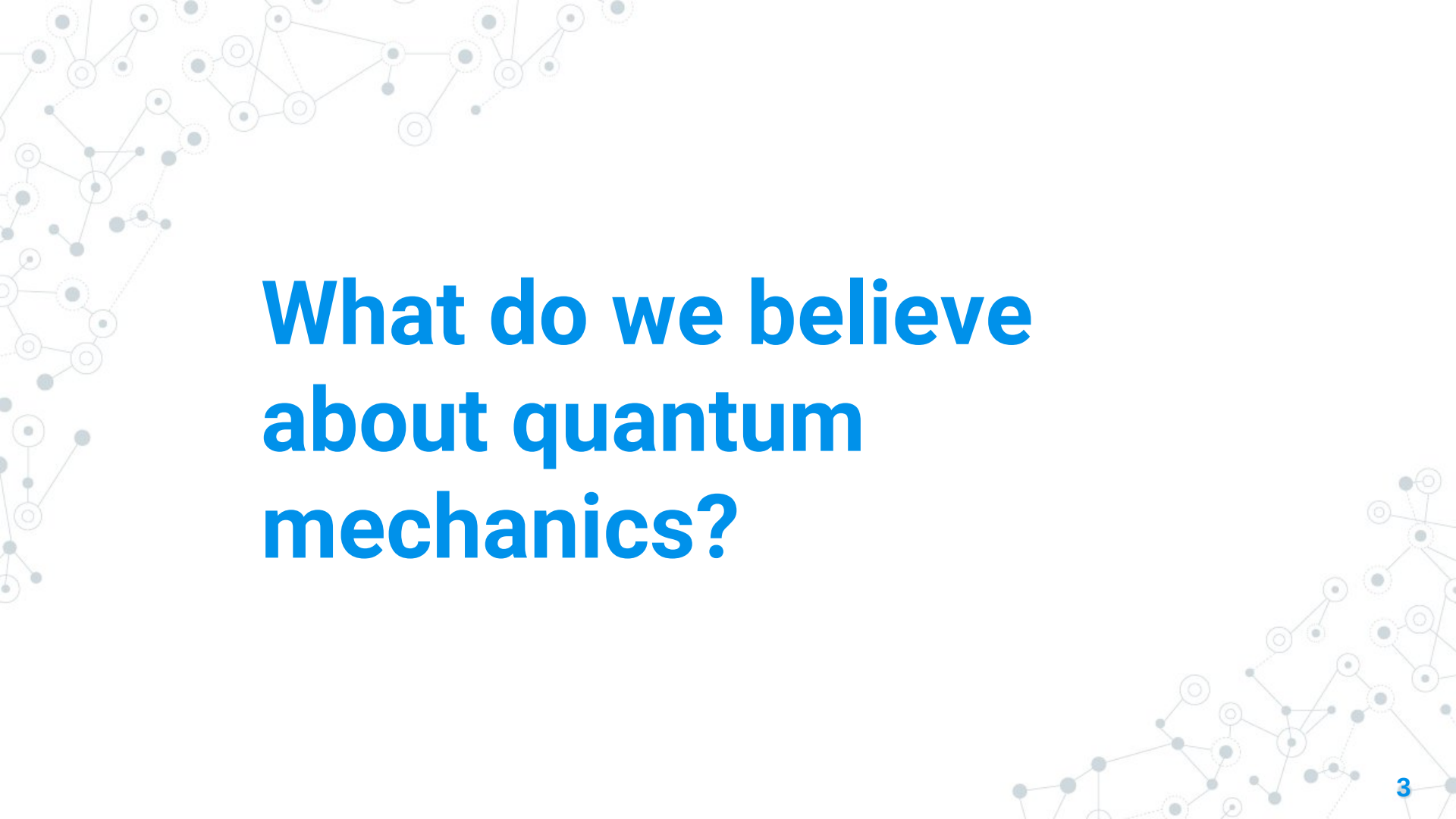


How to be an orthodox quantum mechanic?



