



DAWN TIL DUST

A Perspective on Early-Career Scientific Research
Luke Simons

CONTENTS

1. Everything about PhDs
 - a. **What** is a PhD?
 - b. **Why** would I want to do a PhD?
 - c. What is the **application process**?
 - d. What is the PhD experience?
2. My Research
 - a. Dust in Magnetically Confined Fusion Plasmas
 - b. Simulating Dust in Magnetised Plasmas
 - c. Rapid Rotation and Instability of Liquid Dust

$\sqrt{123}$



WHAT IS A
PhD?

$+ \times \div$



WHAT IS A
PhD?

"(...) the **highest university degree** that
is **conferred after a course of study...**"

- Wikipedia

PhD



Master



Bachelor





WHAT DOES A PhD DO?

1. Conducting and Communicating Research for Public Benefit
2. Develop Capability as an Independent Researcher
3. Build Academic Profile and Renown



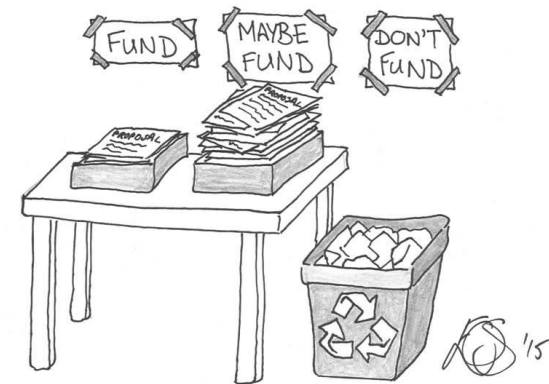
PUBLIC RESEARCH BODIES

- Uk Research and Innovation (**UKRI**): Seven Research Councils
Invest around **£380 million** in PhD training **every year**
- Three Relevant for Physics:
 - Engineering and Physical Sciences Research Council (**EPSRC**)
 - Science and Technology Facilities Council (**STFC**)
 - Natural Environment Research Council (**NERC**)

WHAT IS A
PhD?

PUBLIC RESEARCH BODIES

- **Successful** grant proposals lead to Funding
- Grants aim to generate and (usually) publicise knowledge



Review panel categories.



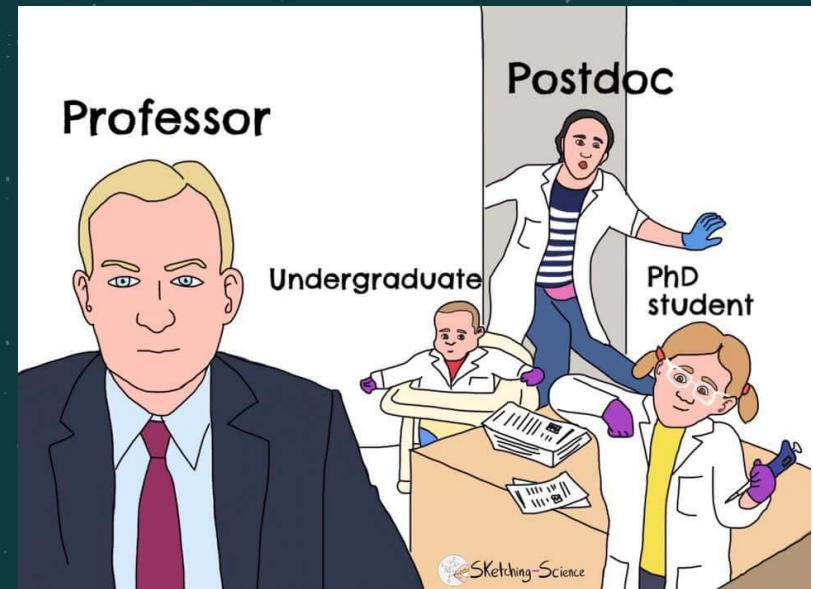
BECOMING A SCIENTIST

1. Develop **Expert** Knowledge and Skills of a **Research Area**
2. Conduct **Original Research** in Research Area
3. **Communicate Results** (Conferences, Journal Articles, ...)

WHAT IS A
PhD?

FIRST STEP IN ACADEMIA

- A PhD Prepares you for a Post-Doc:
 - Identifying Research Areas
 - Communicating Research
 - Project Management
 - Training of Students



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WHY DO A
PhD?

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PROS AND CONS



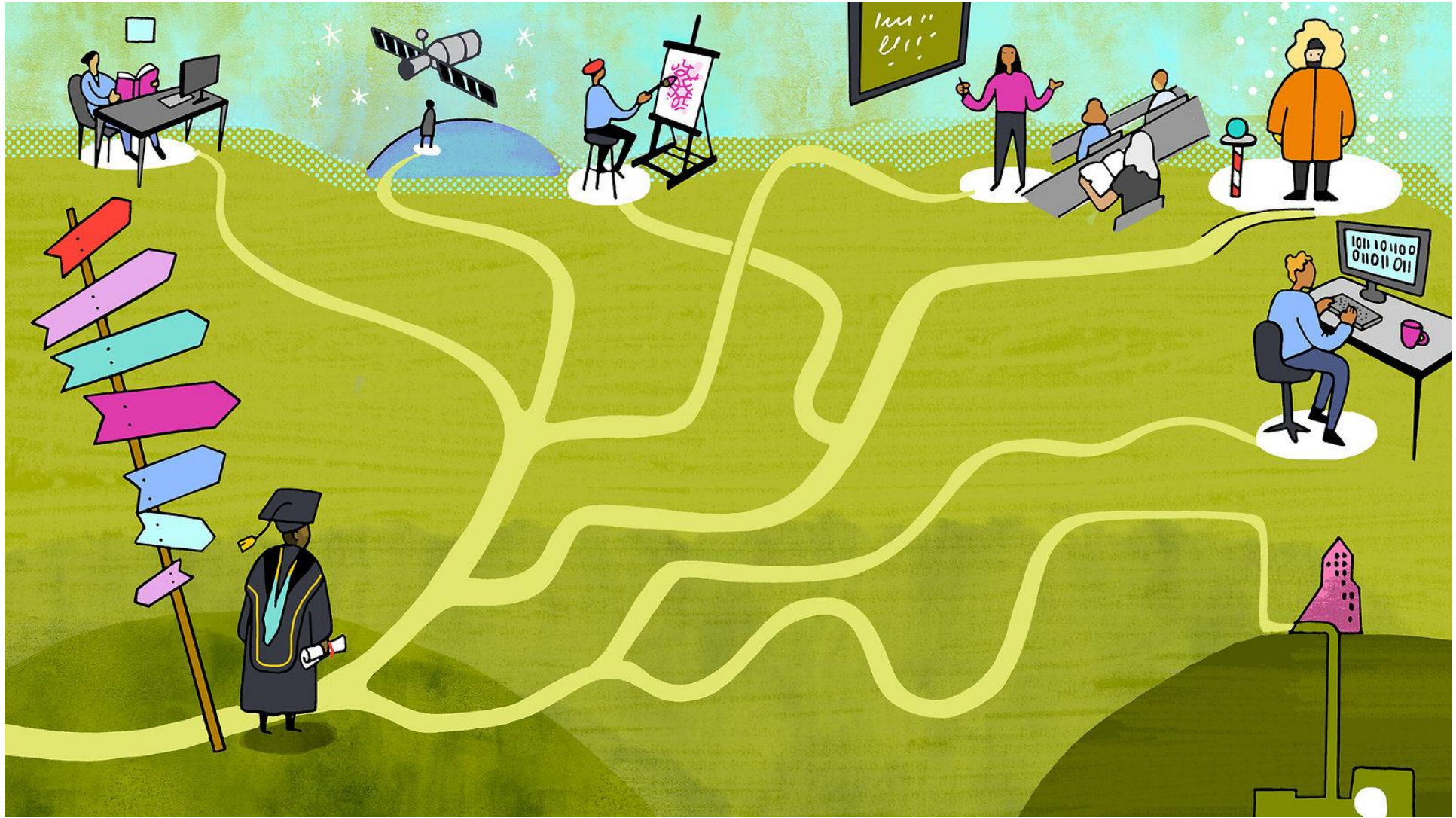
PROS

- Better Employment Prospects
- Training in Research
- Travel and Conferences
- Job Stability
- Personal Recognition
- Becoming a Doctor
- More Independence



CONS

- Relatively Low, Fixed Pay
- Limited "Perks"
- Damage to Mental Health
- Long Term Commitment
- Personal Recognition
- Wrong Kind of Doctor
- More Independence



PHD STIPENDS, 20/21

	DTC
LONDON	£17,798
OUTSIDE LONDON	£15,285

PHD STIPENDS, 20/21

	DTC	EQUIV
LONDON	£17,798	£20,975
OUTSIDE LONDON	£15,285	£17,279

PHD STIPENDS, 20/21

	DTC	EQUIV	AVG
LONDON	£17,798	£20,975	£24,991
OUTSIDE LONDON	£15,285	£17,279	£22,400

PHD STIPENDS, 20/21

	DTC	EQUIV	AVG	CDT	EQUIV
LONDON	£17,798	£20,975	£24,991	<£25,000	<£31,565
OUTSIDE LONDON	£15,285	£17,279	£22,400	<£25,000	<£31,565

PHD STIPENDS, 20/21

	DTC	EQUIV	AVG	CDT	EQUIV	FEES
LONDON	£17,798	£20,975	£24,991	<£25,000	<£31,565	£4,407
OUTSIDE LONDON	£15,285	£17,279	£22,400	<£25,000	<£31,565	£4,407



WHY DO A
PhD?

TRAVEL AND CONFERENCES

1. Typically **at least one funded** Conference/Workshop per year
2. Opportunity to meet and network with other scientists
3. Learn and contribute to leading research with talks and posters

WHY DO A
PhD?

TRAVEL AND CONFERENCES

1. Oxford (1st yr)



WHY DO A
PhD?

1. Oxford (1st yr)
2. Prague (2nd yr)

TRAVEL AND CONFERENCES



WHY DO A
PhD?

