Doctoral College in Statistical Physics
Leipzig-Lorraine-Lviv-Coventry

From the Ising model to a distant academic world and back

StatPhys, Lviv, July 2019

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The Leverhulme Trust
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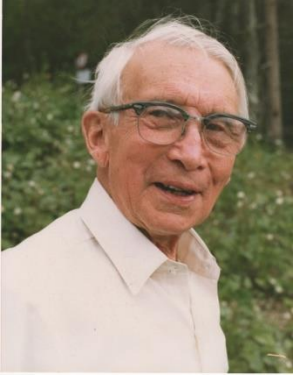
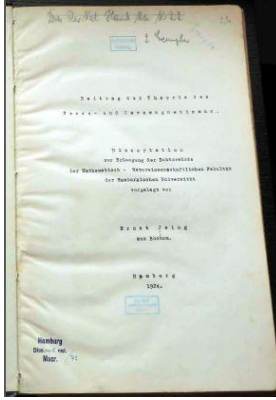
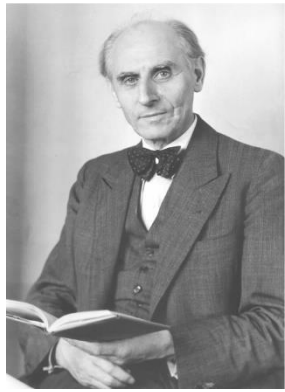


1/5. Ising model



- One of the most important publications for understanding phase transitions = Ising's thesis (1924).

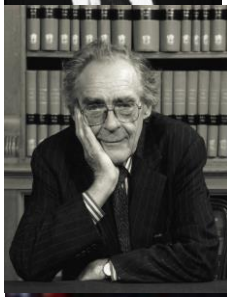
Ising's only paper 1925.



- Wilhelm Lenz had the idea (1920).
- Ising solved it in 1D and showed no phase transition.
- Disappointment.
- Ising => No phase transition in 2D or 3D either.

- But now we know!

Ising model – 1920-2019



- Onsager (Nobel Prize, chemistry, 1968) solved in 2D in 1944.
- 3D remains unsolved.
- Sir John Maddox (Nature Ed 60's-90's) claimed to have solved it in 1952.
- Sorin Istrail (2000) => Is NP complete (computationally intractable)
- Applications – ferromagnetism, condensation and melting, order-disorder transitions in alloys, phase separation in binary solutions, model phenomena in economics, sociology, genetics, the spread of forest fires etc.

Statistical physics

Pistachio trees 'talk' to their neighbours, says physics

The number of nuts on pistachio trees in a given year can be explained by a model from statistical physics normally used to study magnetic materials. So say researchers led by Alan Hastings, a mathematical ecologist from the University of California, Davis, who have used the "Ising model" to analyse the yields of pistachio trees in an orchard in California. Their work explains why

statistics using a 2D Ising model, in which each spin is arranged on a lattice – like the gridded planting of the nut trees – and is either up or down. Neighbouring spins interact with each other via their magnetic moments, but can also be influenced by an external applied magnetic field. For the nut trees, the equivalent variable to the alignment of spins is the productivity: each tree could be in the high- or low-yielding

LGT Capital Partners: News Affects Investors Like a Magnet

Wednesday, 8 May 2019 00:30

Negativity about Ising

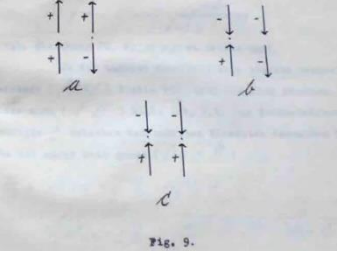
Ising's solution is sometimes trivialised:

Barry Simon (Chapter 1, The Statistical Mechanics of Lattice Gases, 2014):

"It is ironic that on the basis of an elementary calculation and erroneous conclusion, Ising's name has become among the most commonly mentioned in the theoretical physics literature. But history has had its revenge. Ising's name, …".

Andrea Taroni (Chief Editor, Nature Physics, 2015):

Ising's result is "trivial" and are "spectacularly wrong" in 2D & 3d.



Context:

- All these models oversimplified.

- Before Ising model, was not known how macroscopic magnetization could emerge from interactions between elementary magnets.

- First citation in Ising's thesis is to **Richard Kirwan** (Galway, Ireland, 1733–1812).

- for the idea that magnetons in a solid are randomly arranged leading to zero mean magnetization

- **Keep him in mind – we return to him later…**

- So- poor reception and no citations until 1939 (15 years!).

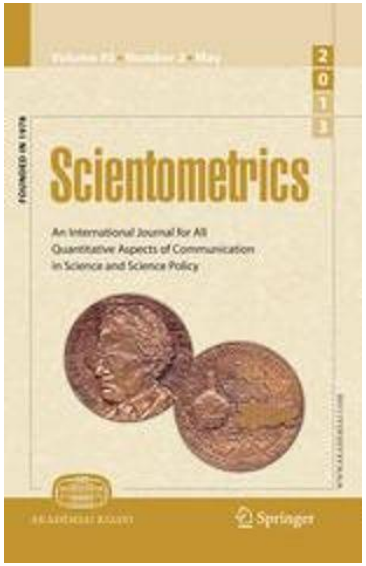
- **Cf Andrij Trokhymchuk talk yesterday.**

2/5:

So how good is a scientific work?

From Ising model to scientometrics

90% of All the Scientists That Ever Lived Are Alive Today.



=> *Scientometrics:*

Opinion of Ising: “trivial”

Citations for Ising: None for 15 years.

How do opinions and citations compare?

Peer review – the UK’s Research Evaluation framework.

Scientometrics – based on citation counts.

REF – Peer review on national scale (UK)

- The REF (Research Excellence Framework) is carried out in the UK about every 7 years.

- These use peer review to measure the quality of research carried out in different departments in different disciplines in different universities.

- Departments have different sizes.

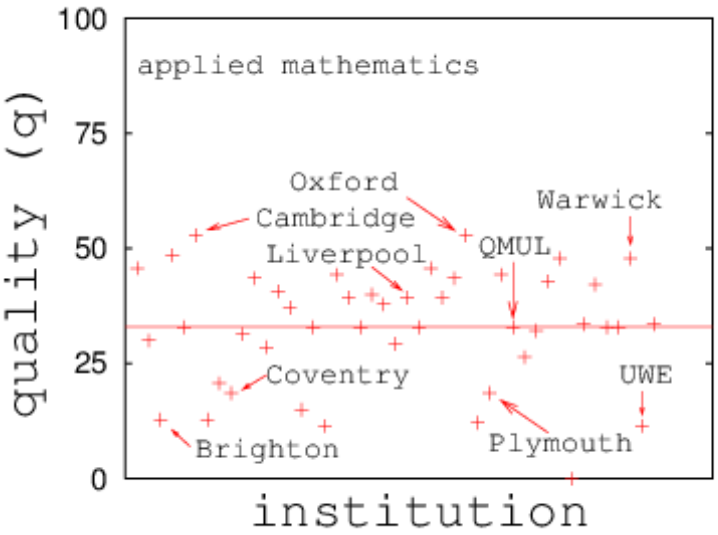
E.g., in 2008 there were 67 disciplines.