Introduction

- ⊙ All scientific theories must be interpreted
- ⊙ Without this we cannot explain anything
- ⊙ What is the mainstream view of QM?
- ⊙ Is it all just “shut up and calculate”?



What do we believe about quantum mechanics?

What do we believe about quantum mechanics?

- ⊙ What is the mainstream view of QM?
- ⊙ Often we hear it is the “Copenhagen Interpretation?”
- ⊙ This is the label most physicists apply to their views (e.g. arXiv: 1301.1069)
- ⊙ But is not well defined!
- ⊙ But what do physicists actually believe?

Overview

- ⊙ Assembled 13 questions in 3 groups
 - ⊙ What is the wavefunction?
 - ⊙ Nature of particles?
 - ⊙ Why are predictions statistical?
- ⊙ Answer options:
 - ⊙ Agree = 1
 - ⊙ Disagree or not mentioned = 0
 - ⊙ Inferred for consistency = 0.5
- ⊙ Survey 22 popular textbooks
 - ⊙ Our own consensus should be reflected here
 - ⊙ Understanding being primary goal

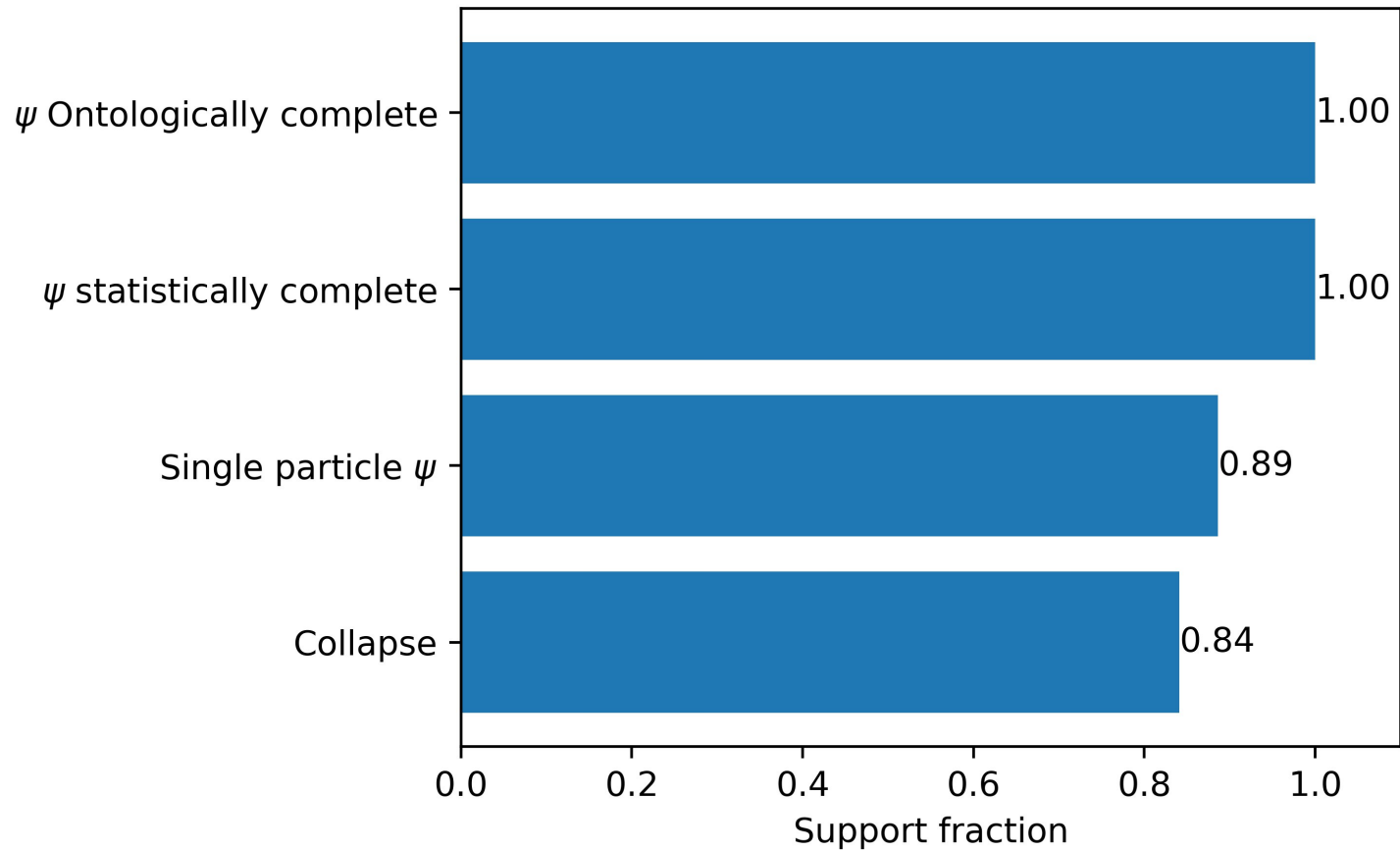
A decorative network diagram in the top-left corner, consisting of interconnected nodes and lines, some nodes being solid circles and others hollow circles.