1. Oxford (1st yr)
2. Prague (2nd yr)
3. Milan (3rd yr)

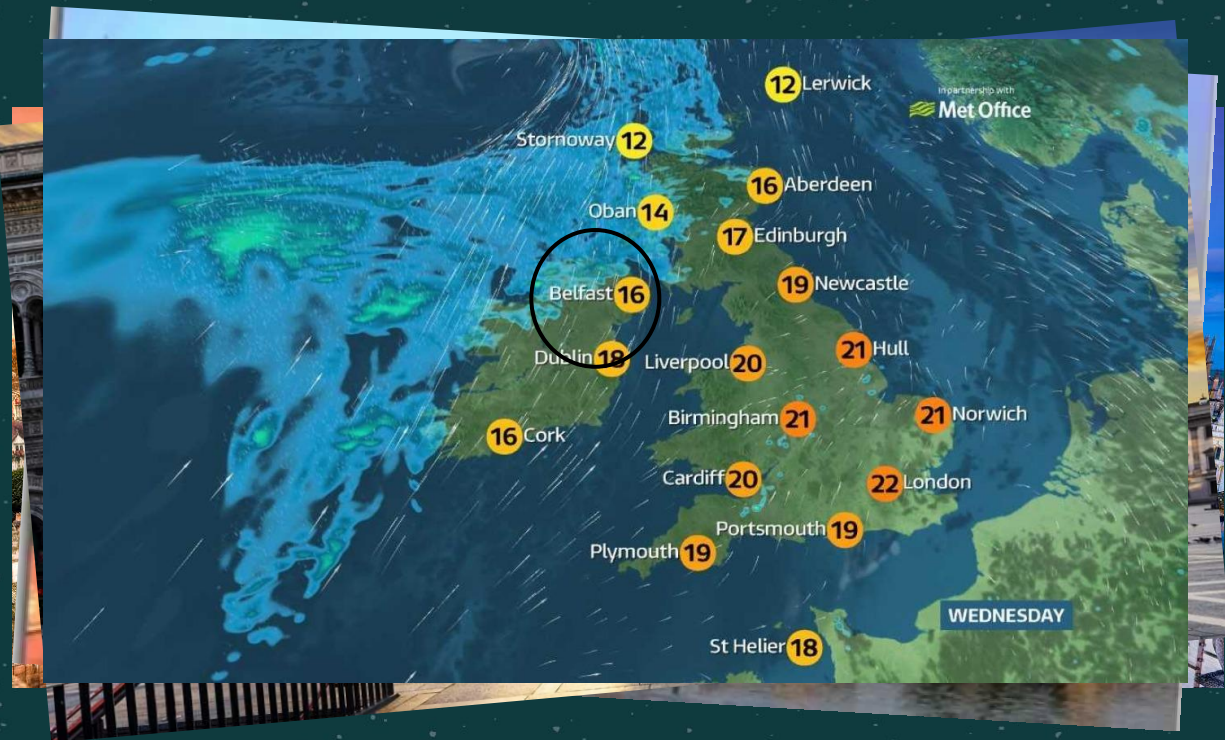
TRAVEL AND CONFERENCES



WHY DO A
PhD?

1. Oxford (1st yr)
2. Prague (2nd yr)
3. Milan (3rd yr)
4. Belfast (2nd yr)

TRAVEL AND CONFERENCES



WHY DO A
PhD?

1. Oxford (1st yr)
2. Prague (2nd yr)
3. Milan (3rd yr)
4. Belfast (2nd yr)

TRAVEL AND CONFERENCES



A PHD ISN'T FOR EVERYONE

ACADEMIA

PRO

YOU CAN WORK WHENEVER
YOU WANT! EVERY DAY
IS A SATURDAY!



CON

YOU WORK ON SATURDAYS.



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APPLYING FOR A PhD



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o

APPLYING
FOR A PhD

ELIGIBILITY

**"The one essential condition... is
evidence of previous academic
excellence, and of future potential..."**

- UNIVERSITY OF OXFORD, Wikipedia





APPLYING
FOR A PhD

ELIGIBILITY

- Good Undergraduate Performance, Upper Second Class (2.1)
- Masters Degree
- Additional Research Experience Helps! (UROP, Work Experience)

FIND THE RIGHT PROJECT



PRE-DEFINED PhD PROJECT

Majority of PhDs and CDTs
Less Freedom with Research Topic
University Supervisor Creates Research Proposal
Grant Money Might be Guaranteed



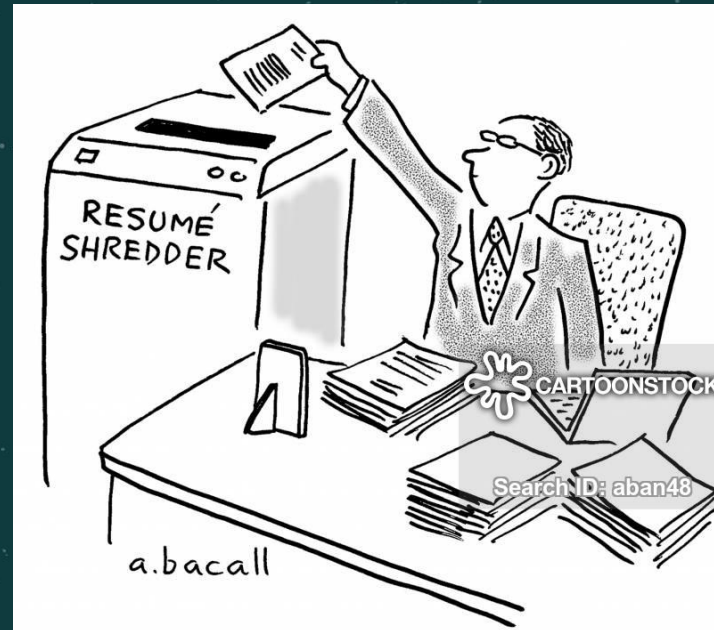
YOUR OWN RESEARCH PROPOSAL

Less Common
Complete Freedom with Research Topic
You Create the Research Proposal
Grant Application can be Unsuccessful

WHAT IS A PhD?

1. Choose Project(s)
2. Contact Supervisor
3. Online Application
CV, Personal Statement
& Cover Letter
4. Interview
5. Accepted!

APPLICATION PROCESS


















PERSONAL ANECDOTE

	MANCHESTER	LIVERPOOL	WARWICK	YORK	IMPERIAL
1) CHOOSE PROJECT					





















PERSONAL ANECDOTE

	MANCHESTER	LIVERPOOL	WARWICK	YORK	IMPERIAL
1) CHOOSE PROJECT					
2) CONTACT SUPERVISOR					

PERSONAL ANECDOTE

	MANCHESTER	LIVERPOOL	WARWICK	YORK	IMPERIAL
1) CHOOSE PROJECT					
2) CONTACT SUPERVISOR					
3) ONLINE APPLICATION					

PERSONAL ANECDOTE

	MANCHESTER	LIVERPOOL	WARWICK	YORK	IMPERIAL
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2) CONTACT SUPERVISOR					
3) ONLINE APPLICATION					
4) INTERVIEW					





Plasma Diagnostics

Invasive Methods: Langmuir probe

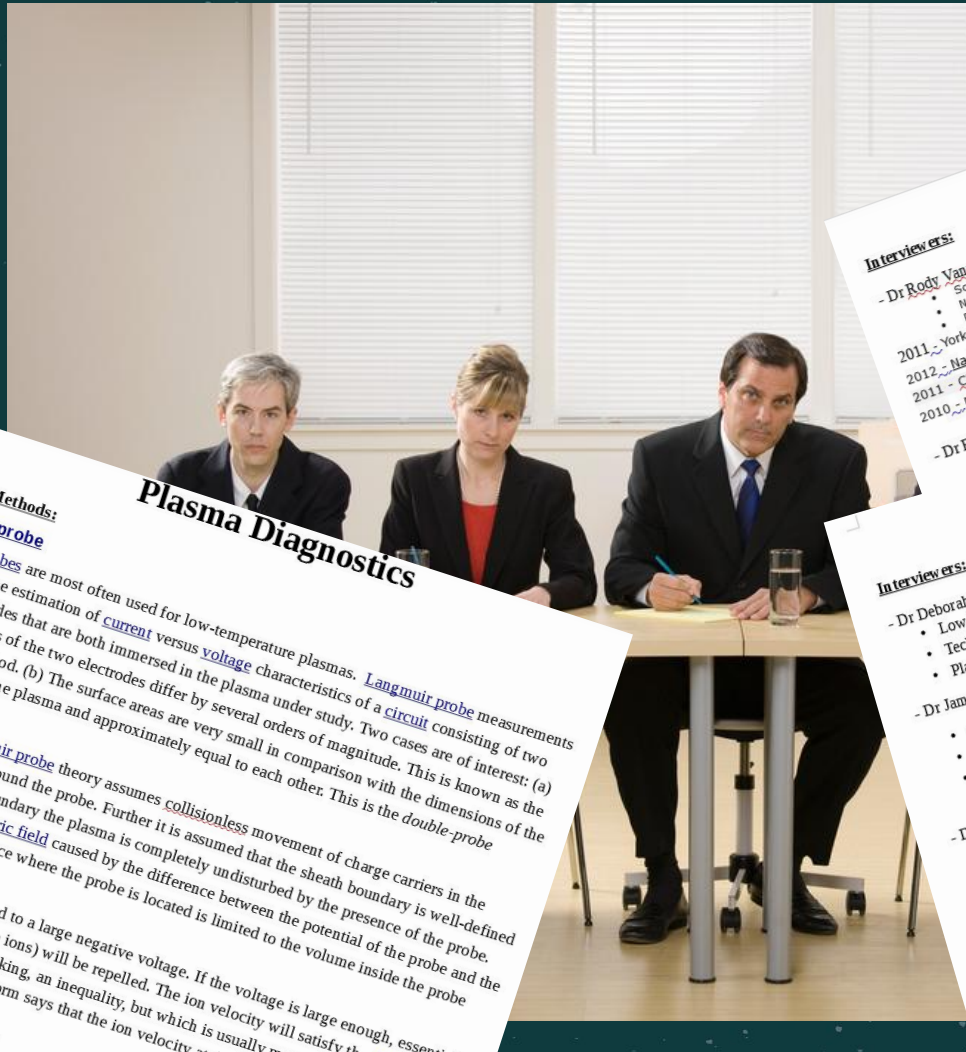
Langmuir probes are most often used for low-temperature plasmas. Langmuir probe measurements are based on the estimation of **current** versus **voltage** characteristics of a **circuit** consisting of two metallic electrodes that are both immersed in the plasma under study. Two cases are of interest: (a) The surface areas of the two electrodes differ by several orders of magnitude. This is known as the *single-probe* method. (b) The surface areas are very small in comparison with the dimensions of the vessel containing the plasma and approximately equal to each other. This is the *double-probe* method.

Conventional **Langmuir probe** theory assumes **collisionless** movement of charge carriers in the space charge sheath around the probe. Further it is assumed that the sheath boundary is well-defined and that beyond this boundary the plasma is completely undisturbed by the presence of the probe. This means that the **electric field** caused by the difference between the potential of the probe and the plasma potential at the place where the probe is located is limited to the volume inside the probe sheath boundary.

