Title: The Everettian Evidential Problem

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Abstract: Much of the evidence for quantum mechanics is statistical in nature. Close agreement between Born-rule probabilities and observed relative frequencies of results in a series of repeated experiments is taken as evidence that quantum mechanics is getting something --- namely, the probabilities of outcomes of experiments --- at least approximately right. On the Everettian interpretation, however, each possible outcome occurs on some branch of the multiverse, and there is no obvious way to make sense of ascribing probabilities to outcomes of experiments. Thus, the Everett interpretation threatens to undermine much of the evidence we have for quantum mechanics. In this paper, I will argue that the Everettian evidential problem is indeed one that Everettians should take seriously, and explain why, in order to deal with it successfully, it is necessary to go beyond existing approaches, including the Deutsch-Wallace decision-theoretic approach.

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Theory and Evidence: a common picture

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- Two theories compatible with a body of evidence are equally well supported by that evidence.
- Extra-empirical criteria (explanatoriness, simplicity, elegance, etc.) are used to choose among such equally-well supported theories.

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- Represent degrees of belief of a rational agent by a *credence function* Cr, satisfying axioms of probability.
- Upon learning an item of evidence e, update credences by conditionalization:

$$Cr(h) \rightarrow Cr(h|e) = \frac{Cr(e|h)}{Cr(e)}\, Cr(h).$$

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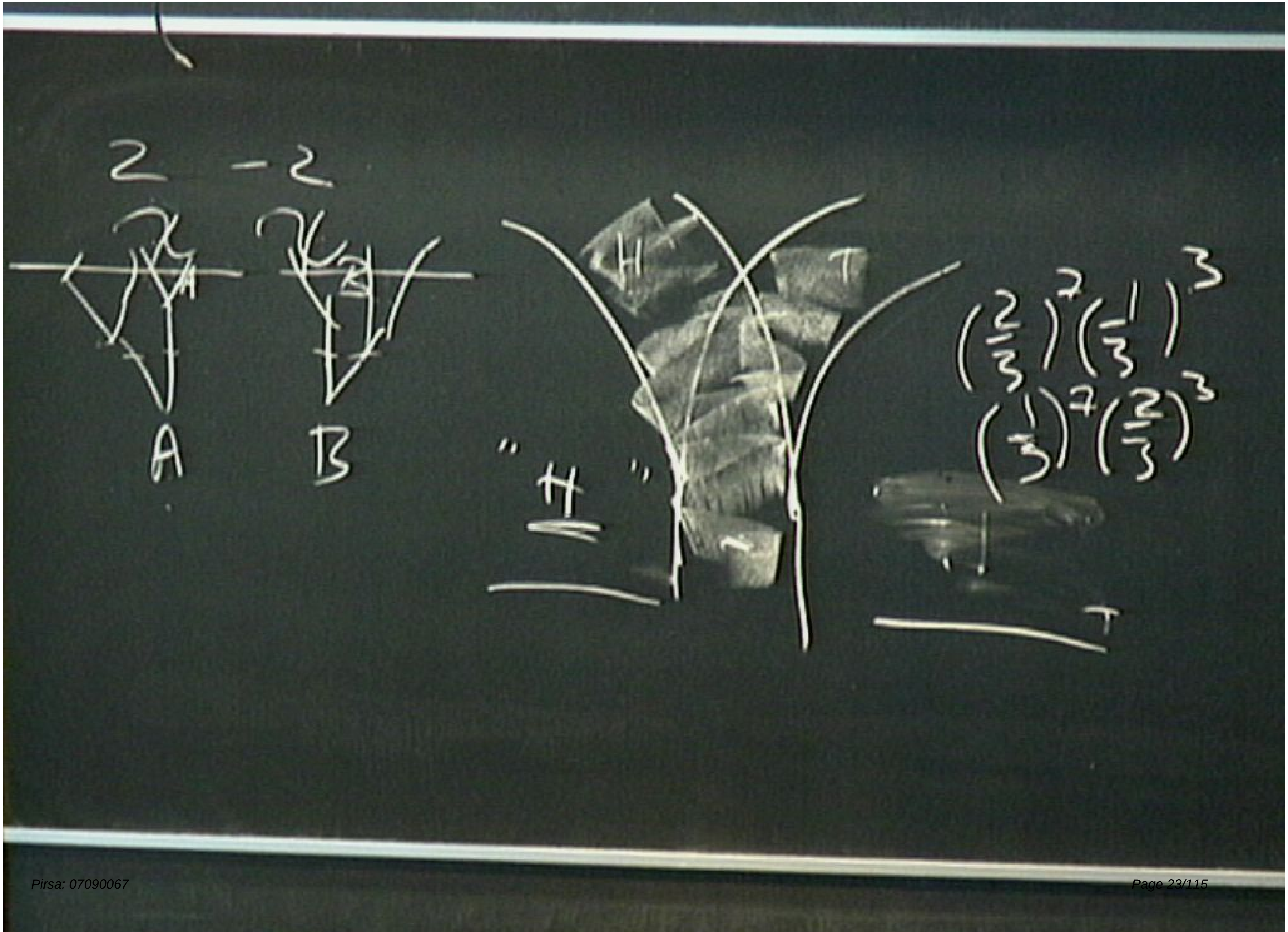
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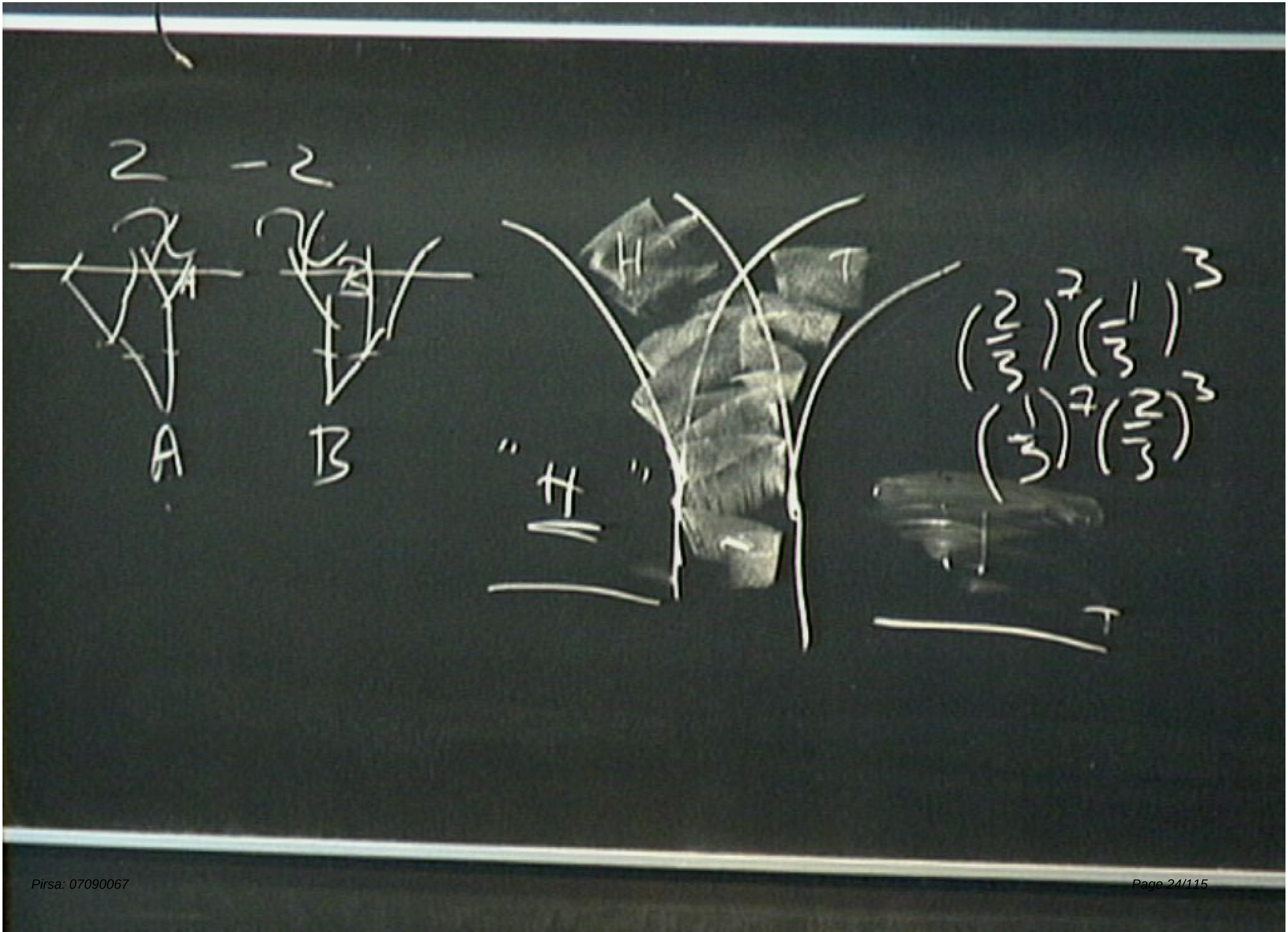
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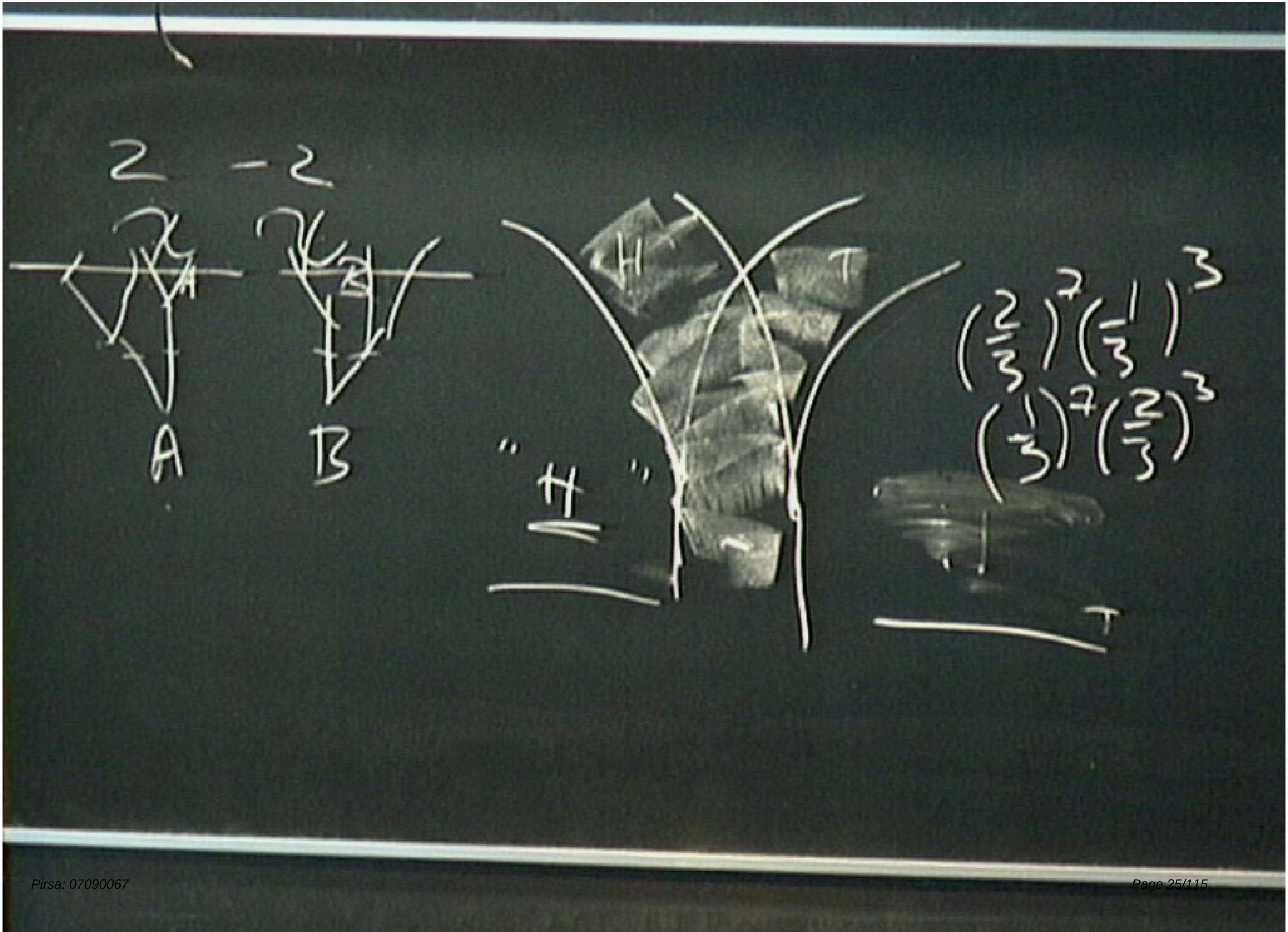
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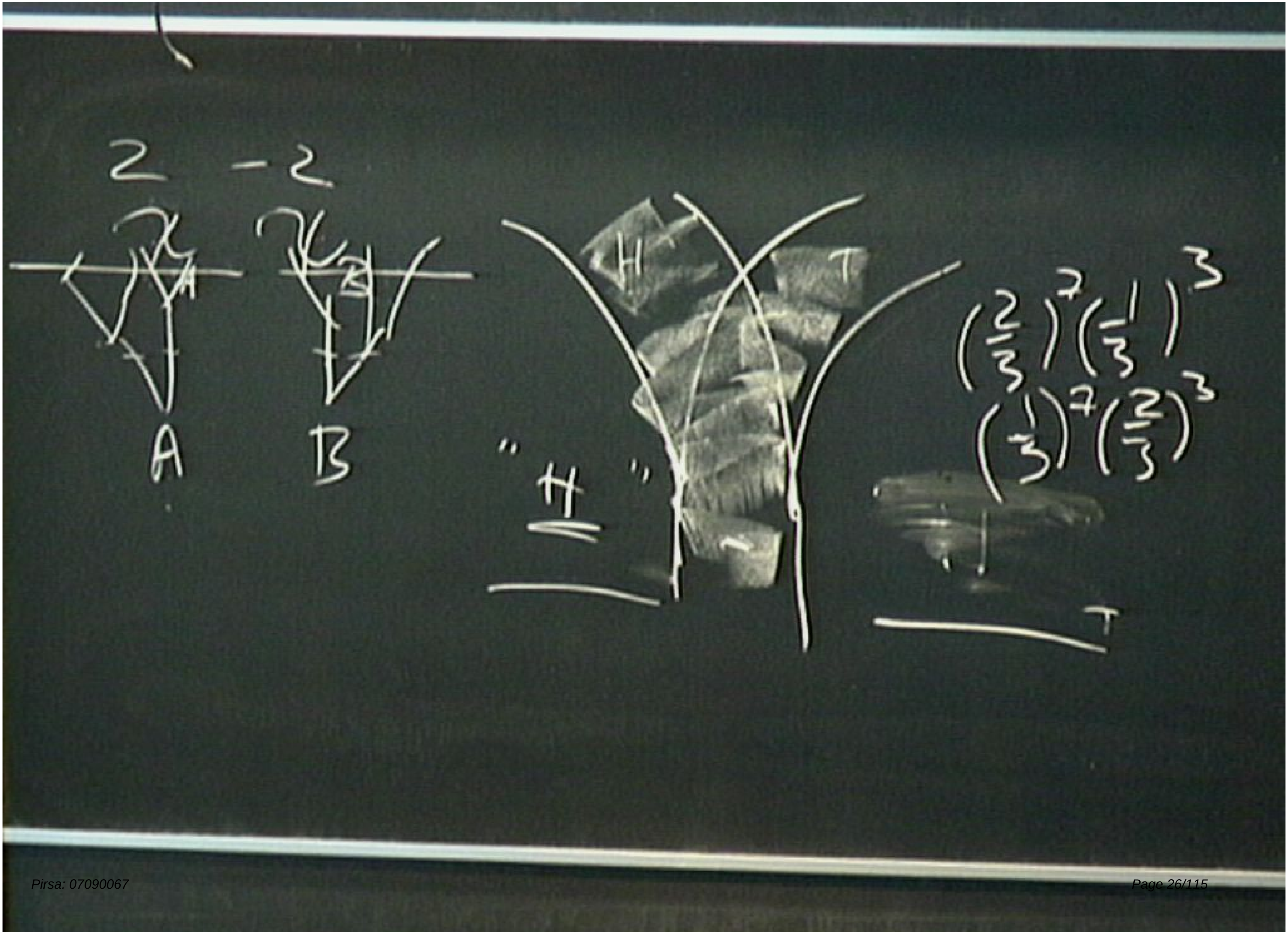
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- (When you know what the objective probabilities are).