Applied Maths (incl theoretical physics) was one.

Coventry University submitted **7 staff** in Applied Maths.

Oxford University submitted **54 staff.**

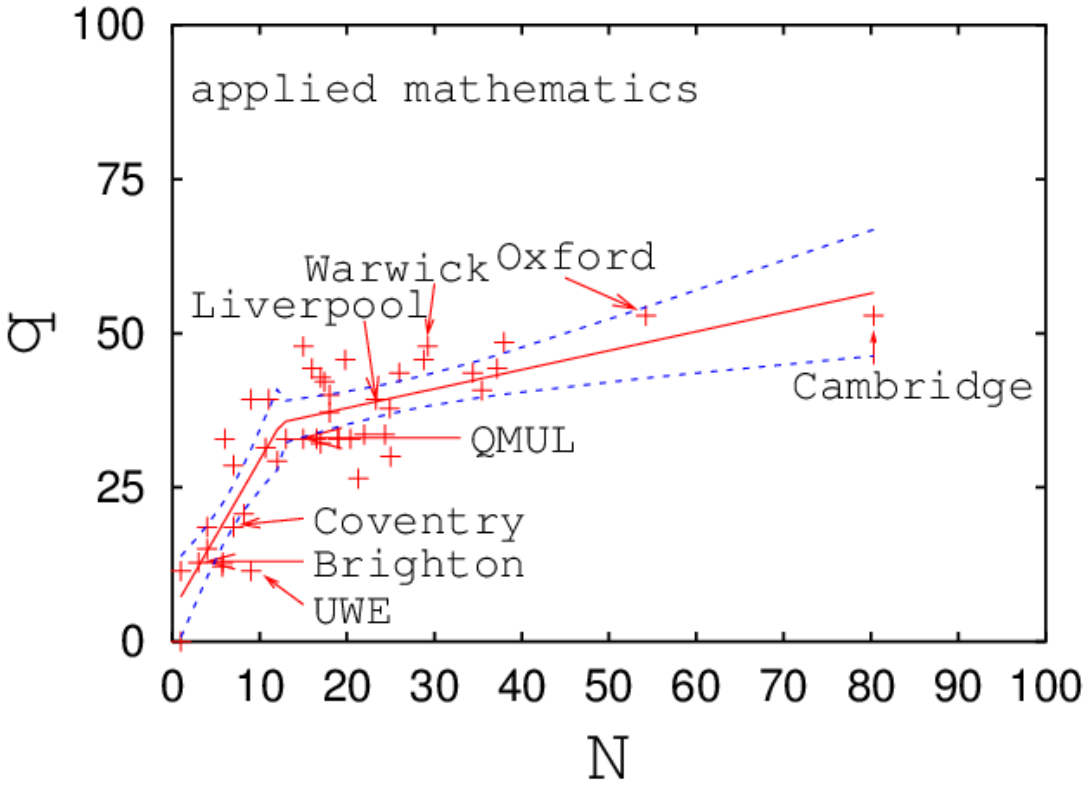
Results in Applied Maths in 2008



This is the basis for league tables and rankings.

Cf welcome speech yesterday (Lviv Poly #4 in Ukraine).

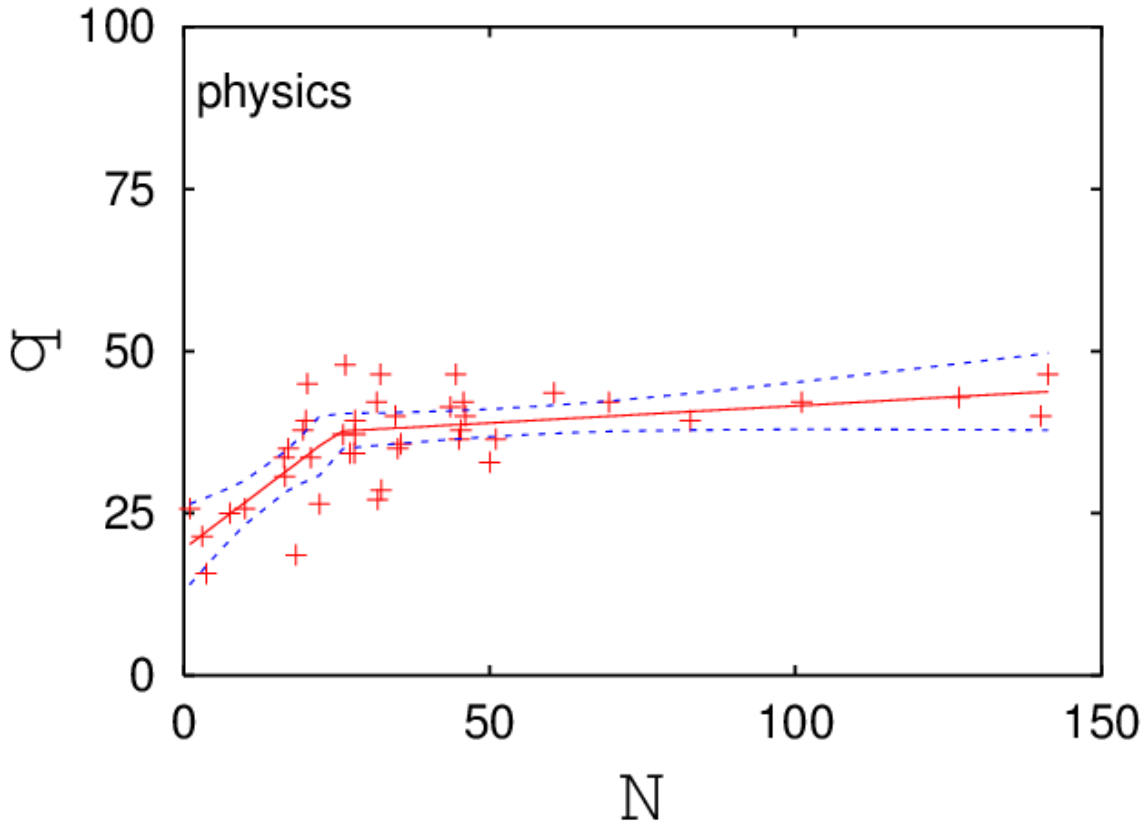
But lets now plot peer review measures of quality versus department size:



There is a structure!

Why is the graph this shape?