Consider first a surface biased to a large negative voltage. If the voltage is large enough, essentially all electrons (and any negative ions) will be repelled. The ion velocity will satisfy the **Bohm criterion**, which is, strictly speaking, an inequality, but which is usually approximated by the **Bohm criterion** in its marginal form says that the ion velocity must be at least equal to the ion sound speed given by

$$v_i = \sqrt{k_B(ZT_e + \gamma_i T_i)/m_i}$$

on temperature



Plasma Diagnostics

Invasive Methods:

Langmuir probe

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on temperature

Interview Revision

Interviewers:

- Dr Roddy Vann,
 - Scientific supercomputing
 - Nuclear fusion
 - Plasma physics
- 2011 - York Plasma Institute Management Team: IT Infrastructure and Remote Learning
- 2012 - Natural Sciences Programme Director
- 2011 - CIPCATS Management Team
- 2010 - Member of University Teaching Committee
- Dr Rob Akers,



Modelling

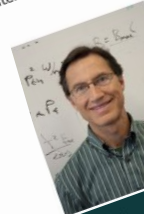
Interview Revision

Interviewers:

- Dr Deborah O'Connell, Finished PhD in 2004, University of Dublin Undergrad and Postgrad
 - Low T plasmas: low pressure rf plasmas, atmospheric pressure plasma jets, microplasmas
 - Technological applications of plasmas, including plasma medicine
 - Plasma diagnostics
- Dr James Dedrick, PhD at Australian National University
 - Low-temperature plasmas
 - Plasma propulsion
 - Atmospheric-pressure plasmas
 - Flow control
- Dr James Harrison, Finished PhD in 2011, UoM Undergraduate and UoY Postgraduate
 - Plasma Edge Physicist
 - Controls Direction (Sam's Supervisor)
- Dr Kirsty McKay, PhD at Loughborough and BSc from Glasgow
 - Biological and Medical applications.
- Dr Paul Bryant, PhD at Oxford (2001), MSc Queen Marys
 - Dust in Magnetised Plasmas.
 - Electronics
 - Langmuir Probes



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plays a role in
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the kamak
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ugh leading the
erials to
interactions



Interview Revision

Questions York - Notepad

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Why you want to go to this City?
The basic principles of the subject?
What you've learned before?
Why did you choose this University?
Intelligent questions for them.
Conference travel.

For David:

How open ended are the research projects being offered.
After the first year, will there be more of a computational focus rather than experimental.
The simulations performed using G52.
What is ballooning.
Is it clear that understanding ELMs will provide a path to commercial fusion
How many PHD students will the university be accepting.
How many PHD students will you be supervising.

For Others:

Where do students typically live in their first year.
Is there guaranteed university accommodation for prospective postgraduate students.
Are there any examinations to sit in the first year.
How bad has the flooding been.

Questions to Answer:

Why do you want to study Fusion?
- Passionate about climate change and energy crisis
- Interested in renewable energy and carbon capture technologies
- Ultimately believe that these are not permanent solutions
- Larger sources are needed
- I think Fusion is an extremely brave and hopeful option
- I'm enthusiastic about the potential for development of this technology in my lifetime

Why do you want to do this course?

- Through my undergraduate study, I've become more specifically interested in computing and simulations.
- I believe that my skills learnt at undergraduate level are best suited to focusing on software development
- York university especially has some of the best contacts and experts in the field.
- York is also very closely linked to CCFE which I would consider to be a future work place.

Why do you want to do a PhD?

- Originally, I was interested in entering straight into work.
- However, I realised the aspects of developing fusion technology which I wanted to be involved

Invasive Methods:

Langmuir probe

are based on the estimation of current versus voltage characteristics of the two electrodes immersed in the plasma using the single-probe method. (b) The surface areas are very small in a vessel containing the plasma and approximately equal to each other.

Conventional Langmuir probe theory assumes collisionless move space charge sheath around the probe. Further it is assumed that and that beyond this boundary the plasma is completely undisturbed. This means that the electric field caused by the difference between the plasma potential at the place where the probe is located is limited to the sheath boundary.

Consider first a surface biased to a large negative voltage. If the voltage is negative enough, all electrons (and any negative ions) will be repelled. The ion velocity will be given by the Bohm criterion in its marginal form says that the ion velocity v_i is given by $v_i = \sqrt{k_B(ZT_e + \gamma_i T_i)/m}$

Plasma Diagnostics

Infrastructure and Remote Learning



Modelling

Revision

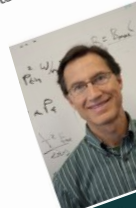
University of Dublin Undergrad and Postgrad
atmospheric pressure plasma jets, microplasmas
including plasma medicine



plasma density
kamak
plays a role in
now
the tokamak
ma interaction
ugh leading the
erials to
interactions

11, UoM Undergraduate and UoY Postgraduate

revisor)
ough and BSc from Glasgow.
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001), MSc Queen Marys
is.





PERSONAL ANECDOTE

	MANCHESTER	LIVERPOOL	WARWICK	YORK	IMPERIAL
1) CHOOSE PROJECT					
2) CONTACT SUPERVISOR					
3) ONLINE APPLICATION					
4) INTERVIEW					
5) ACCEPTED					

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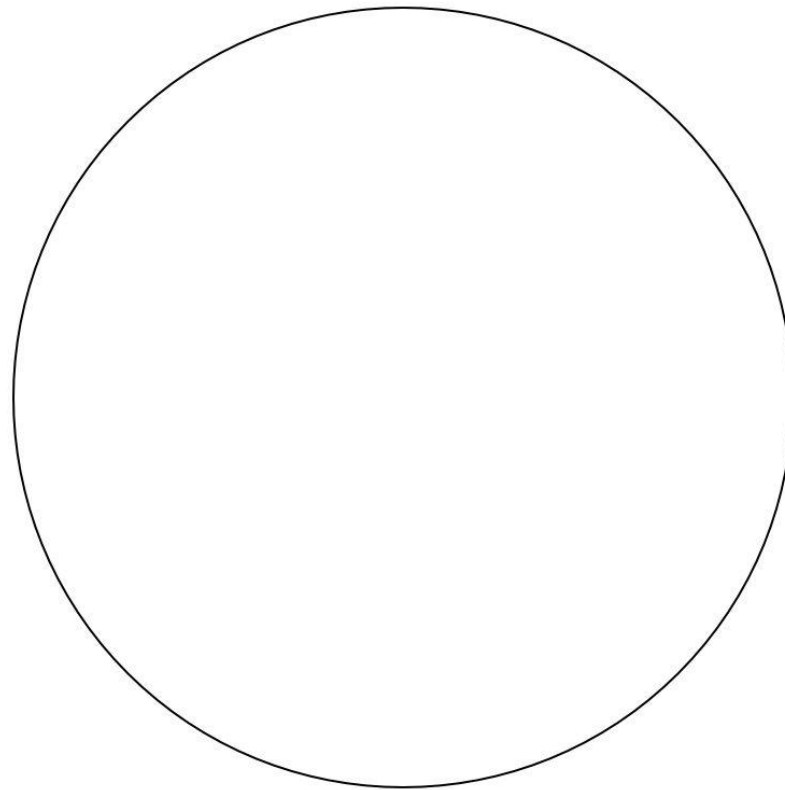
THE PHD LIFE

