



# P vs NP

## A DESPERATE SEARCH

BY SANDOR DALECKE







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The background is a dark blue gradient. In the corners, there are white line-art illustrations of circuit boards or neural networks, with lines connecting to small circles.

IS THERE A DIFFERENCE BETWEEN CHECKING A  
PROOF AND FINDING ONE?

# SOME BASICS

- **P** is the class of problems solvable by a Turing machine in polynomial time
  - Sort a list:
    - Bubblesort is in  $O(n^2) \rightarrow P$   $300^2 = 90\,000$
- **NP** is the class of problems for which, if the answer is yes, then there's a polynomial-size *proof* of that fact that you can *check* in polynomial time.
  - SAT (Check if a Boolean formula is TRUE):
    - Checking one solution is easy
    - Finding a solution? Best we know is Brute Force  $O(2^n)$   $2^{300} = ?$

# WHY DO WE CARE?

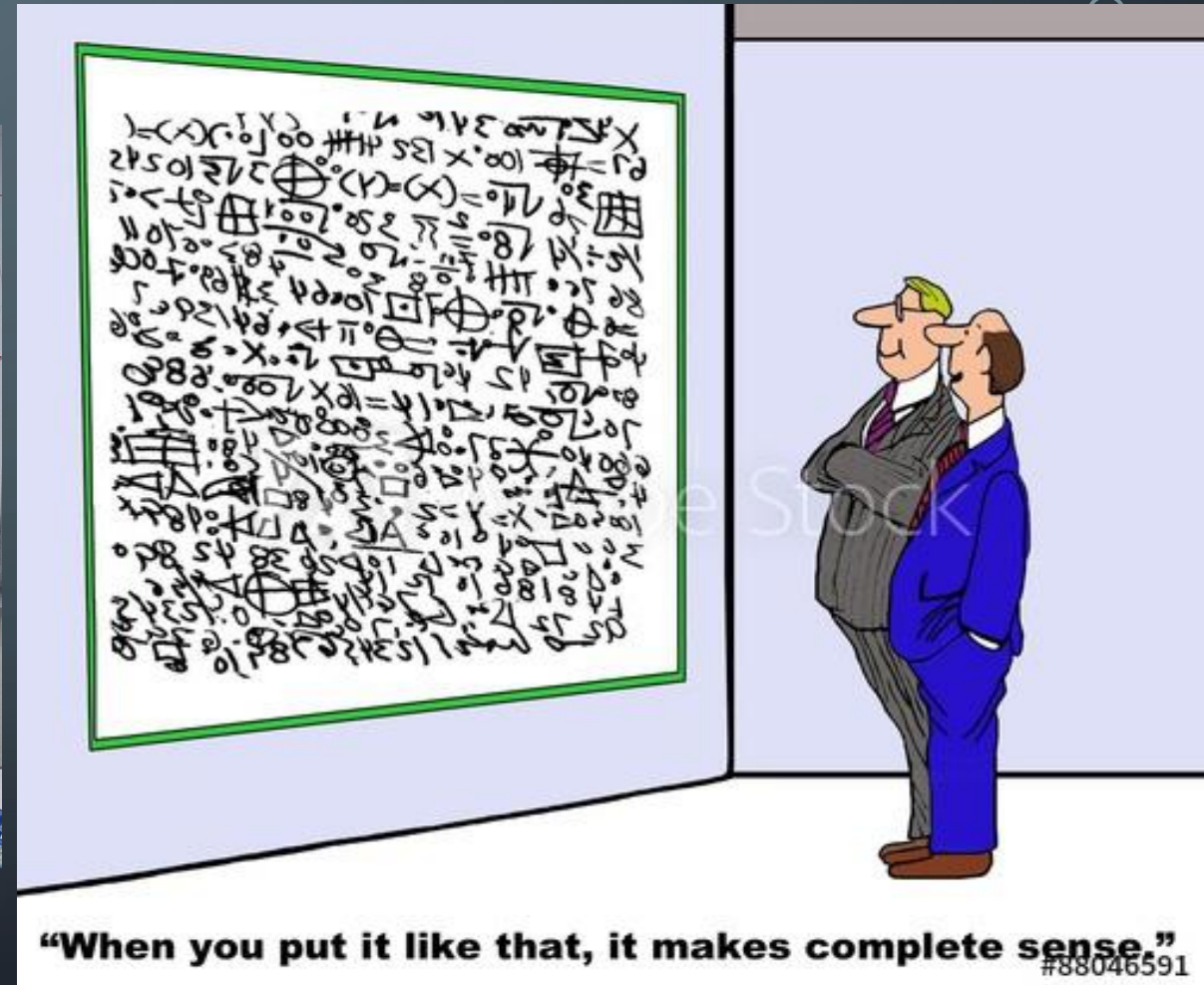
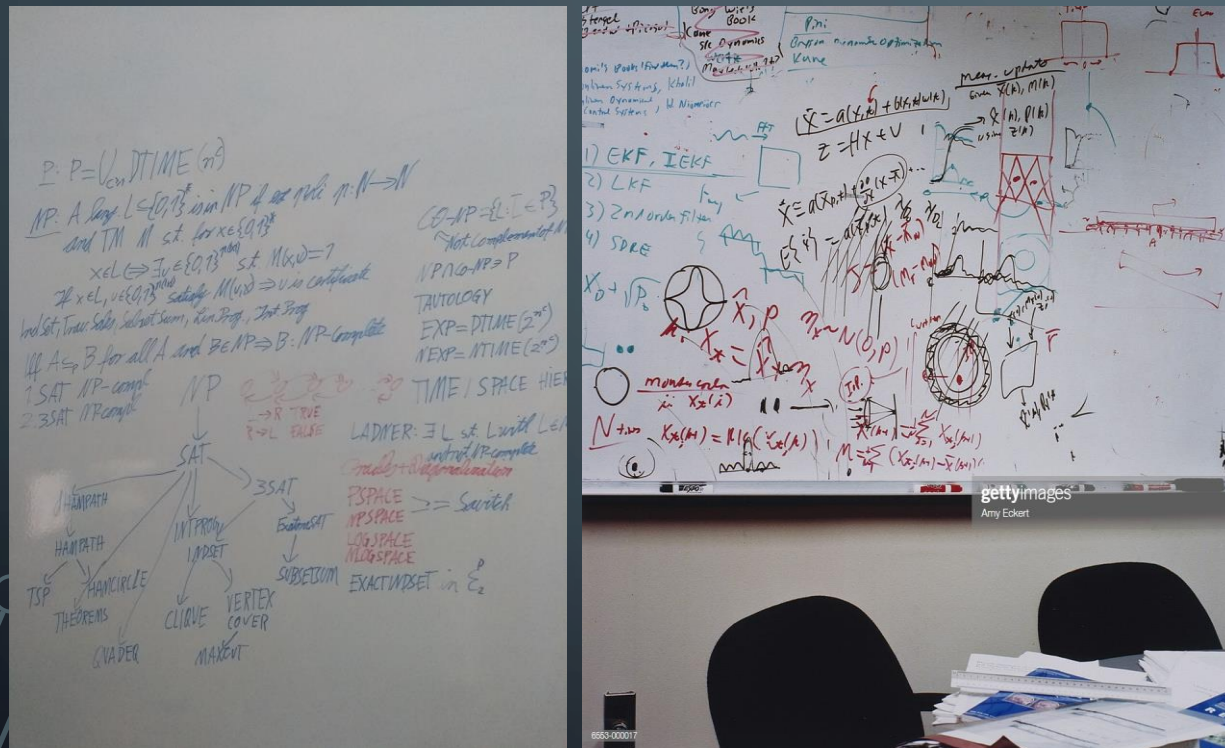
- If  $P = NP$ :
  - Fold Proteins ✓
  - Break most cryptography ✓
  - Packing Boxes perfectly ✓
  - Always find the best travel route ✓
  - Always find the shortest prove for every theorem ✓