Similar for physics



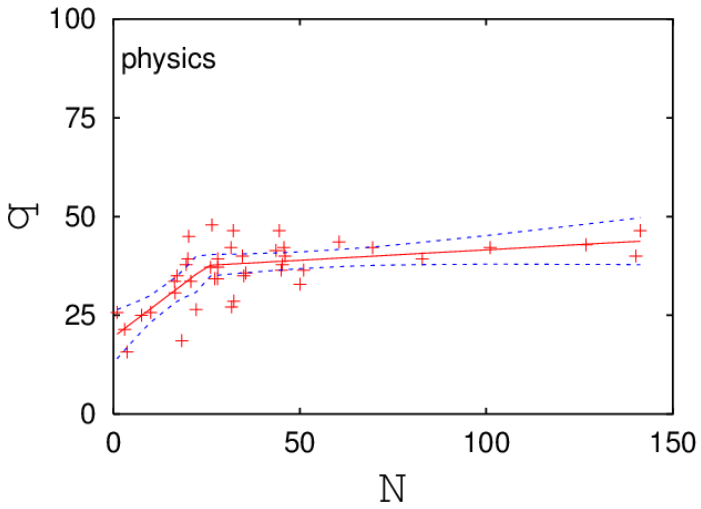
Similar for many other disciplines – universality!

We built a mathematical model.

It explains the “breakpoint” observed in the figure.

It all hinges on the interactions

Between researchers.



If you have 10 researchers, everyone has 9 potential interactions.

(10x19/2 = 95 potential links.)

If you have 100 researchers everyone has potentially 99! (4950 links)

Interactions are the prime drivers of group research strength!

But what about citation counts?

Does peer review correlate with citation counts ?

There was enormous pressure in the UK to use metrics

- to save money
- to save time
- to put even more control in the hands of managers

There are many different types… Amongst these are

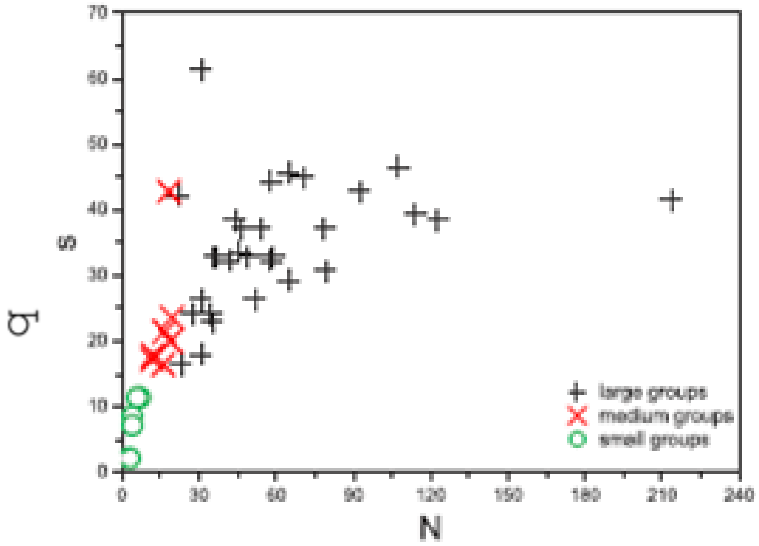
- Thompson Reuter's *normalised citation impact*
- *The h-index,* suggested in 2005 by Jorge Hirsch (initially for theoretical physics)

- 2013/2014 we investigated these and how they compare to peer review.

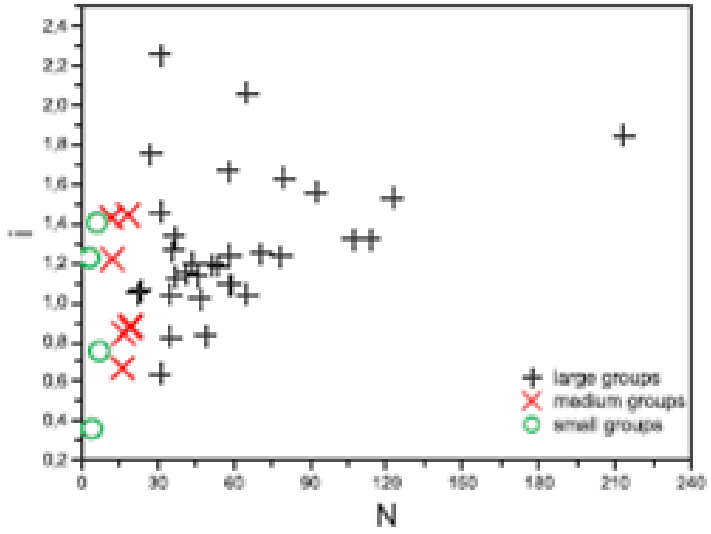
At first sight they might look OK.

E.g., compare peer-review measures against metrics for biology :

(we use Thompson Reuter's *normalised citation impact*)

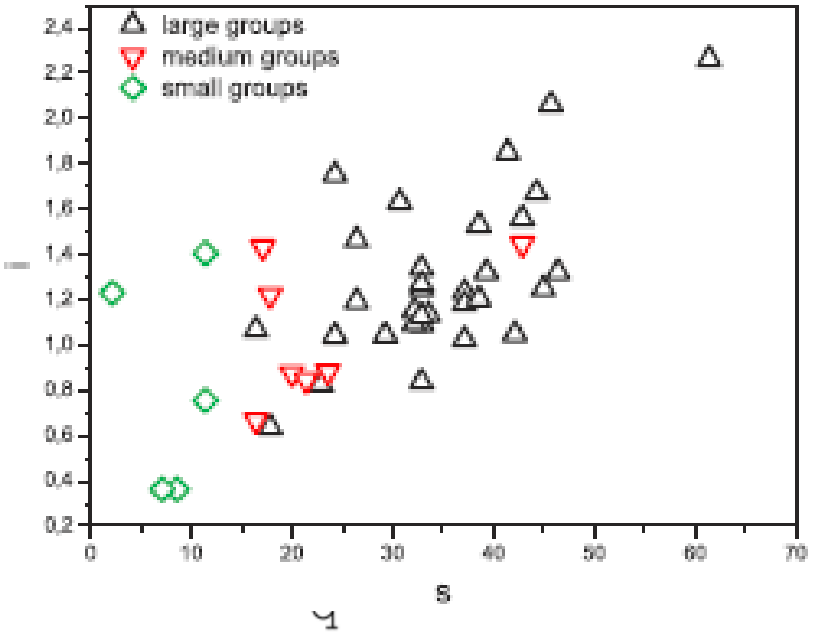


Peer review



Scientometrics

But closer examination shows poor correlation:



Scientometrics vs peer-review measures of “quality”.

The correlation coefficient is only about 60%.

Worse for small groups and best for large.

We used citations to predict peer-review outcomes In 2014 (using h-index).

Results were very poor.

We published that in 2015.

Metrics failed to predict REF outcomes

2 April 2015 Maria Burke

Like 2 Tweet G+1 0 Share 7

A team of mathematicians who used metrics to **predict the outcomes of the UK's national assessment of research in 2014** have reported that their results were 'wildly inaccurate'. The Research Excellence Framework (REF) relies on peer review, and some have claimed using metrics, such as citations, would be simpler and cheaper. But university managers would get more accurate predictions by tossing a coin, the researchers claim.

The researchers said tossing a coin would produce more accurate predictions © Shutterstock

Ralph Kenna and colleagues at the Applied Mathematics Research Centre at Coventry University, UK, used a measure called the departmental Hirsch index, or departmental h-index, to predict REF 2014 outcomes. This attempts to measure the productivity and citation impact of a department. They looked at groups in biology (31), chemistry (29), physics (32) and sociology (25), but **their predictions did not come close to either overall REF outcomes**, or how institutions moved in the rankings relative to 2008's exercise.