+ x ÷



HUMAN
KNOWLEDGE

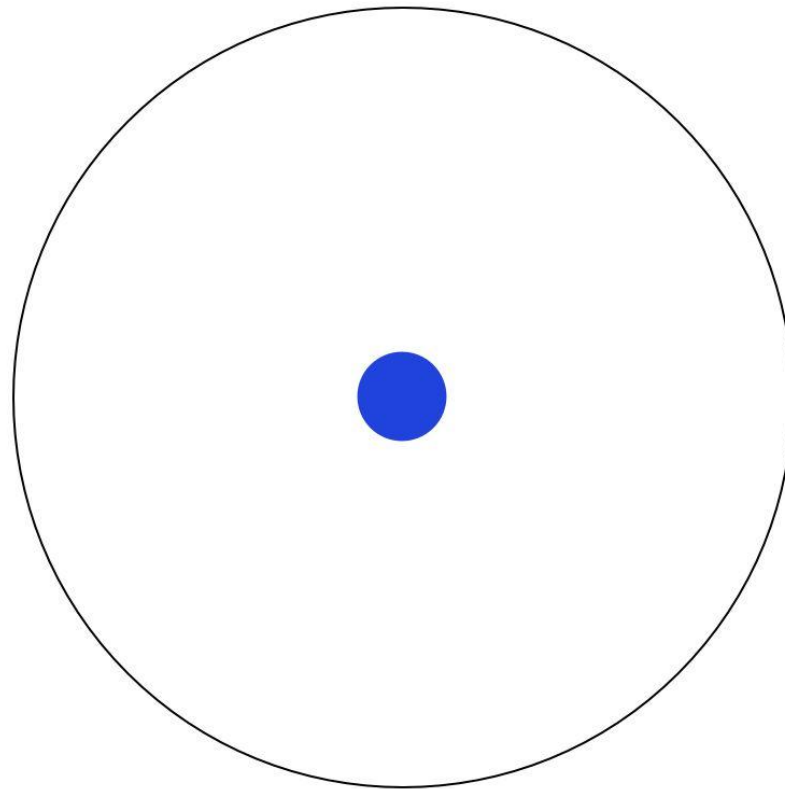
ILLUSTRATED PhD





SCHOOL
EDUCATION

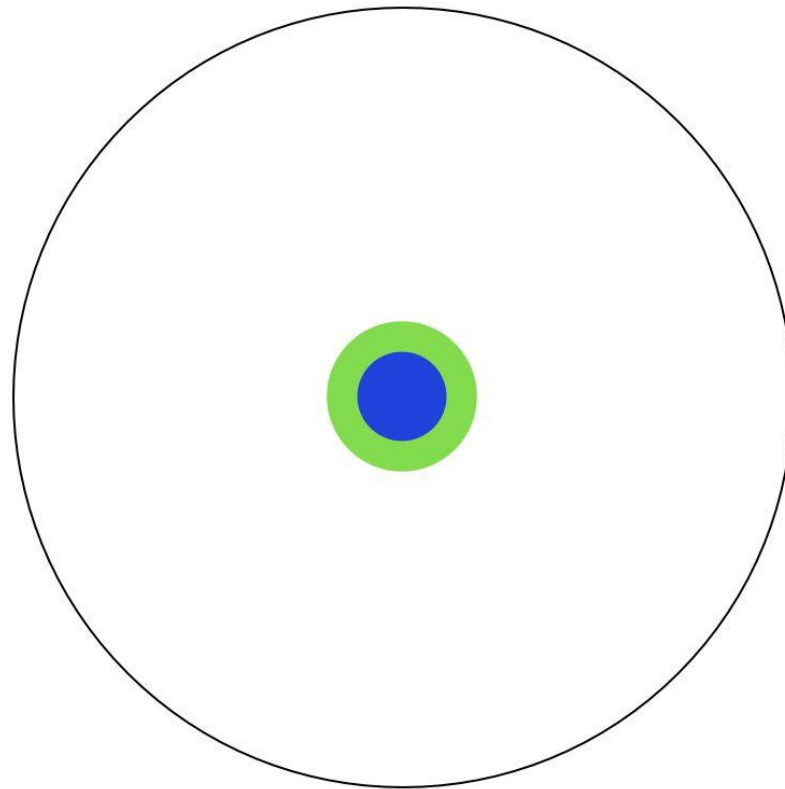
ILLUSTRATED PhD





COLLEGE
EDUCATION

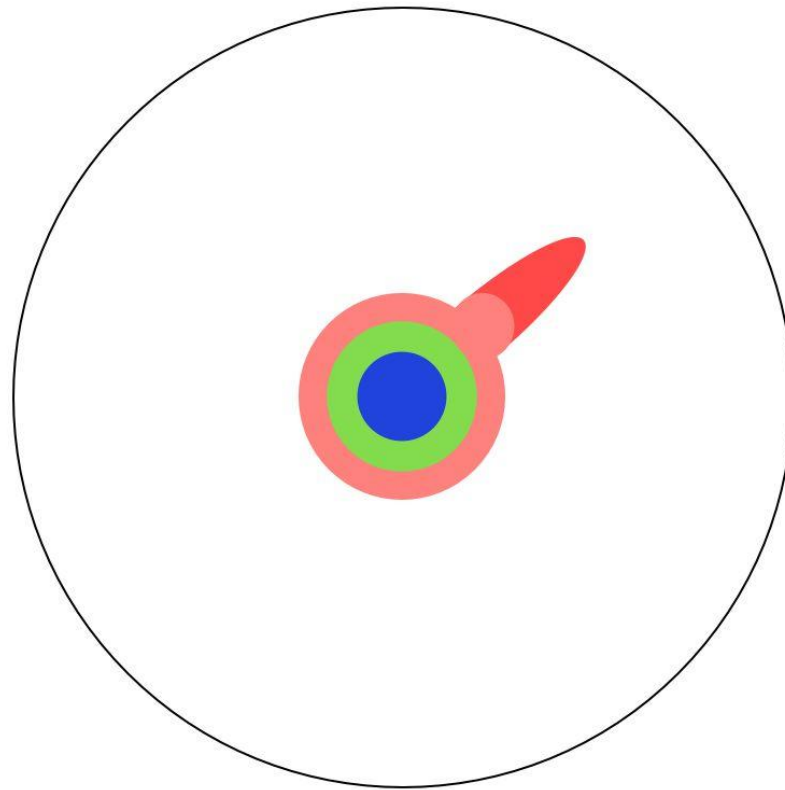
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ILLUSTRATED PhD

THE PhD
LIFE

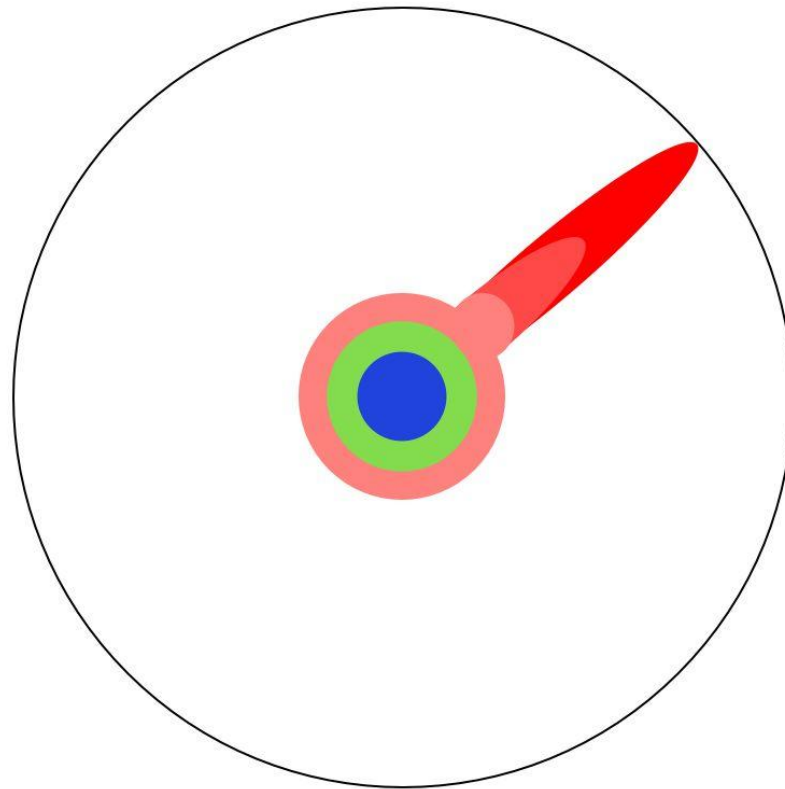
UNDERGRADUATE
DEGREE





PhD

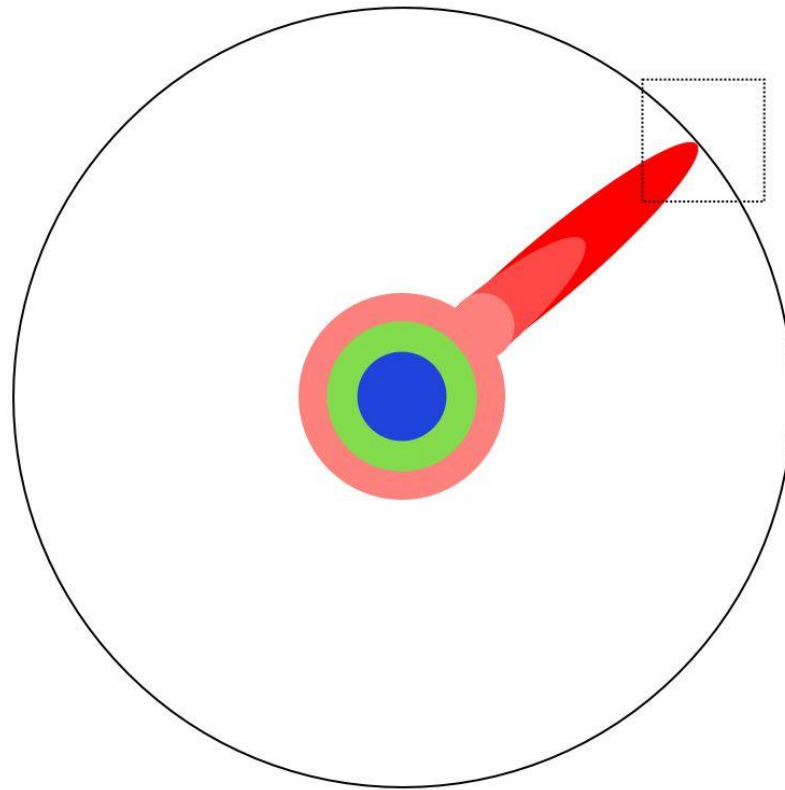
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ILLUSTRATED PhD