What is the wave function?

What is a wave function?

- ⊙ Is it ontologically complete?
 - All information about real situation
- ⊙ Is it statistically complete?
 - Can answer all statistical questions
- ⊙ Does it describe 1 particle or an ensemble?
- ⊙ Does it collapse on measurement?

What is ψ ?



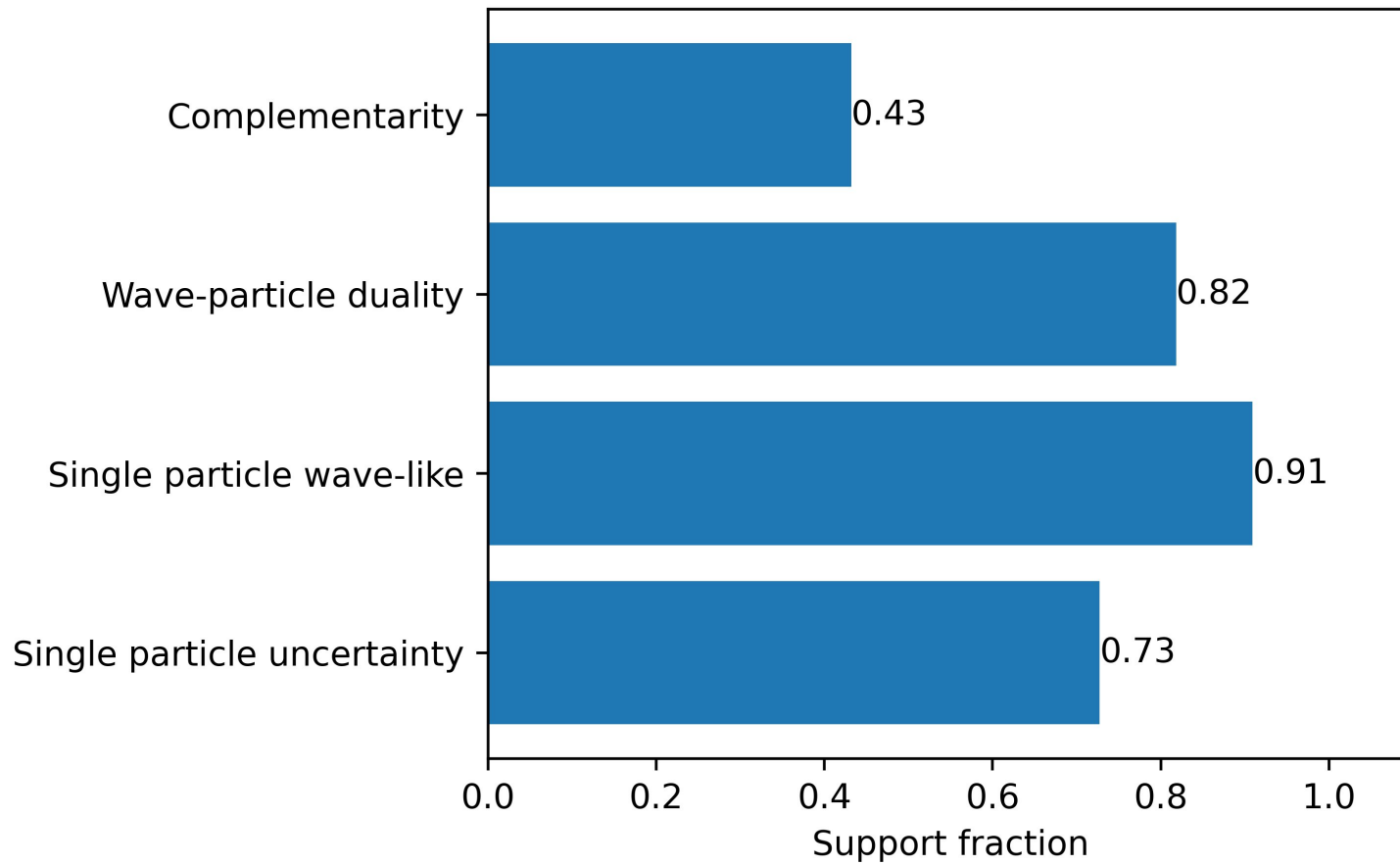


The nature of particles

What are particles like?

- ⊙ Are particles wave-like?
- ⊙ Does HUP apply to single particle measurements?
 - Does it limit our knowledge of non-commuting variables?