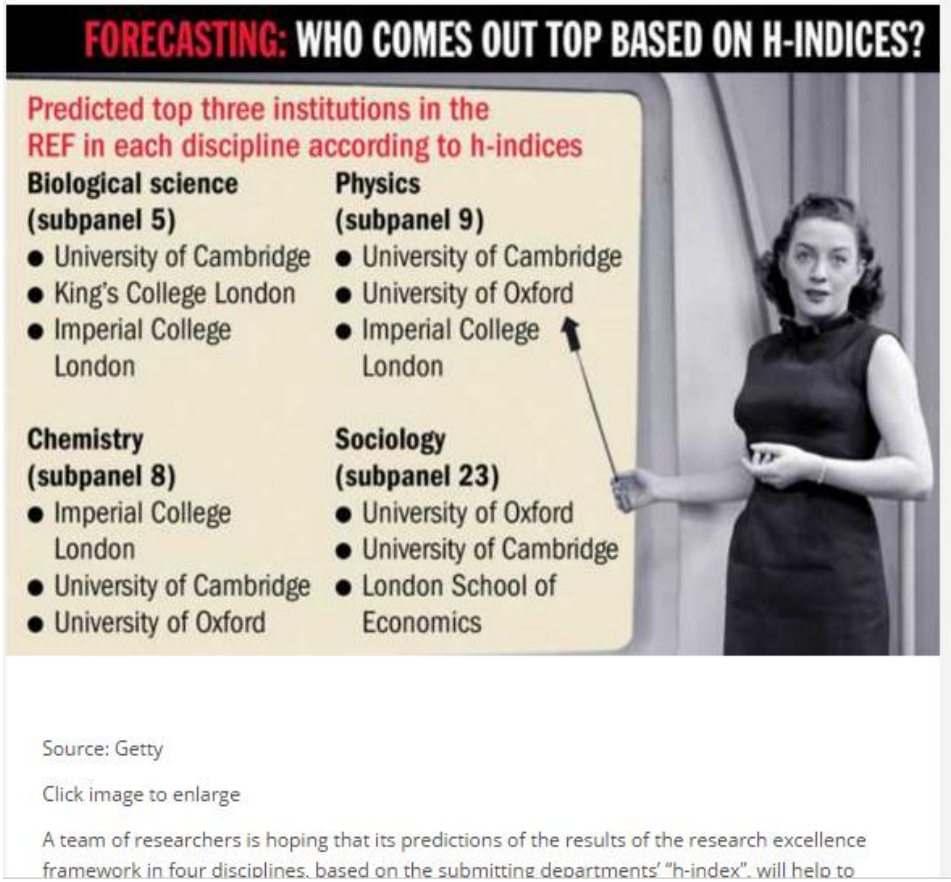
'We found that the h-index is quite useless as a tool for predicting REF results,' says Kenna. 'Our recommendation is to forget about metrics as a proxy to REF.'

The (predicted) results for the 2014 REF are in

Research team hopes that predictions will help to clarify the value of metrics in assessment

November 27, 2014

By Paul Jump Twitter: @Pauljump

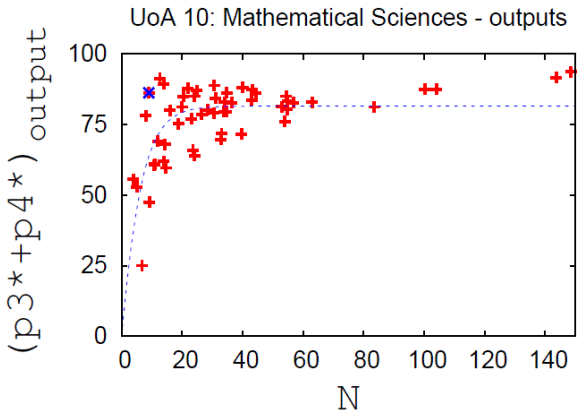


Source: Getty

Click image to enlarge

A team of researchers is hoping that its predictions of the results of the research excellence framework in four disciplines, based on the submitting departments' "h-index", will help to

Impact of our work:



Our group grew (and is growing).

We "had a massive impact on UK“ (external review, 2019).

In 2015, the Report of the Independent Review of the Role of Metrics in Research Assessment and Management” was published.

“The Metric Tide” quotes & cites us heavily.

It was very firmly against the use of metrics.

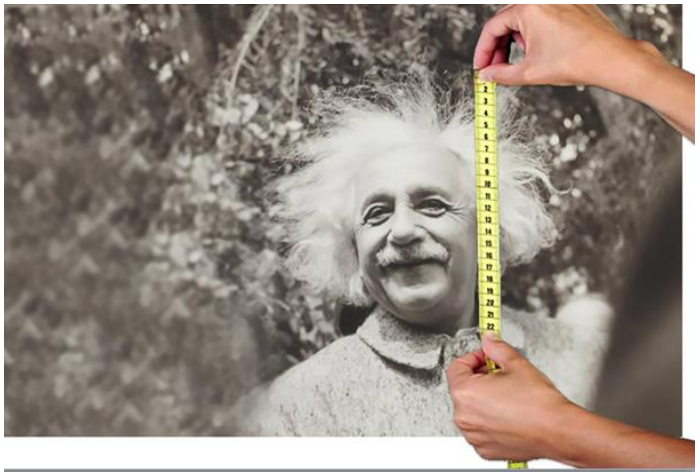
REF2021 does not use metrics!

King Canute Rebukes His Courtiers

Conclusions

If metrics tell us anything, they do not tell us about expert opinion of quality.

If peer review tells us anything, it does not tell us about academic impact.



They’re even worse at small or individual levels. – e.g. Ising

3/5. Back to the Ising model:

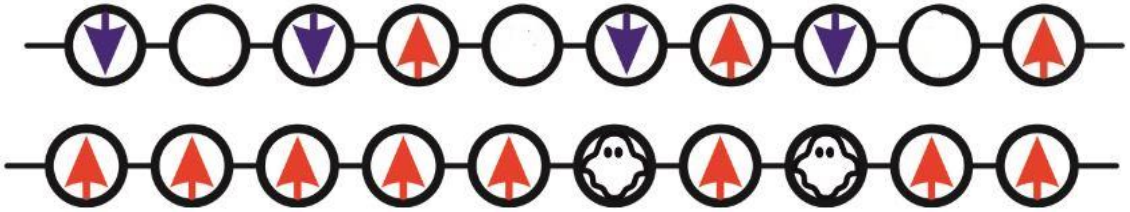
So why is there no phase transition in 1D?

No-go theorems…

The essence of no-go arguments is that the entropy excess in 1D systems relative to interaction energy scuppers the balance needed.

So… let's add more entropy!

We add "invisible states"



Then we remove them.

Negative number of invisible states!

It is magnetised!

Lenz & Ising were right!

A negative number of invis states would have countered negativity!