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- We should resist temptation to recast probabilistic inferences in a quasi-deductivist vein, say, by adding an extra assumption, such as "Assume your data are typical."

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- We can use relative frequency data to estimate chances of experimental outcomes, independently of any physical theory about the numerical values of those chances.
- Much of the evidence we have for quantum mechanics is of this sort: evidence that the Born-rule chances are at least approximately correct.

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- No *obvious* sense in which I can have degrees of belief that, say, spin-up will be *the* result.
- No obvious sense in which I can talk about the chances of outcomes.

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- The worry: Inability to make sense of statistical data providing support for QM.
- This is the *Everettian Evidential Problem*.

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  - A way of making sense of probability, in an Everettian context.

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   - Principles of Rationality + Substantive physical assumption $\Rightarrow$ Born-rule decisions
   - Principles of Rationality alone won't do; it is not irrational to entertain theories with probabilities that differ from Born rule probs.

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- Is this an empirically testable assumption?
- Need: an evidential link between frequencies and Born-rule branch weights, that does not depend on an argument that takes Everettian QM for granted.

- Suppose we needed a DW argument in order to have our relative frequency data count as confirming a theory that posits Born-rule branch weights. Then the best we could hope for is:
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  Probability is an obscure and mysterious concept; the Everettian is no worse off than the non-Everettian.
- Specific:
  Orthodoxy adopts an undefended Principal Principle; the Everettian can adopt a parallel undefended principle regarding branch weights.

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- Two sources of confusion:
  - Taking probability to be unambiguous, and assuming that we have to choose one sense to fit all uses of the word.
  - Identification of the objective sense of probability with a frequency concept.

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- Consider an analogous problem: How to justify the rule to maximize expected utility?
- Savage's approach
  - Impose rationality constraints on preferences between wagers.
  - Prove a representation theorem: an agent whose preferences satisfy the Savage axioms acts as if she is maximizing expected utilities.
  - It is only via this representation that we ascribe credences and utilites to our agent, and we do so in such a way that the condition of maximizing expected utility is automatically satisfied.

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- That is, the credences are as if the agent believes that each toss has the same chance, whose value may be unknown to the agent, and the agent's credences about these chances mesh with her credences about outcomes in the way prescribed by the Principal Principle.

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- That is, the credences are as if the agent believes that each toss has the same chance, whose value may be unknown to the agent, and the agent's credences about these chances mesh with her credences about outcomes in the way prescribed by the Principal Principle.
- Combined with Savage Thm, this is a representation of your preferences as maximizing your *epistemic expectation* of the

De Finetti and chances

- In a similar way, we can uncover implicit beliefs about chances in an agent's credences.
- An agent treats a sequence of experiments as *exchangeable* if permutation of the sequence of results does not change the credence.
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Determinsistic Chances

- Even in a deterministic theory, there *might* be a limit to the information about the initial state that is accessible to agents placing bets.
- My credences will be mixtures of probability functions that are invariant under conditionalization on all *accessible* information.
- These probability functions will play the role of objective chance.

Lewis on Chances

Like it or not, we have this concept. We think that a coin about to be tossed has a certain chance of falling heads, or that a radioactive atom has a certain chance of decaying within the year, quite regardless of what anyone may believe about it and quite regardless of whether there are any other similar coins or atoms. As philosophers we may well find the concept of objective chance troublesome, but that is no excuse to deny its existence, its legitimacy, or its indispensability.