THE PhD
LIFE

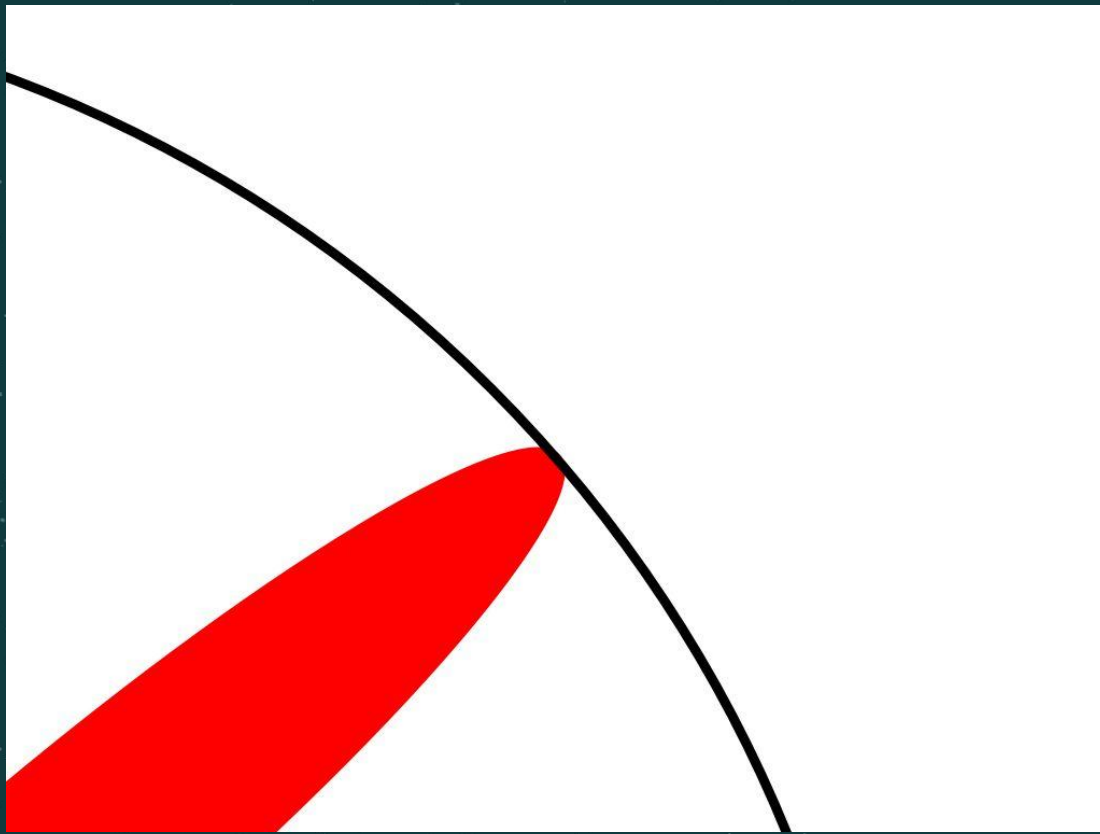
PhD



ILLUSTRATED PhD

THE PhD
LIFE

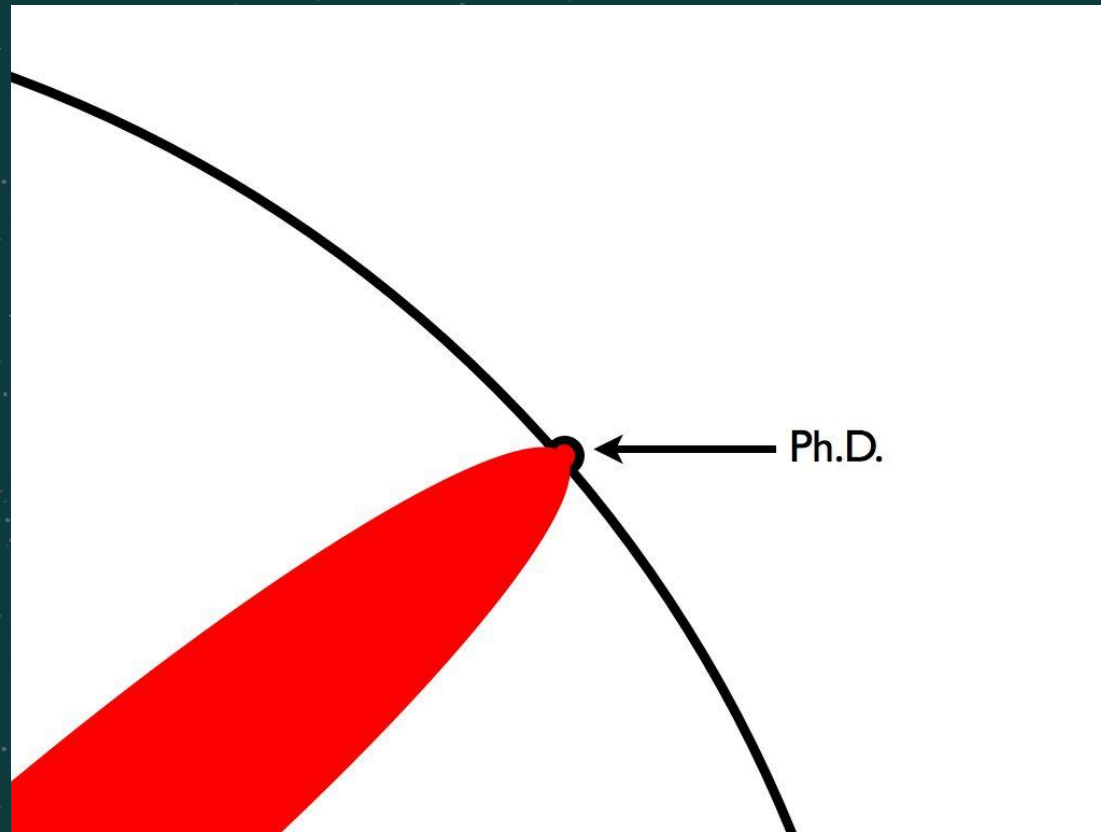
PhD



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THE PhD
LIFE

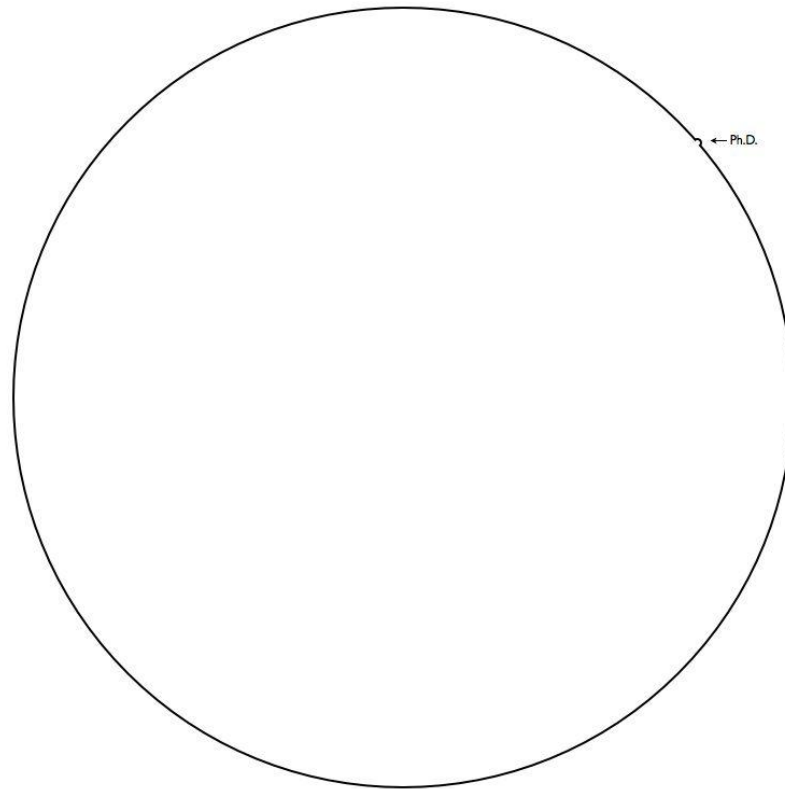
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PhD

ILLUSTRATED PhD





WHAT IS A
PhD?

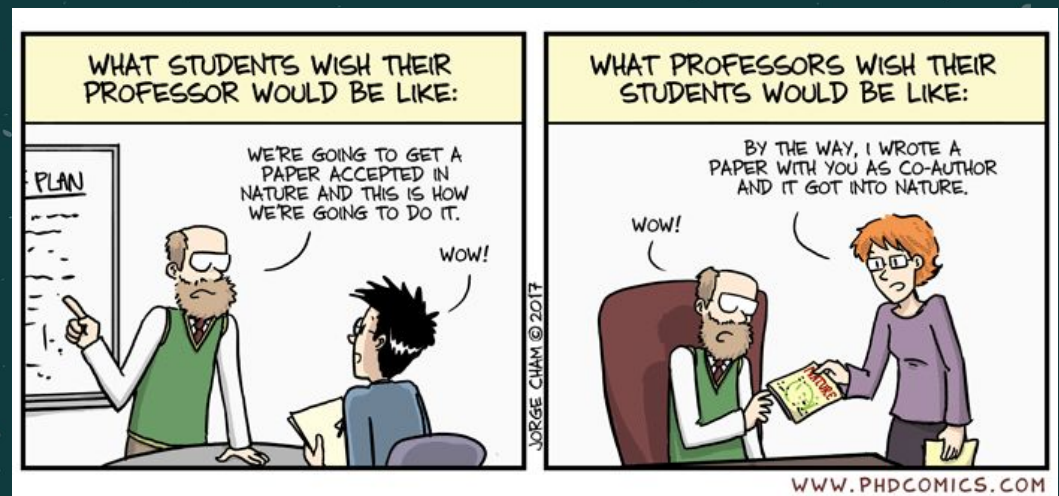
DEGREE PROGRESSION

- 3 Month: Initial Research Plan
- 9 Month Early and 18 Month Late Stage Assessment (ESA & LSA)
- Thesis Submission and Defence (Viva)

THE PhD LIFE

- Lab and Safety Training
- Lecture Courses
- READING

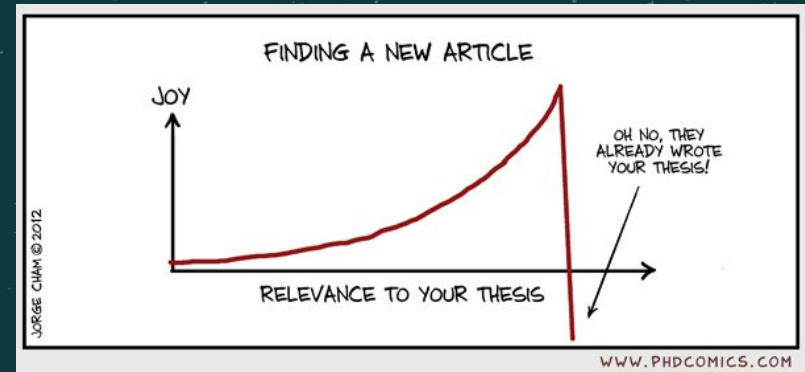
BEGINNING



THE PhD LIFE

- Planning and Conducting Research
- Conferences, Workshops & Publications
- READING

MIDDLE



THE PhD LIFE

- Compile Work for Thesis
- Write Thesis
- READING

END



1st Yr

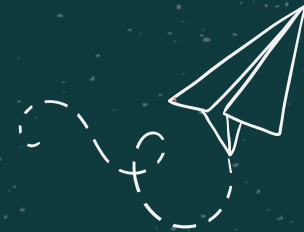
READING

Lab and Safety Training
Attending Lecture Series
Background Reading

2nd Yr

TESTING

Preliminary Research
Conferences & Workshops
Background Reading



3rd Yr

RESEARCH

Complete Research
Conferences & Publications
Background Reading

4th Yr

THESIS

Compile Research
Write Thesis
Background Reading



CONTENTS

1. Everything about PhDs

- a. **What** is a PhD?
- b. **Why** would I want to do a PhD?
- c. What is the **application process**?
- d. What is the PhD experience?

2. My Research

- a. Dust in Magnetically Confined Fusion Plasmas
- b. Simulating Dust in Magnetised Plasmas
- c. Rapid Rotation and Instability of Liquid Dust