Is this real?

Er… yes…

Petro Sarkanych

Complex magnetic fields and negative numbers of invisible states are linked mathematically through a duality relation.

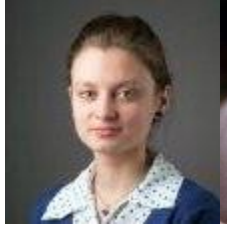
The “ghost states” can be manifest through complex magnetic fields which, after 60 years of theory, were experimentally realised in 2015.

Note that Onsager’s solution of the Ising model in 2D was experimentally verified in 2017.

A realisation of complex magnetic fields through attachment of a quantum probes was proposed in 2015.

Cf Volodymyr Tkachuk talk yesterday.

Mariana Krasnytska got the prize as well!



Ising model on annealed complex networks with degree distribution decaying algebraically $p \sim k^{-\lambda}$(scale free).

Second-order phase transition at finite temperature if $\lambda > 3$

λ is like dimension.

Lee-Yang zeros theorem holds for $\lambda > 5$ (mean field).

But it fails for $\lambda < 5$ (like low dimensions).

Why?

Go to the Scottish café

and look in Scottish book!

Scale free networks important in socio-systems.

But what is that to do with physics?

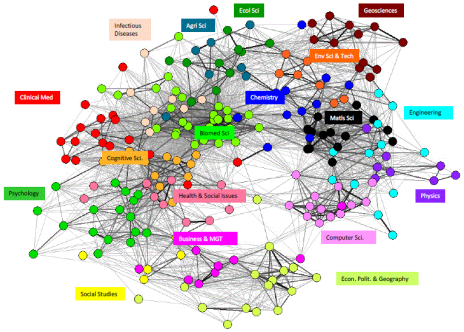
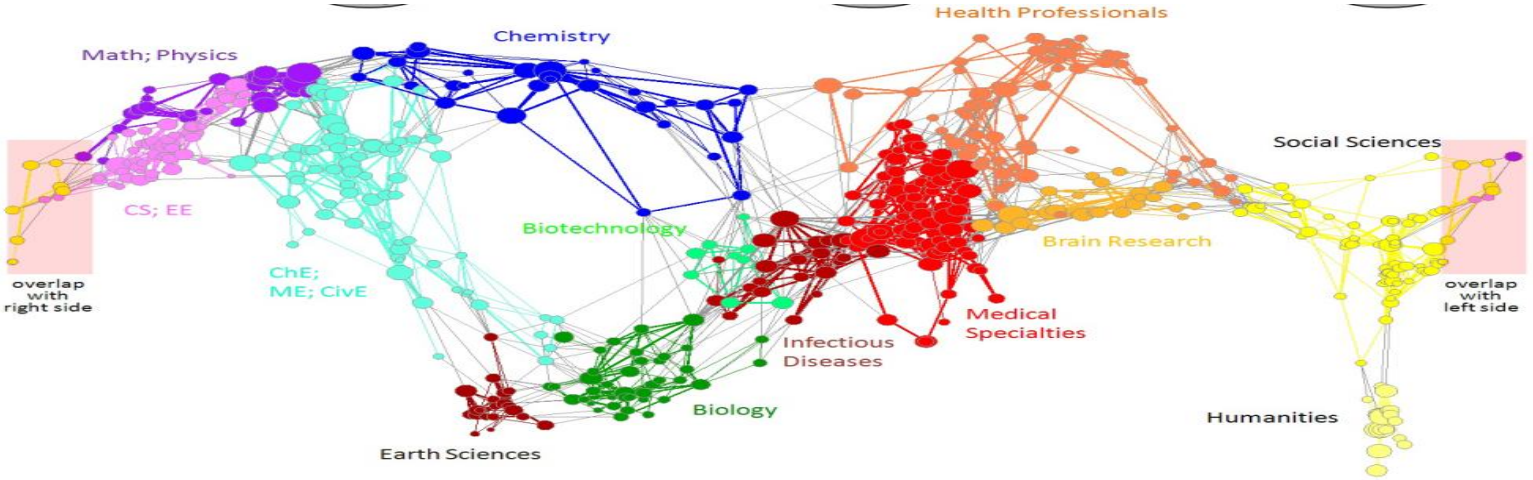


Figure 1. The global map of science, illustrating the cognitive distance between disciplines. Source: Rafols, Porter and Leydesdorff (2010).



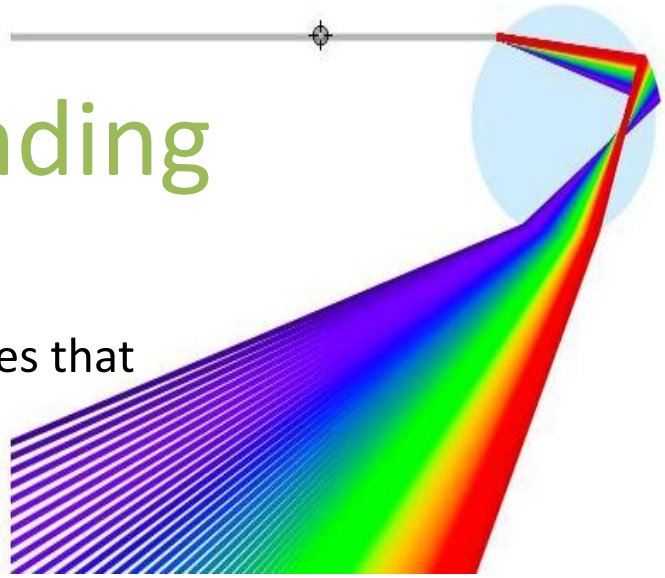
So let's explore "the far side"…

But would they welcome us?

4/5: Charting the far side….

Here be dragons. . .

Mistrust/Misunderstanding



19th Century - John Keats poem *Lamia* (1819) argues that the new sciences of physics and chemistry might "unweave the rainbow."

20th Century - "The humanities need to be defended today against the encroachments of physical science."
– Irving Babbitt (Critic and Professor of French Literature, died 1933)

21st Century – "Humanities aren't a science. Stop treating them like one."
By Maria Konnikova (Russian-American writer & journalist) in a New Scientist blog, August 10, 2012

Objections Typical criticisms are along lines of

- Humans (characters) are not numbers
- True, <u>but some questions are</u>: Referendums (Brexit)

- The approach neglect details
- True, but the planets are more complicated than simple points, yet Kepler's laws are correct.
  Of course, a geographer cannot simplify like this! (Stauffer, 2004)
  <u>The same model may be good for some purposes and bad for others.</u>

- Physicists don't know what they're doing
- "If we knew what it was we were doing, it would not be called research, would it?" -**Albert Einstein**

We don't know the questions but we may help point to some answers.

This is why we need to collaborate!