- ⊙ Do we endorse wave-particle duality?
- ⊙ Complementarity
 - Mutually exclusive wave and particle pictures
 - No logically consistent single explanation

The nature of particles



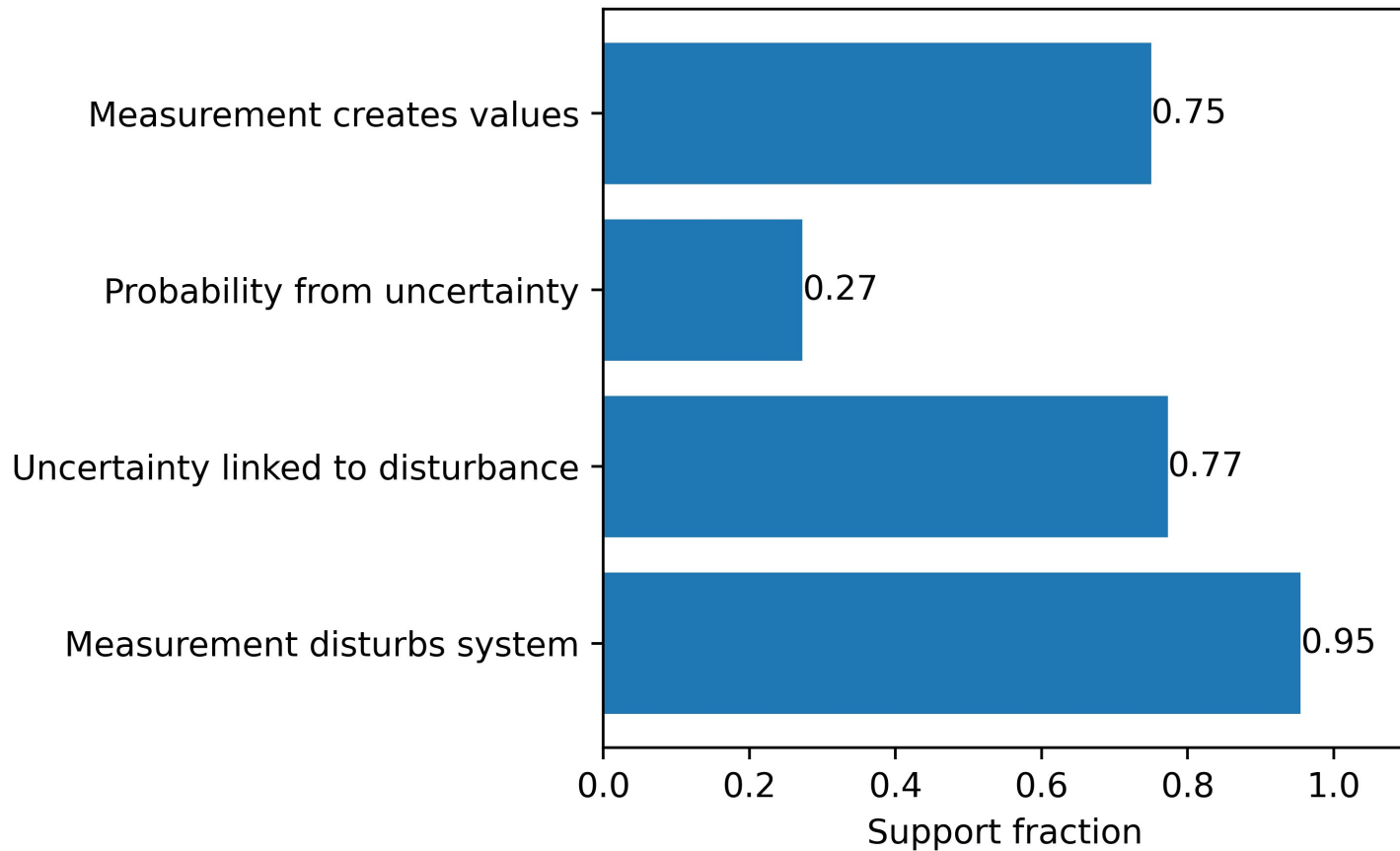
A decorative network diagram in the top-left corner, consisting of various sized grey circles (nodes) connected by thin grey lines (edges). Some nodes are solid grey, while others are hollow with a grey outline. The network is dense and irregular, extending from the top-left towards the center of the slide.