CONTENTS

1. Everything

- a. **What** is a
- b. **Why** would
- c. What is
- d. What is

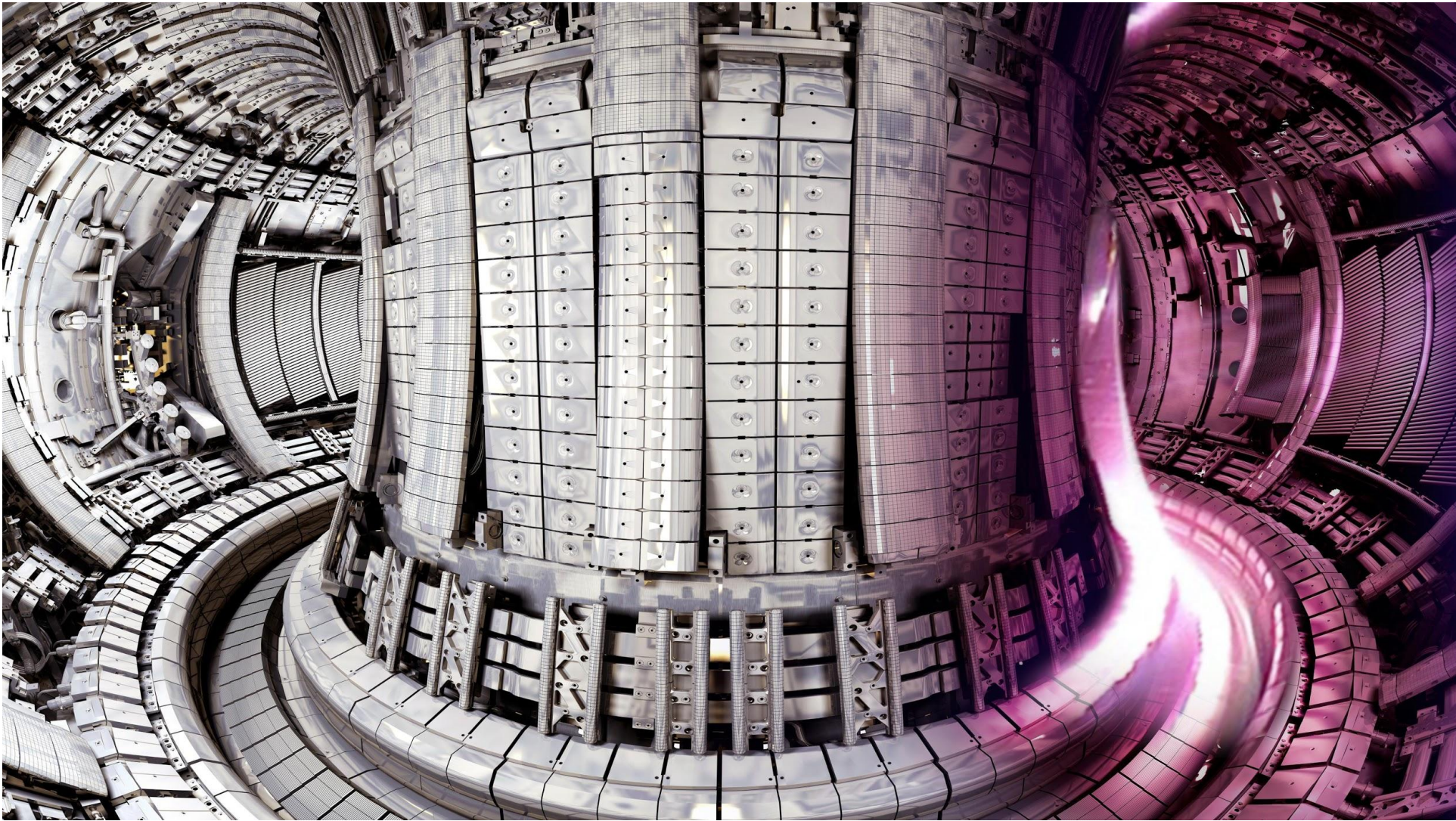
2. My Research

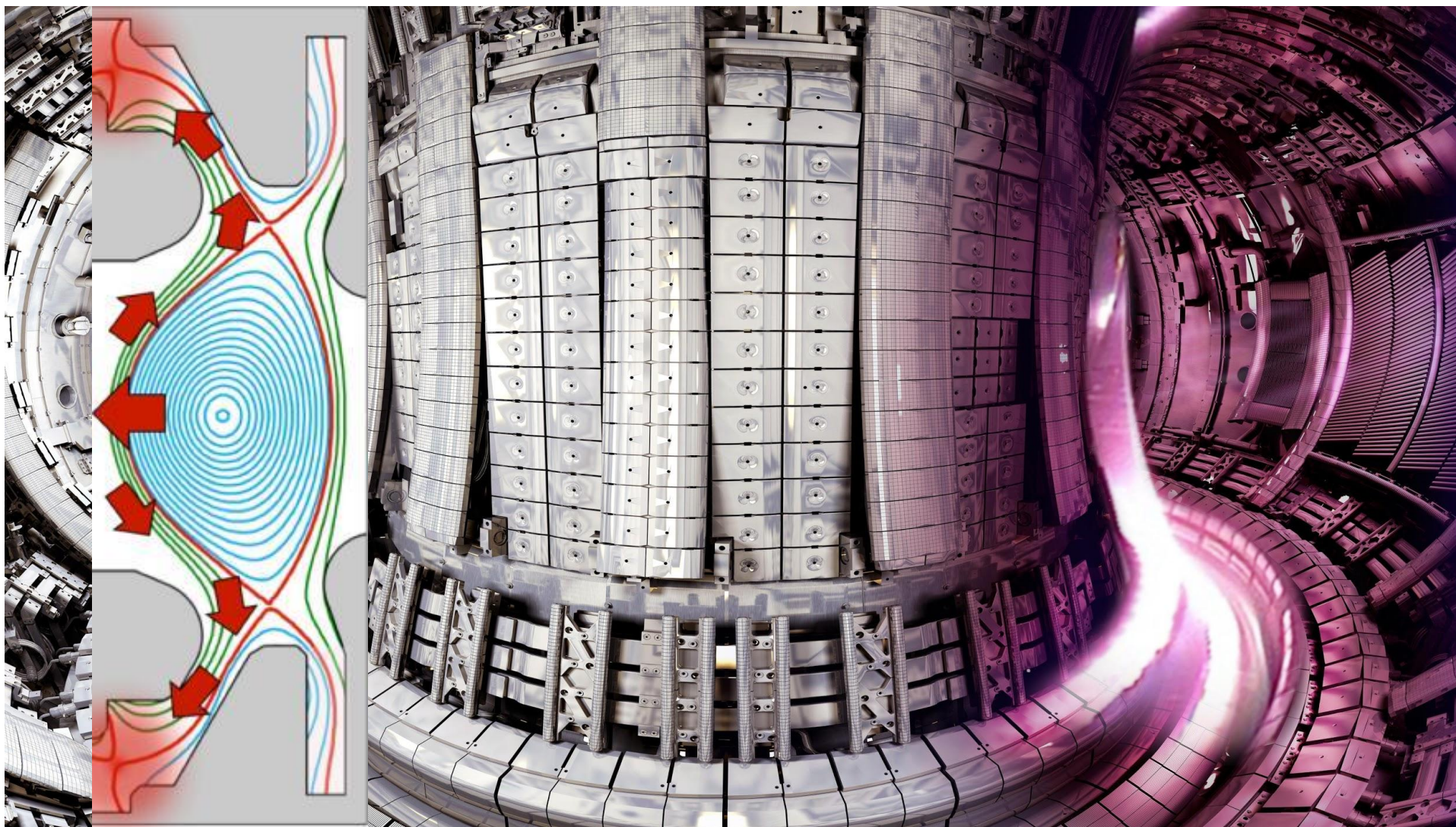
- a. Dust in H II regions and protoplanetary disks
- b. Simulating the growth of dust grains in protoplanetary disks
- c. Rapid Rotation and Instability in Protoplanetary Disks

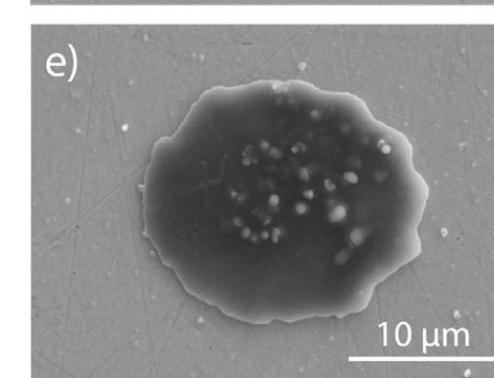
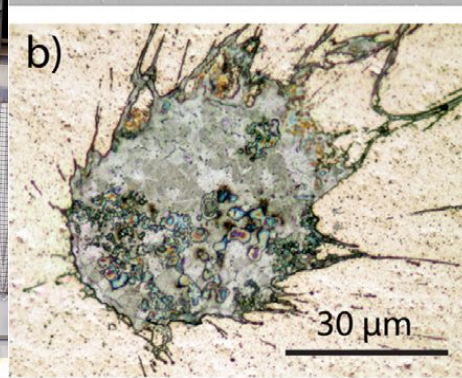
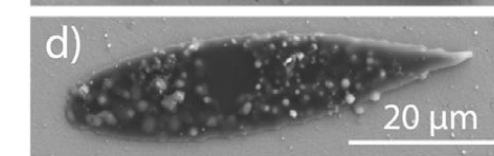
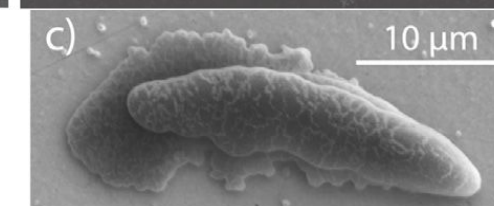
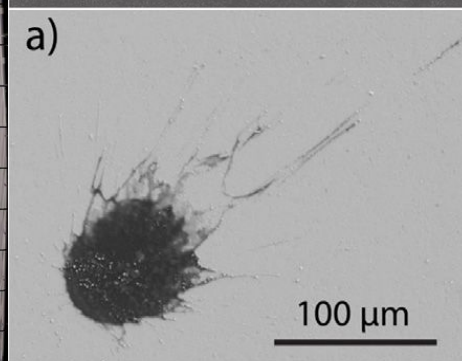
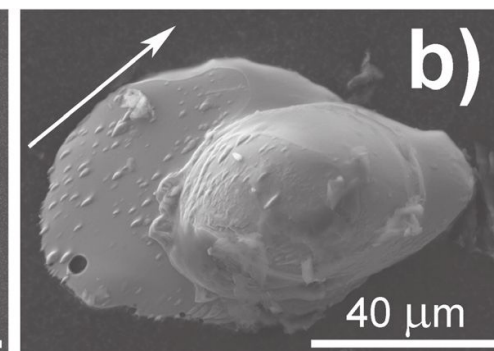
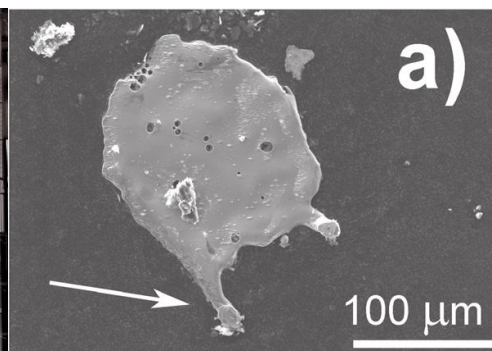
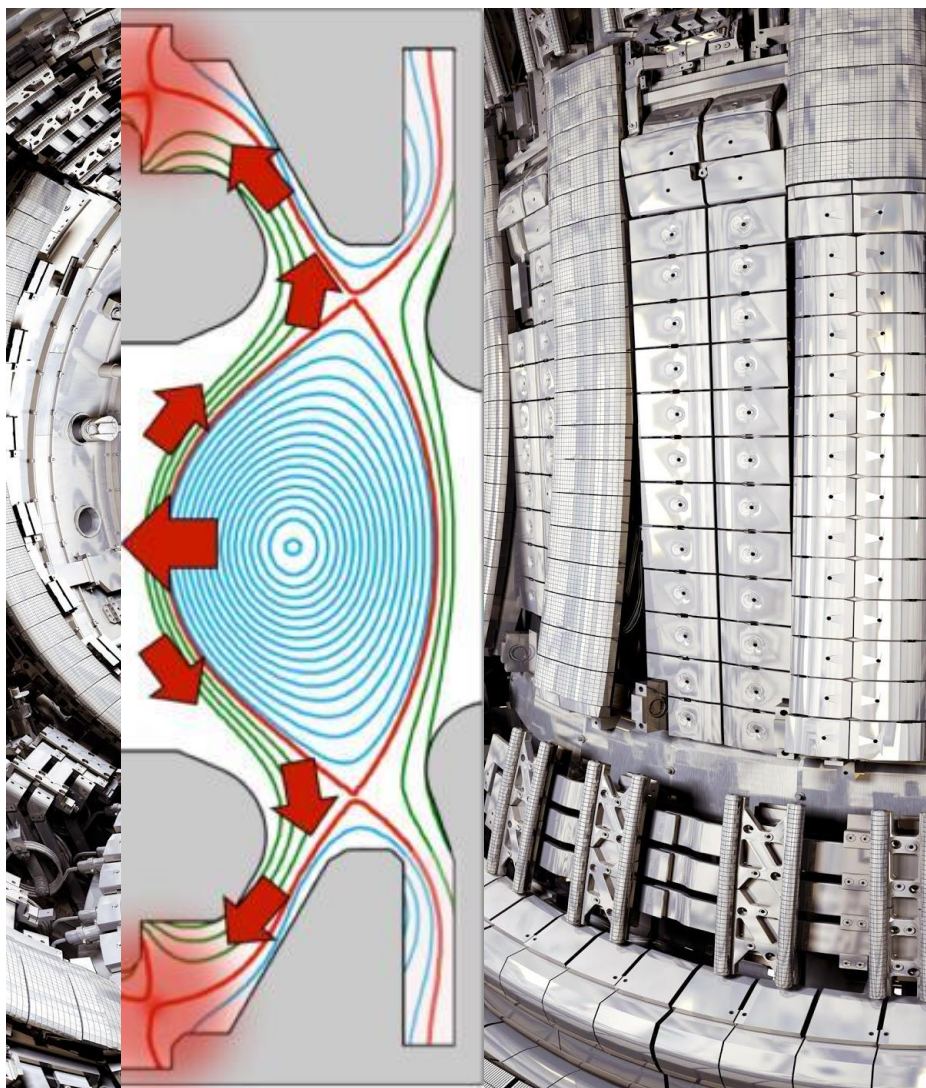