Objections by physicists

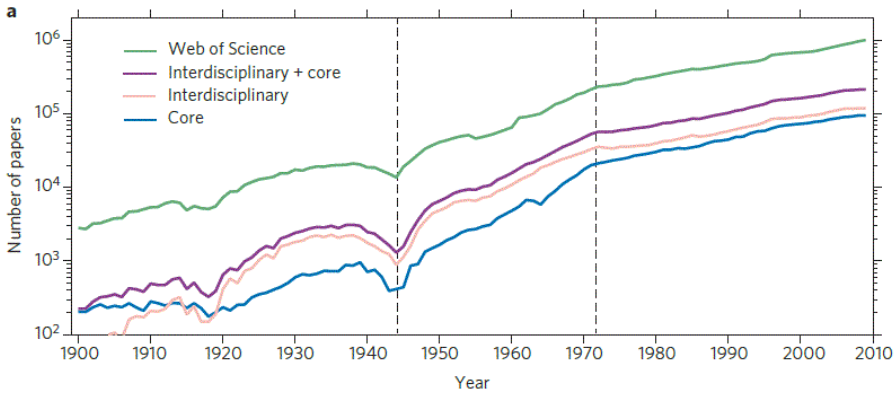
- Serge Galam's first paper (1980) was initially confiscated by his Head of Dept!
- Some think this is not physics!

What is physics?

IOP: "physics is about asking fundamental questions and trying to answer them by observing and experimenting."

Sam Edwards (condensed matter physicist): "Physics is what physicists do".

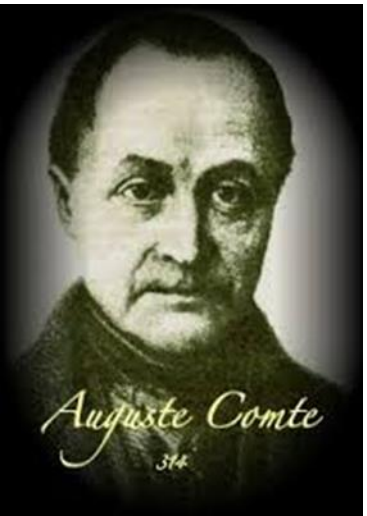
Sinatra et al (2015) Growth is exponential and "publishing outside core integral to developing physics".



Remember Steven Hawking

"I think the next century will be the century of complexity."

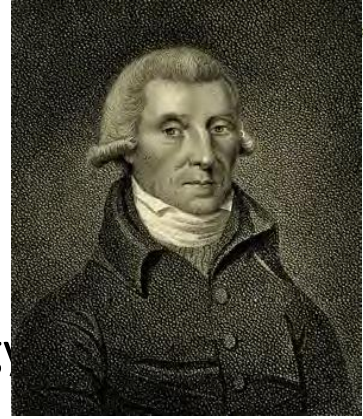
Steven Hawking, 2000



"Now that the human mind has grasped celestial and terrestrial physics, …there remains one science … social physics. This is what men have now most need of."

Auguste Compte, 1856

Remember Richard Kirwan



Published in mineralogy, geology, and meteorology, epistemology linguistics and comparative mythology!

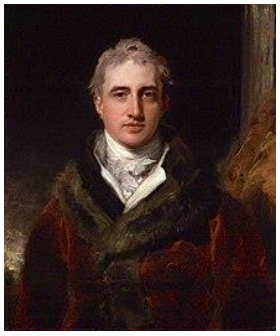
("dismissed as the product of Kirwan's dotage" by historians.)

Believed to have joined United Irishmen in 1790's (rebellion!)

Declined peerage offered by Lord Castlereagh.

"I met Murder on the way-- He had a mask like Castlereagh–
Very smooth he looked, yet grim; Seven blood-hounds followed him."

Percy Bysshe Shelley 1819
following the Peterloo massacre
(Manchester)



5/5 – The final step to the far side… cultural misappropriation




Controversy: *The Epic Poems of Ossian*

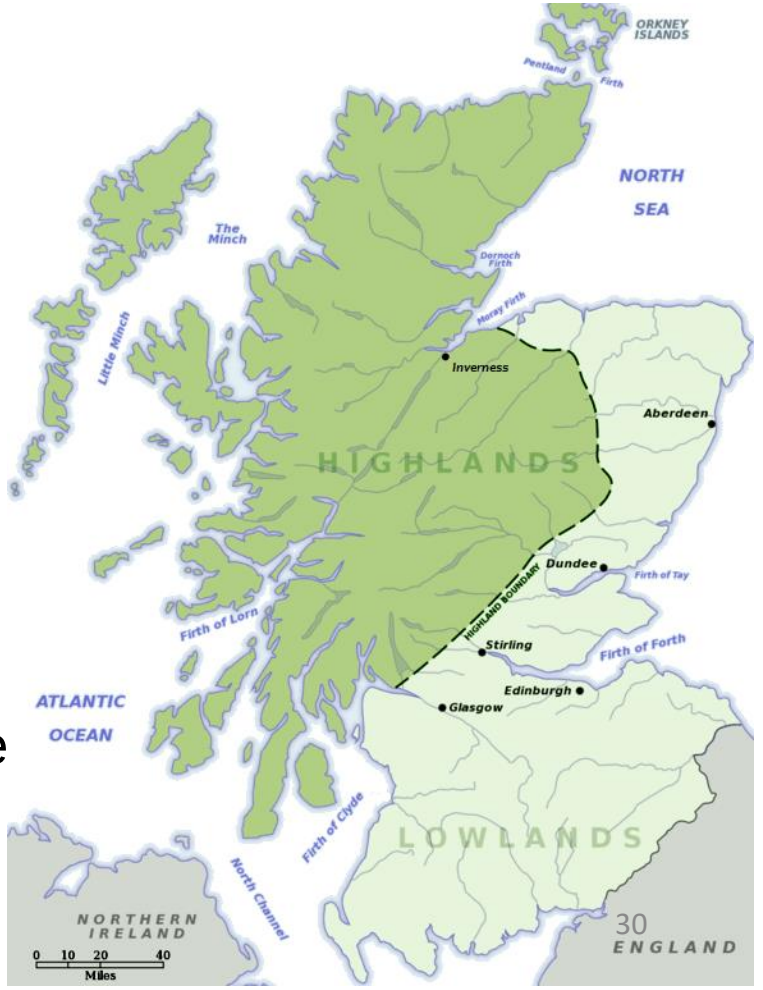
Ossian's Dream, Jean Auguste Dominique Ingres, 1813

The Background

- 1746: Battle of Culloden, Scotland.

- 1760: James Macpherson published *Fragments of Ancient Poetry, Collected in the Highlands of Scotland, and Translated from the Galic or Erse Language*

- Rhythmic prose and sparse diction created an ethereal atmosphere which captured the interest of a receptive public.



The Background

- 1760, 1761: Expedition to Highlands & Islands delivered

  Fingal: An Ancient Epic Poem in Six Books, Together with several Other Poems composed by Ossian the Son of Fingal

"[illegible]"

Fragments of Ancient Poetry

[illegible]

HIGHLANDS OF SCOTLAND

[illegible]

Gaelic or Erse Language.

1760

[illegible]

JAMES MACPHERSON

[illegible]

PRIVATELY PRINTED FOR THE ANDERSTON SOCIETY,
EDINBURGH.
1760.