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In conclusion

- The Evidential Problem is one that Everettians should take seriously.
- What is needed: either a way of making sense of probability in an Everettian multiverse, or a surrogate for probability-talk, on which observed relative frequencies that closely match Born-rule chances still counts as evidence in favour of the theory, achieved in a way that does not presuppose the correctness of QM.
- Without this, the threat looms that the Everett interpretation will be empirically self-undermining: it will cut away much of the reason we have for taking quantum mechanics seriously in the first place.

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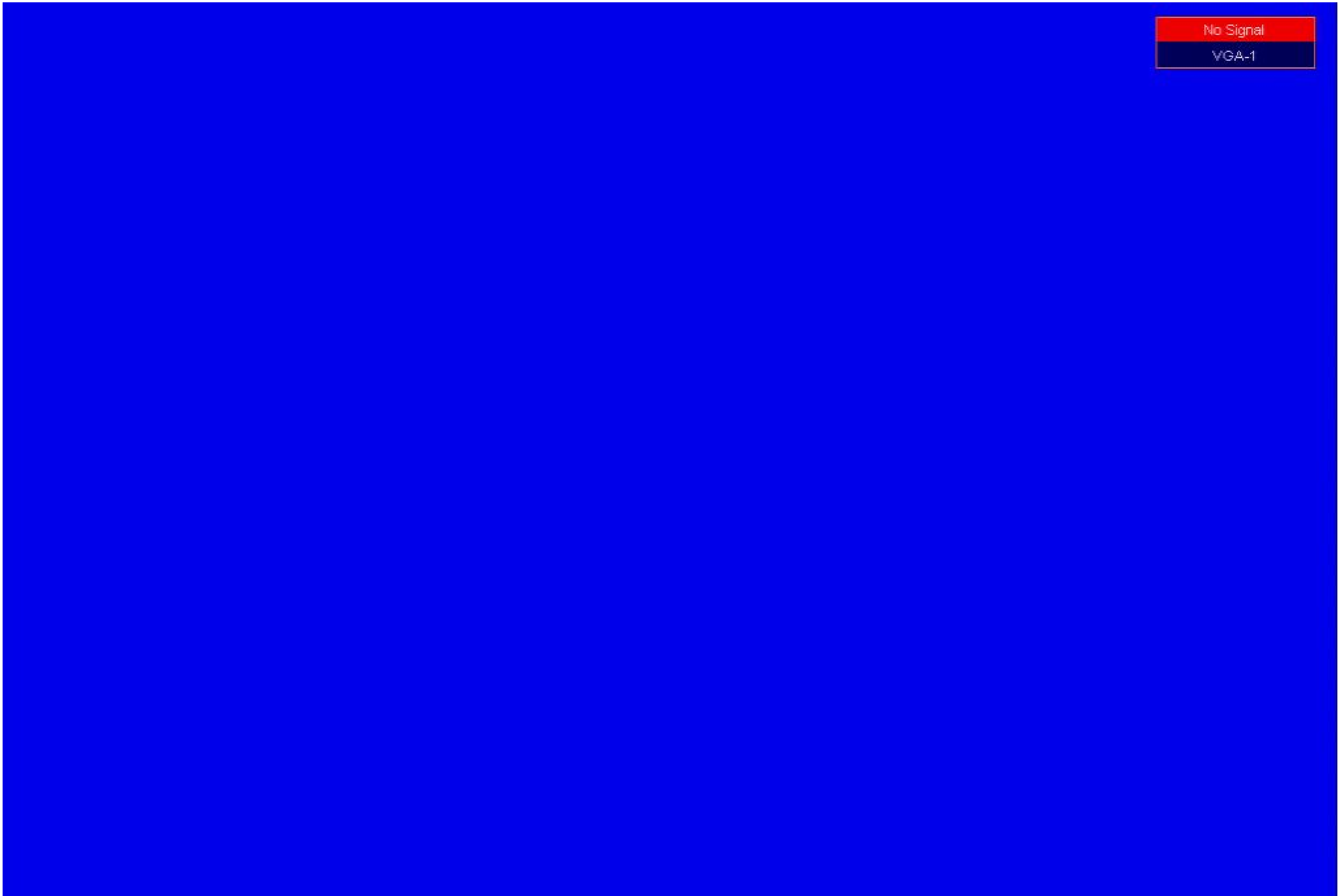
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