Why are our predictions statistical?

Why are our predictions statistical?

- ⊙ Measurement disturbs system
 - Uncontrollable random disturbance
- ⊙ Uncertainty linked to disturbance
 - Disturbance creates uncertainty in variables
- ⊙ Measurement creates values
 - Systems have no properties until measured
 - Disturbance creates values during measurement
- ⊙ Probability from uncertainty
 - QM is only statistical due to HUP

Why is ψ statistical?



A decorative network diagram in the top-left corner, consisting of various sized grey circles (nodes) connected by thin grey lines (edges). Some nodes are solid grey, while others are hollow with a grey outline. The network is dense and irregular, extending from the top-left towards the center of the slide.

How orthodox is each book?

Orthodoxy

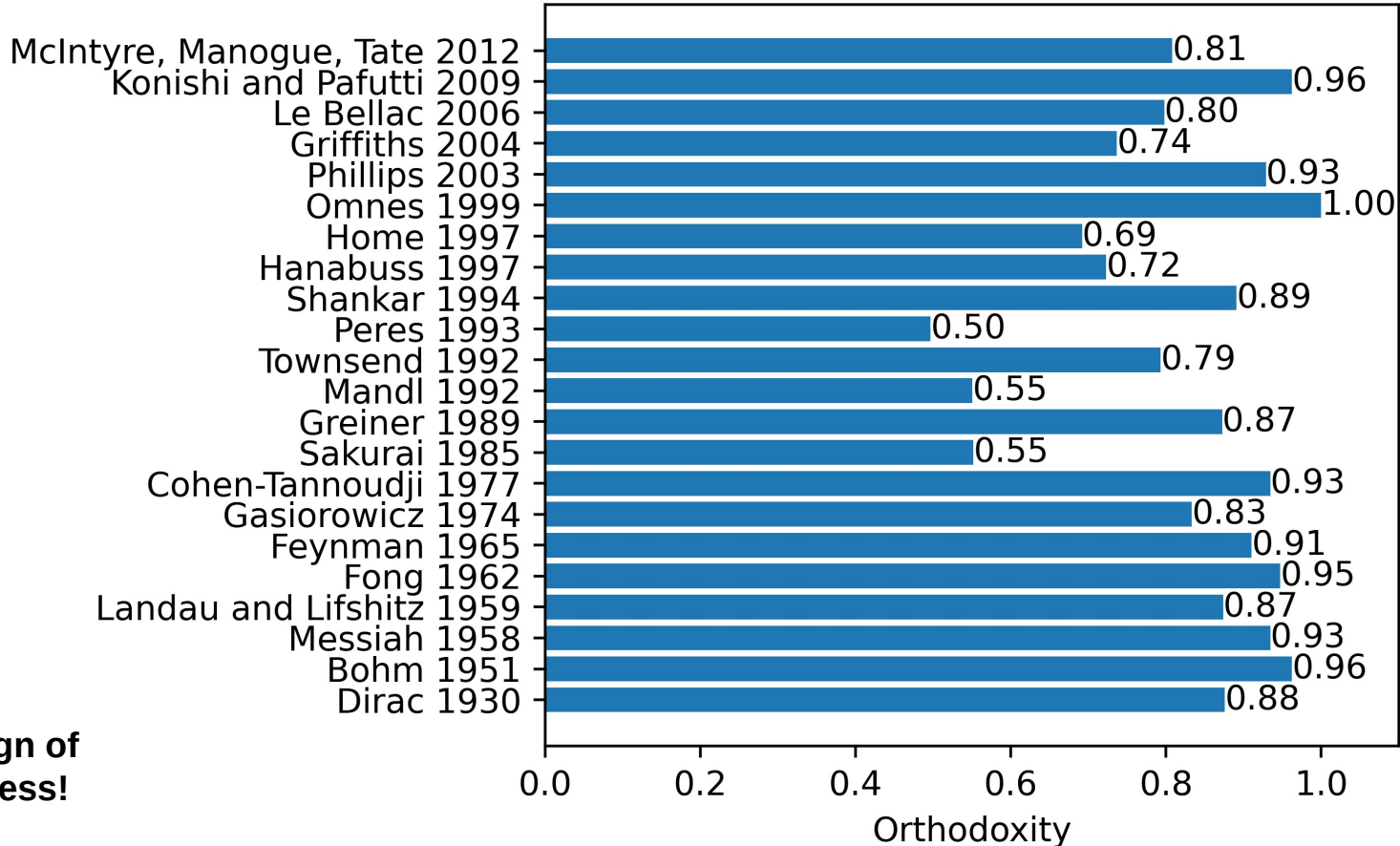
- ⊙ Can we classify how close each book is to orthodoxy?
- ⊙ Yes! We can use a simple relation for orthodoxy degree O

$$O = \frac{\sum_i a_i w_i}{\sum_i w_i}$$

Answer to each question

Orthodoxy weight

How orthodox is each book?



**90's outliers
are "shut up
and
calculate"
books!**

**One big
outlier
Ballentine
1998 (0.1)**

**No sign of
progress!**



What is the orthodoxy?

So what is the orthodoxy?

1. ψ is complete in all senses
2. ψ does **NOT** describe an ensemble (but must be tested as such)
3. ψ collapses on measurement
4. Individual particles are wave-like (duality)
5. Individual measurements are subject to the HUP
6. Measurements disturb quantum systems
7. This **creates** definite property values for systems

Why does this matter?

1. doesn't make sense unless ψ provides some explanation
- 2-3. imply measurement is not unitary even though interactions are all unitary
4. Duality means we accept contradictions to deal with 2
5. Is just wrong
- 6-7. Imply science is futile (our measurements are creating values not discovering them)

Is it all just a matter of taste?

- No differences in predictions, why care?
- But why do we prefer Einstein to Lorentz in relativity?
- It is a better explanation (all maths identical)

- We selectively “shut up and calculate”
- Epistemology without ontology has got us nowhere
- QFT doesn't resolve the issues (nor do “QG” theories)
- We undermine public trust in science

In conclusion

- ⊙ The orthodoxy is anti-realist (6-7)
- ⊙ Measurement problem from 2 and 3
- ⊙ Wave-particle contradiction required by 2
- ⊙ Hardy's excess baggage from 2
- ⊙ We still have the same problems, no progress!