- 1763: *Temora: An Ancient Epic Poem in Eight Books…*

Taras Shevchenko in Lviv

Reception was enormously positive:

- **Literature:** Blake, Byron, Coleridge, Goethe, Scott, Shevchenko, Wordsworth, …
- **Music**: Brahms, Mendelssohn, Schubert, …
- **Art:** Abildgaard, Gérard, Girodet, Ingres, Kauffmann, Krafft, Runge
- Thomas Jefferson stated that Ossian was "the greatest poet that has ever existed"

Prompted other nations to look at their ancient literature

Comparison with Classics was immediate (e.g., Hugh Blair):

Ossian = "Homer of the North"

Hugh Blair

Madame de Staël

- However…Samuel Johnson was not happy.

  "strong temptation to deceit"

- But… Johnson viewed Gaelic as

  "the rude speech of barbarous people"

- During the Imperial Era, British scholars and administrators aligned their attitudes towards classical history with imperialist ideologies.

- They thought they carried the "torch of civilization".

- Thus conflict was …

Scotland vs England

Romanticism vs Classicism

Nationalism vs Imperialism

- Reaction in Ireland was outrage!

Charles Ó Connor

Sylvester O'Halloran

Ossianic poems were corruptions of the tales of the Fenian Cycle of Irish mythology.

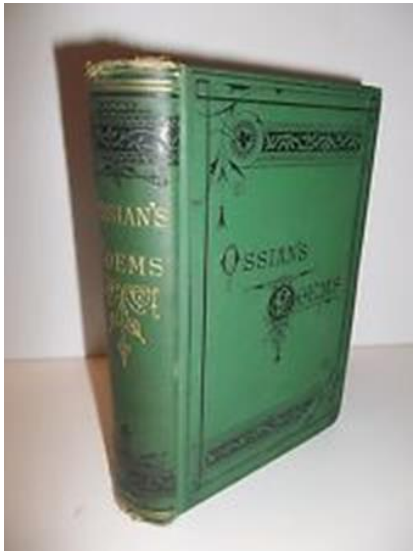
Thinly veiled characters, places, and situations from the Irish epic tradition were identified.

Macpherson	Irish Mythology
Ossian = "an illiterate Bard of an illiterate Age"	Oisín = warrior poet of the Fenian cycle
Fingal (Ossian's father) = 3rd century Scottish king	Finn MacCumhail = Leader of the Fianna Éireann (warrior band)
Cuchullin ="the General or Chief of the Irish tribes"	Cúchulainn, boy hero of Ulster cycle

Misappropriation of Ireland's Gaelic heroes for Scotland

=> **"imposture"**

- **So… is Ossian the “Homer of the North” or an “imposture”?**

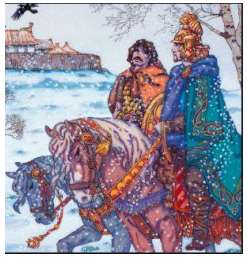


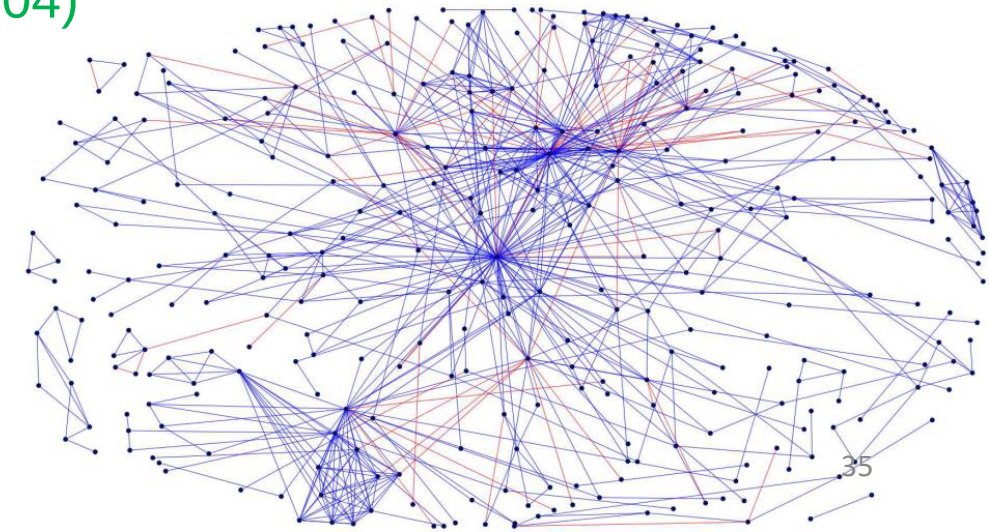
- Lets look at the networks

- We examine:
  - *Ossian*
  - *The Iliad*
  - *The Odyssey*
  - *Acallam na Senórach (Colloquy of the Ancients)*
  - A text by Lady Gregory (1904)


Achilles


Ossian


Oisín



- We looked at the network statistics…

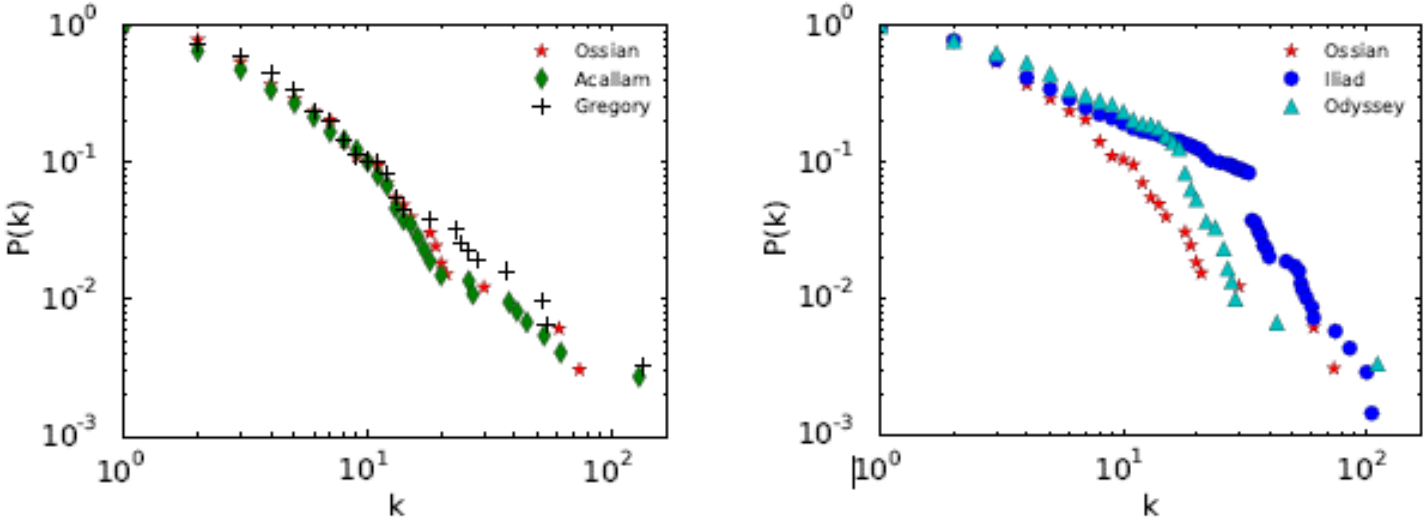
	Narrative	N	M	$\langle k \rangle$	ℓ	ℓ_{rand}	C	C_{rand}	C_T	r	Δ	G_c
Full	*Ossian*	325	748	4.60	3.62	3.91	0.49	0.01	0.27	-0.08	0.95	88.62%
	Acallam	732	1606	4.39	3.79	4.57	0.37	0.01	0.19	-0.10	0.97	76.91%
	Gregory	355	913	5.14	3.10	3.73	0.44	0.01	0.16	-0.18	0.97	94.65%
	Iliad	694	2684	7.74	3.49	3.42	0.44	0.01	0.45	-0.08	0.98	99.42%
	Odyssey	301	1019	6.77	3.29	3.18	0.45	0.02	0.38	-0.08	0.97	98.34%
Positive	*Ossian*	309	666	4.31	3.65	4.03	0.42	0.01	0.31	-0.06		82.20%
	Acallam	722	1513	4.19	3.72	4.69	0.38	0.01	0.20	-0.09		71.33%
	Gregory	337	833	4.94	3.23	3.78	0.45	0.01	0.18	-0.17		91.99%
	Iliad	640	2329	7.28	3.80	3.47	0.44	0.01	0.58	0.02		85.94%
	Odyssey	299	989	6.62	3.42	3.21	0.45	0.02	0.40	-0.08		97.32%
Negative	*Ossian*	87	82	1.89	5.30	6.61	0.00	0.02	0.00	-0.31		70.11%
	Acallam	86	93	2.16	2.32	5.53	0.00	0.00	0.00	-0.30		24.42%
	Gregory	95	80	1.68	4.75	8.13	0.00	0.01	0.00	-0.30		45.26%
	Iliad	321	355	2.21	4.46	7.00	0.00	0.00	0.00	-0.45		90.34%
	Odyssey	41	30	1.46	1.88	8.74	0.00	0.04	0.00	-0.18		26.83%