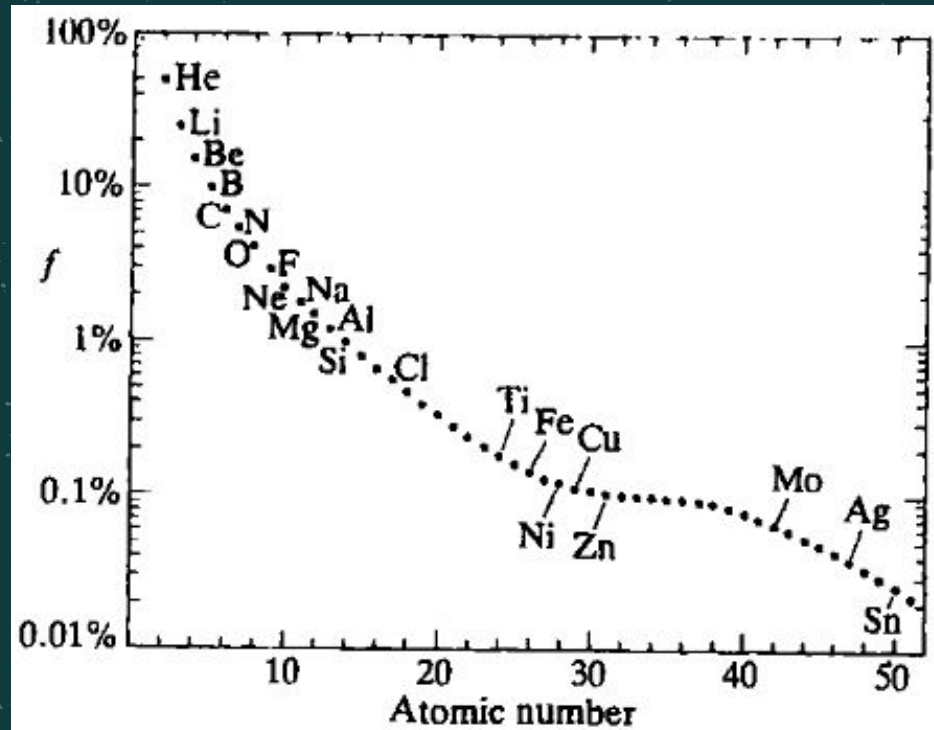






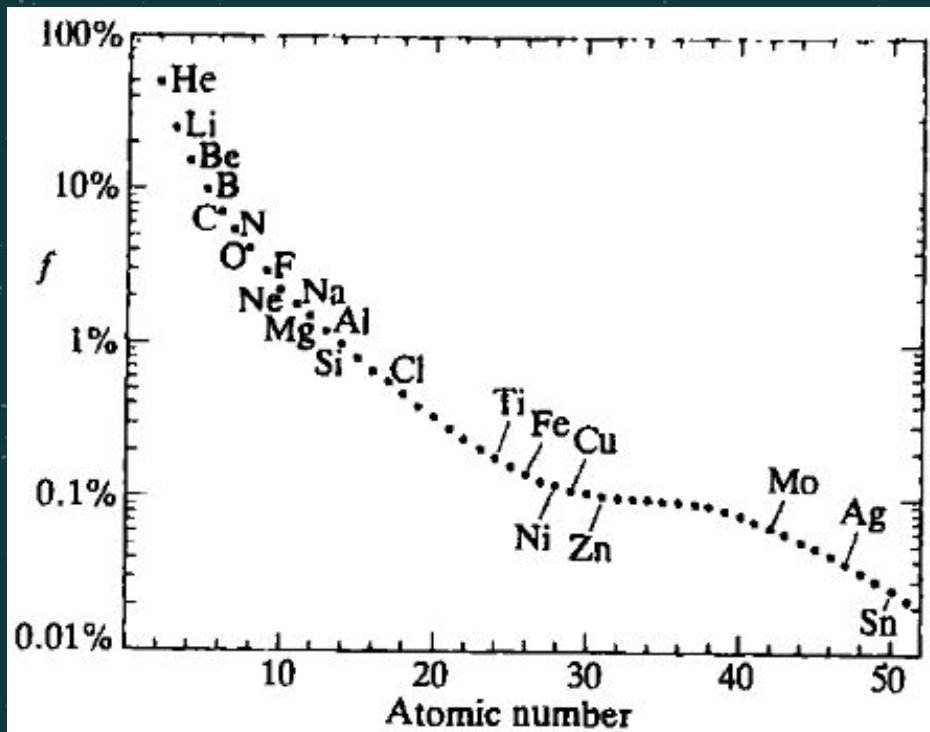
WHY DUST?

- Reduces Fusion Yield



WHY DUST?

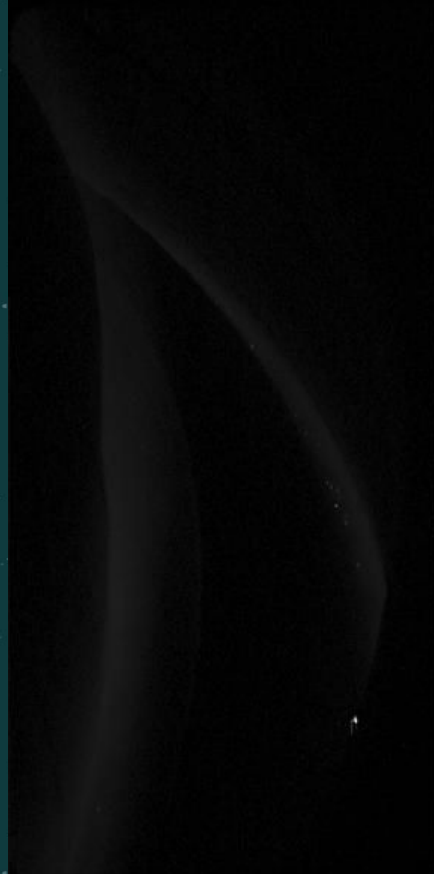
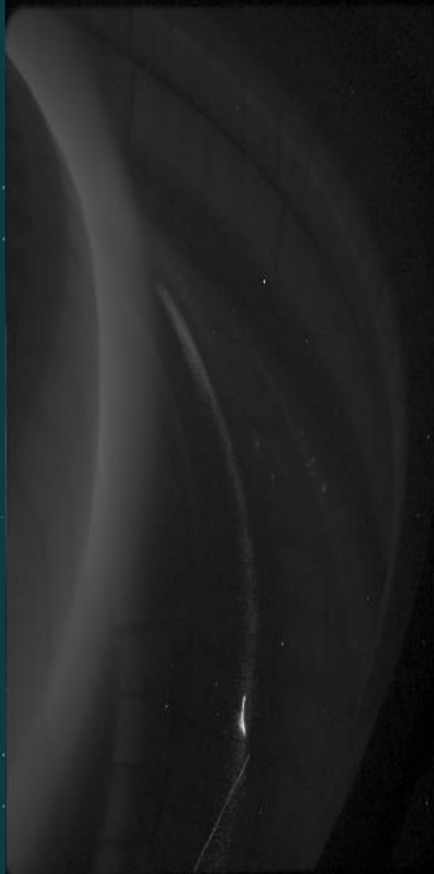
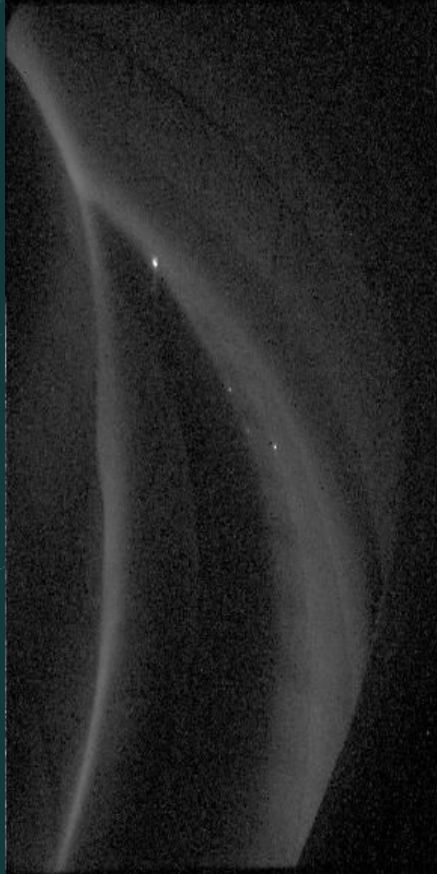
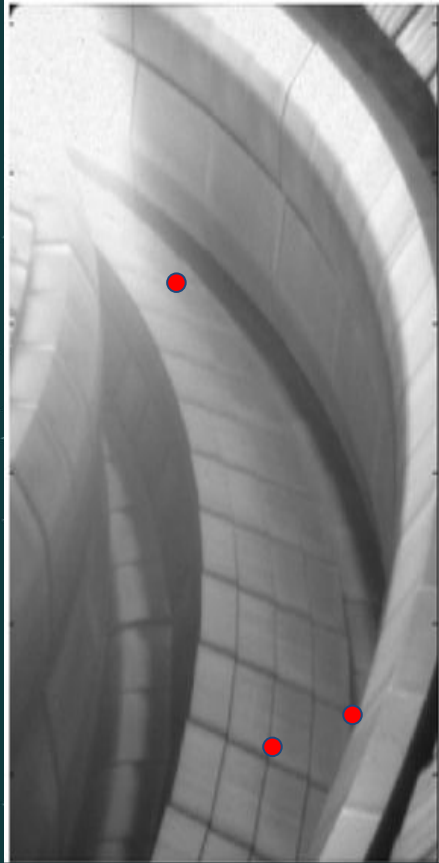
- Reduces Fusion Yield
- Safety Concerns for Radioactive Dust

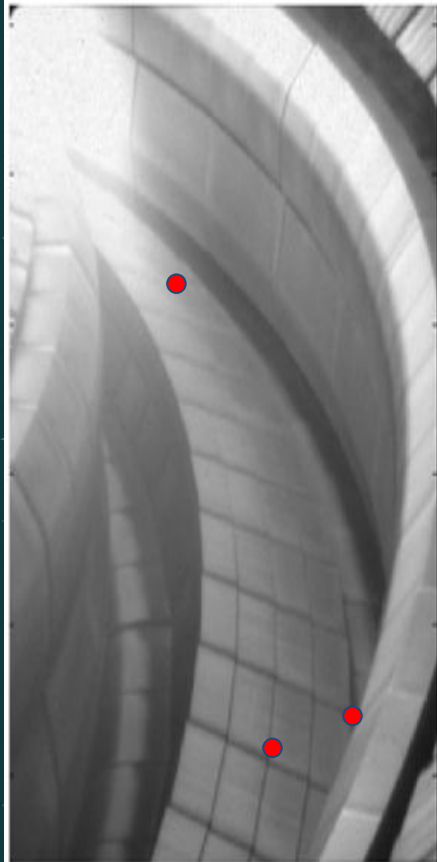


WHY DUST?

