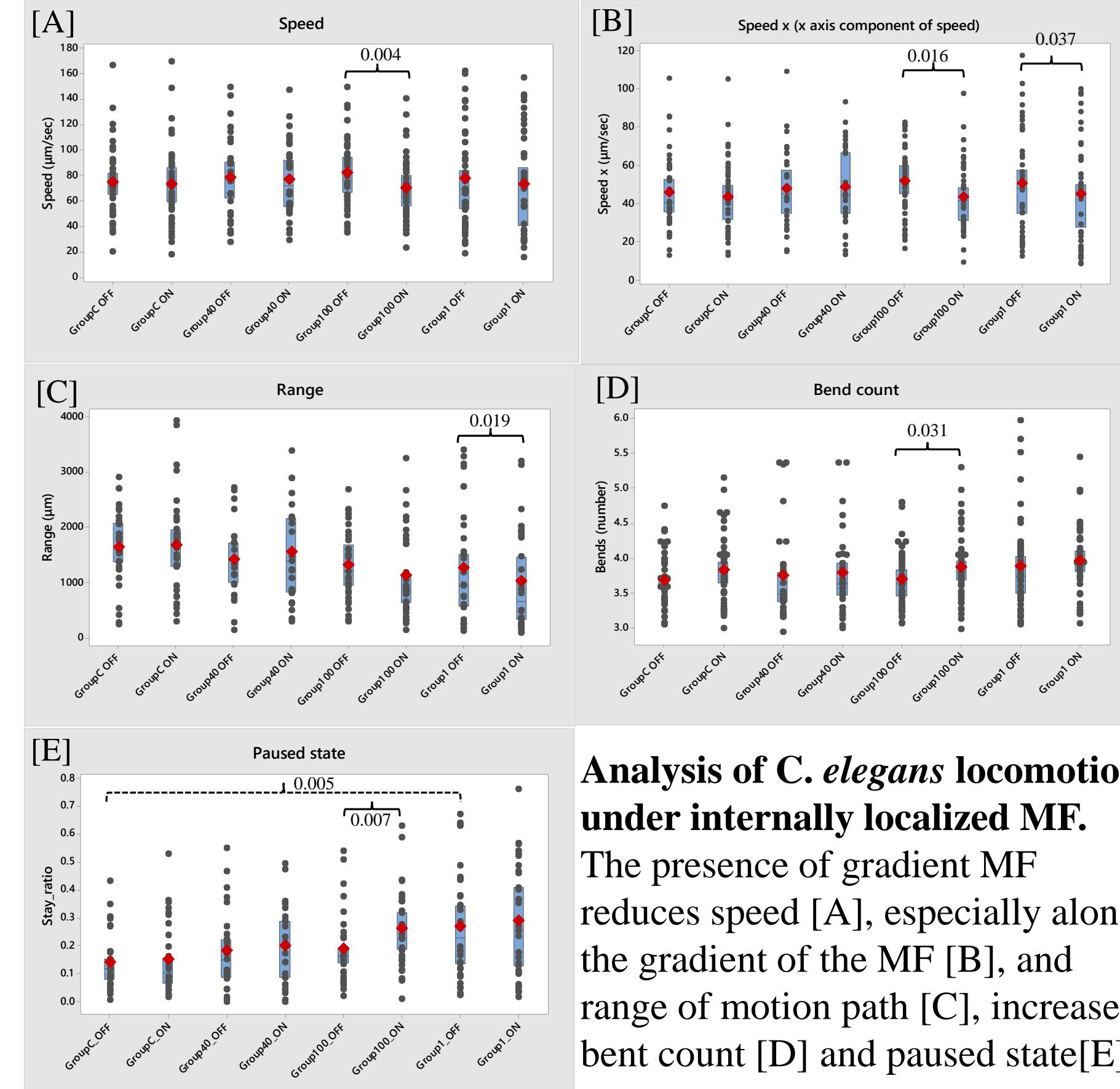
1. Morphology: Length, Centroid.
2. Posture: Bends, Bend count.
3. Motion: Motion state, Velocity.
4. Path: Path Curvature, Range.



## Discussion & Conclusions

- Internally localized MF, generated by magnetic nanoparticles, affects the dynamics of *C. elegans* locomotion (8).
- MF alone does not have an impact on worms' locomotion.
- The gradient of the MF (up to  $2 \times 10^5$  T/m, 1  $\mu$ m particles) is well above the threshold that may impact mechano-sensitive ion channels ( $10^3$  T/m) (9).
- Findings are added to the discussion on *C. elegans* magnetotaxis (6) and are among the few available data on the *in vivo* effect of internally localized MFs (7).
- The effect of localized MFs on animals' behavior, combined with use of particles with different properties, could pave the way for further studies on the sensitivity of biological systems to MFs.

## Results



### Analysis of *C. elegans* locomotion under internally localized MF.

The presence of gradient MF reduces speed [A], especially along the gradient of the MF [B], and range of motion path [C], increases bent count [D] and paused state [E].

## Next steps

To test targeted neurons that could be affected by gradient MF, such as DVA neuron, with its mechanosensitive TRPN channels, and VB, VD, DB, DD motor neurons.

## References

1. Lewczuk B & Redlarski G, BioMed Research International. 2014;2014:13.
2. Cheung BH et.al Curr Biol. 2005 May 24;15(10):905-17.
3. Khare P et.al Journal of Biomedical Nanotechnology. 2011 //;7(1):116-7.
4. Pierce-Shimomura JT, et al. PNAS. 2008 12/12
5. Yemini E et.al. Nature methods. 2013 07/14;10(9):877-9.
6. Vidal-Gadea et.al . Elife. 2015 Jun 17;4.
7. Sensenig R, et.al. Nanomedicine. 2012;7(9):1425-42.
8. Gourgou E, et al, bioRxiv 2017, 248369; doi: <https://doi.org/10.1101/248369>
9. Zablotskii V, et al, 2016. Sci Reports. 6:37407

## Acknowledgements

We thank Nikos Chronis for the use of equipment, Syeda Maisa for help with preliminary videos; Jinhong Qu and Jiawei Zhang from Kenn Oldham lab for the power supply; UoM Electron Microbeam Analysis Laboratory (EMAL), with support of UoM College of Engineering; we thank John Mansfield, Kai Sun and Haiping Sun for the training.