- But we don't discern much…

- The full networks are similar to the positive one

- And they are all structurally balanced small worlds with non-trivial topologies and large proportions of nodes belong to their giant components (universal properties).

Compare Degree Distributions → CONCLUSION



- Bottom Line: Ossian is like the Irish texts. It is not like the Classics.

- We perform various statistical tests to confirm this – fitting to degree distributions, Kolmogorov-Smirnov comparisons and measuring spectral distances (details on request).

So how could Macpherson have done it?




- We imagine a sparsification process as follows:

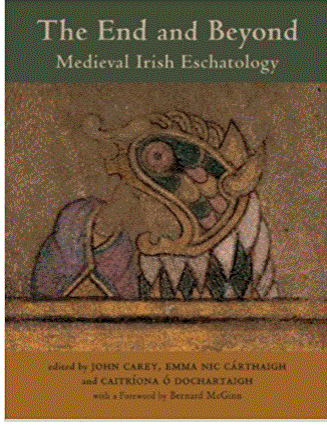
- *Acallam* has 732 nodes & 1606 edges (515 & 1364 in GC)
- *Ossian* has 325 nodes & 748 edges (254 & 596 in GC)
- Try to sparsify Acallam to get something like *Ossian*

- We need a method to sparsify without fragmenting.

- We're investigating this now.

- Then simplicial complexes

- So this feeds back into network theory



The End (nearly)

A criticism (rarely given) of digital humanities is that it brings little new; merely confirming knowledge already gained from traditional approaches to humanities.

The rebuttal is that agreement is precisely what one would expect from a new approach which is valid and still evolving.

Ossian illustrates that.

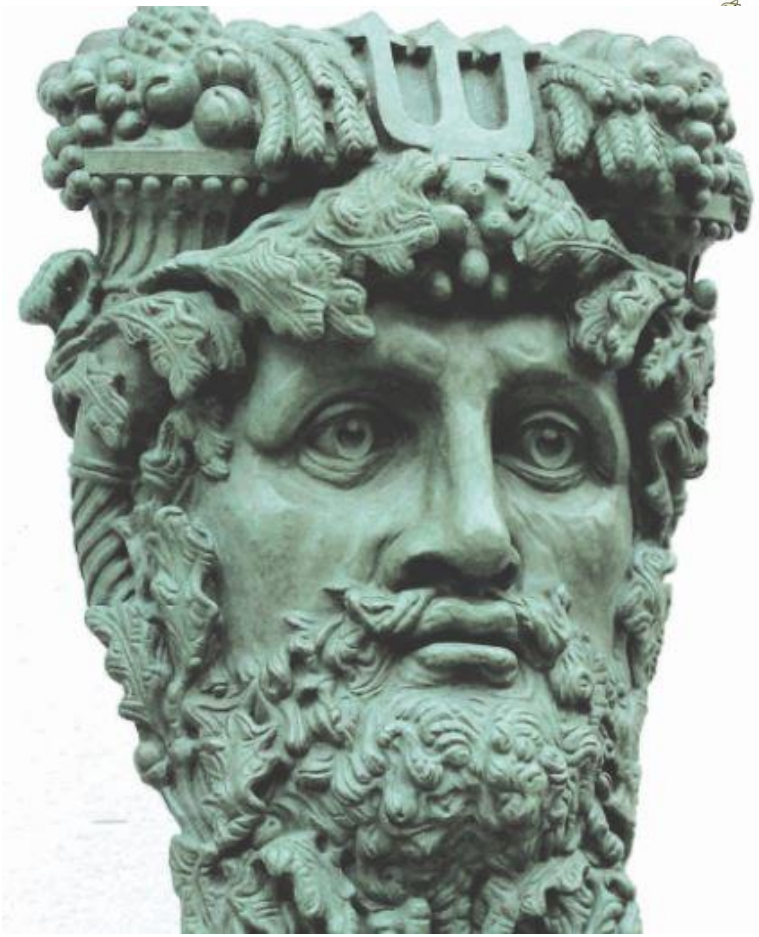
We have since developed further and gave new answers on the Viking age in Ireland.

(Another talk, another time…)

What next – and how to come back?

- We're writing a book/paper about Ising history (2020)
- We're writing interdisciplinarity in MECO (2020)
- We're writing about Bylyny (2019)
- We're writing about odd citation patterns etc. (2019)
- We're investigating gender networks in early medieval narratives (2020)
- We are doing "physicsy" physics as well (forever)
- Jozef Sznajd knows how to come back – next talk
- I don't… yet; cf the statue saga….

Cultural eclipse in Athlone



Goddess → God (Gender misappropriation)
People → Profit (Custom House)
Irish mythology → Fake (Cultural imperialism).

Based upon:
J. Yose, R. Kenna, P. MacCarron, T. Platini & J. Tonra, *A Networks-Science Investigation into the Epic Poems of Ossian*, **Advances in complex Systems**, 19 (2016) 1650008.

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