- Reduces Fusion Yield
- Safety Concerns for Radioactive Dust
- Toxic Beryllium

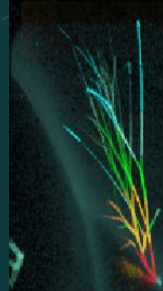






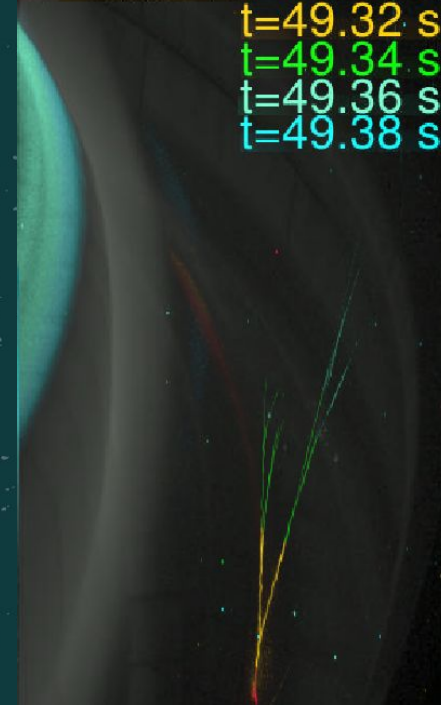
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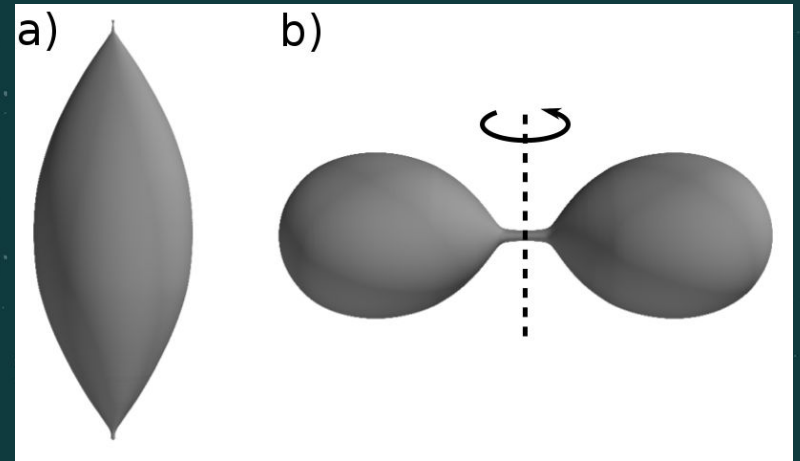
Shot #86124





MODELLING BREAKUP

A. Electrostatic breakup:
Small droplets released



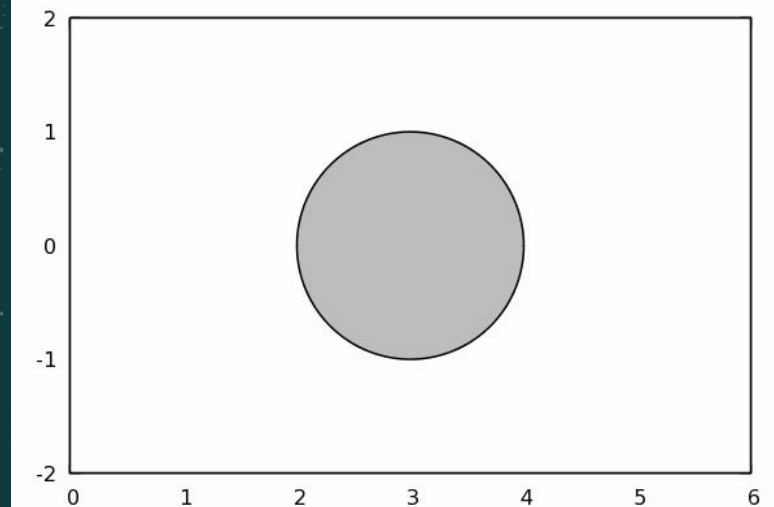
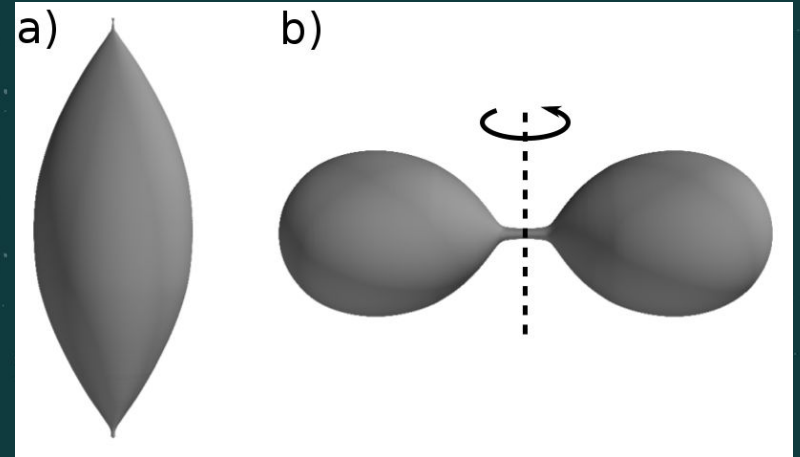
MODELLING BREAKUP

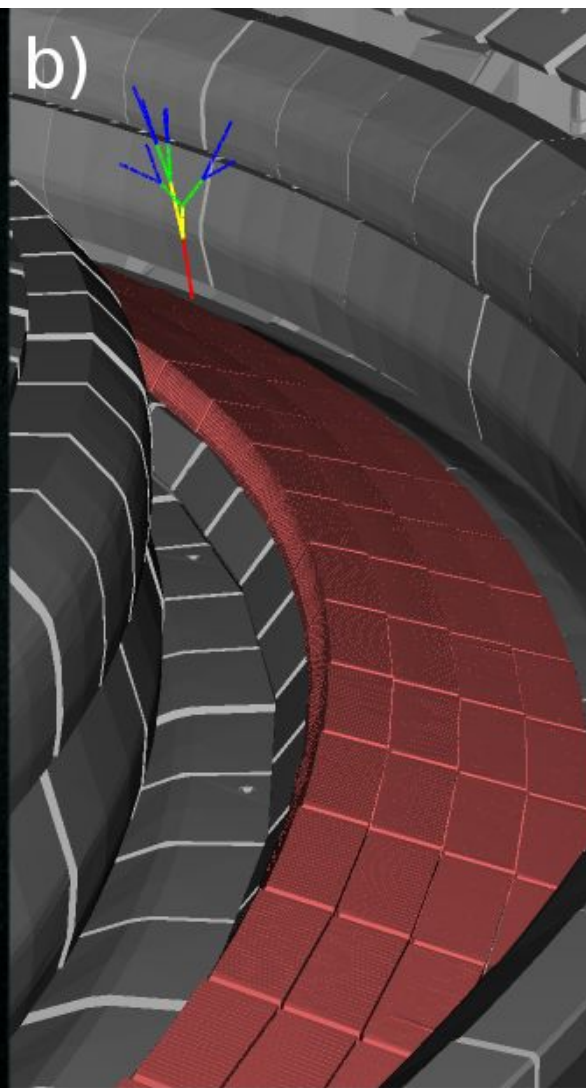
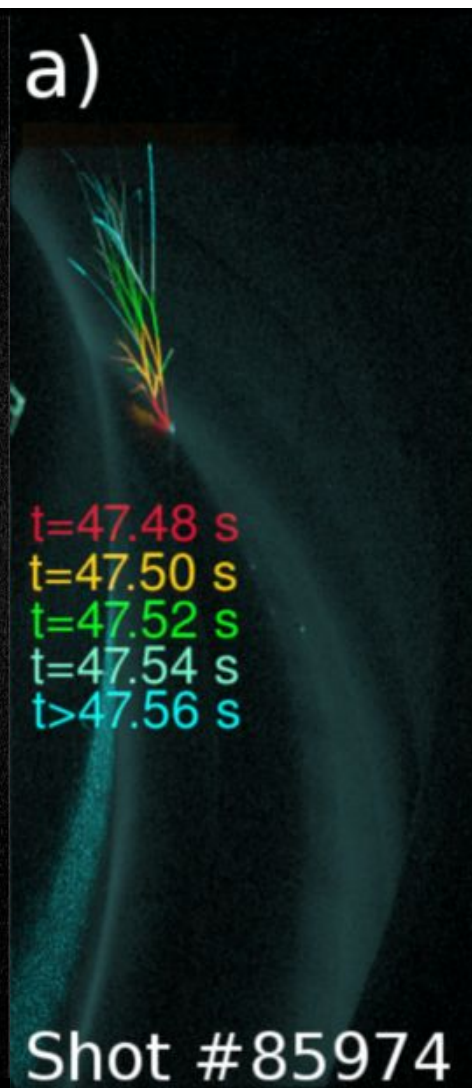
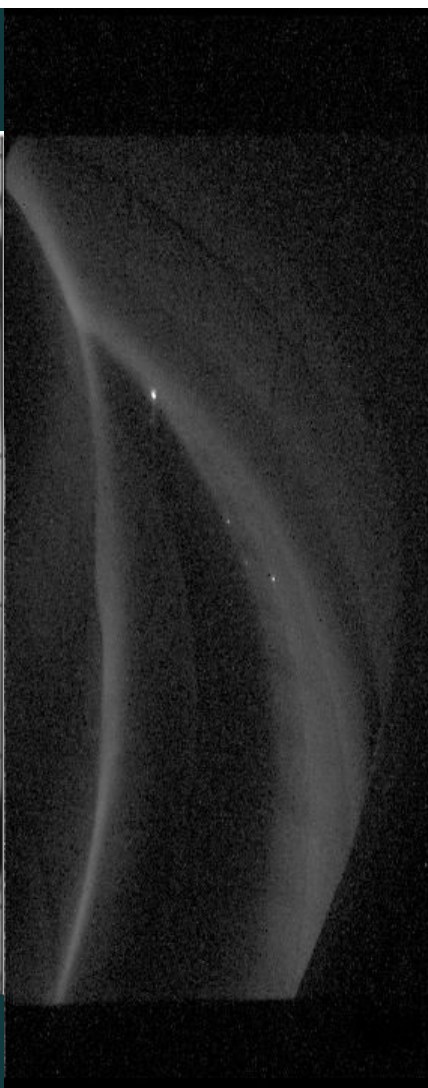
A. Electrostatic breakup:

Small droplets released

B. Rotational breakup:

Re-produces observed behaviour







CONCLUSION

- PhD – Worthwhile opportunity available to many graduates
- Training as an independent researcher and scientist
- Dust dynamics in tokamak plasmas is affected by magnetic fields

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THANKS!

Questions?

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