# LET'S PROVE THIS: USE MATH!

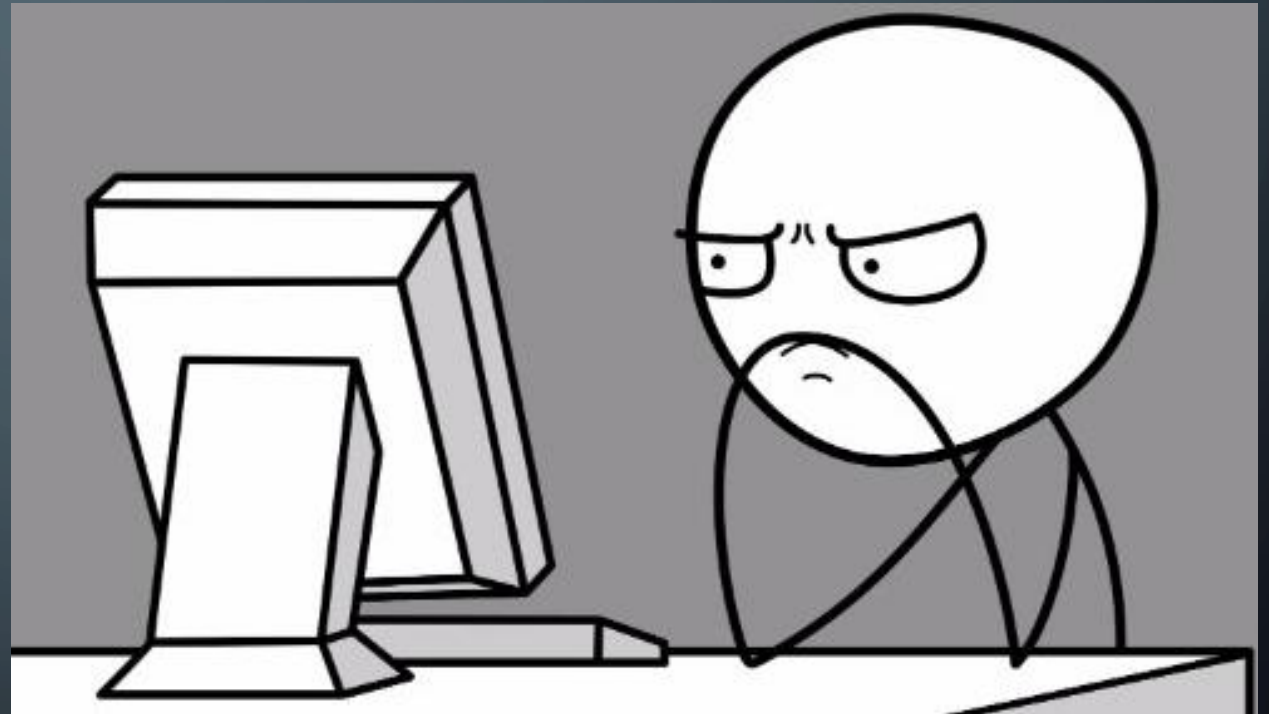


#88046591



# METHOD: COMPLEMENT

- $P = \text{Co-P}$
- SATISFIABILITY vs TAUTOLOGY
- IF  $NP \neq \text{Co-NP} \rightarrow P \neq NP$
- We don't know

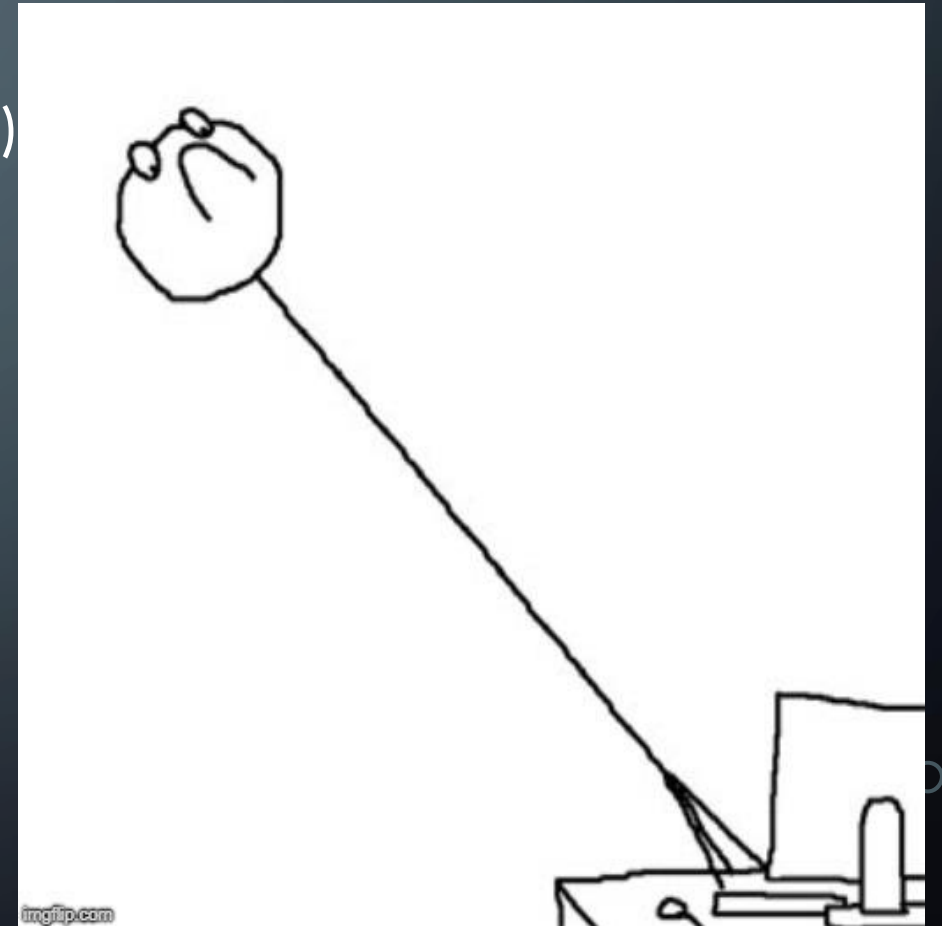


# METHOD: MAYBE SPACE?

- PSPACE: Computation in Polynomial Space
- Obviously  $NP \subset PSPACE$
- ... well  $NP \subseteq PSPACE$  is true!

# METHOD: WELL...HOW ABOUT RANDOMIZATION?

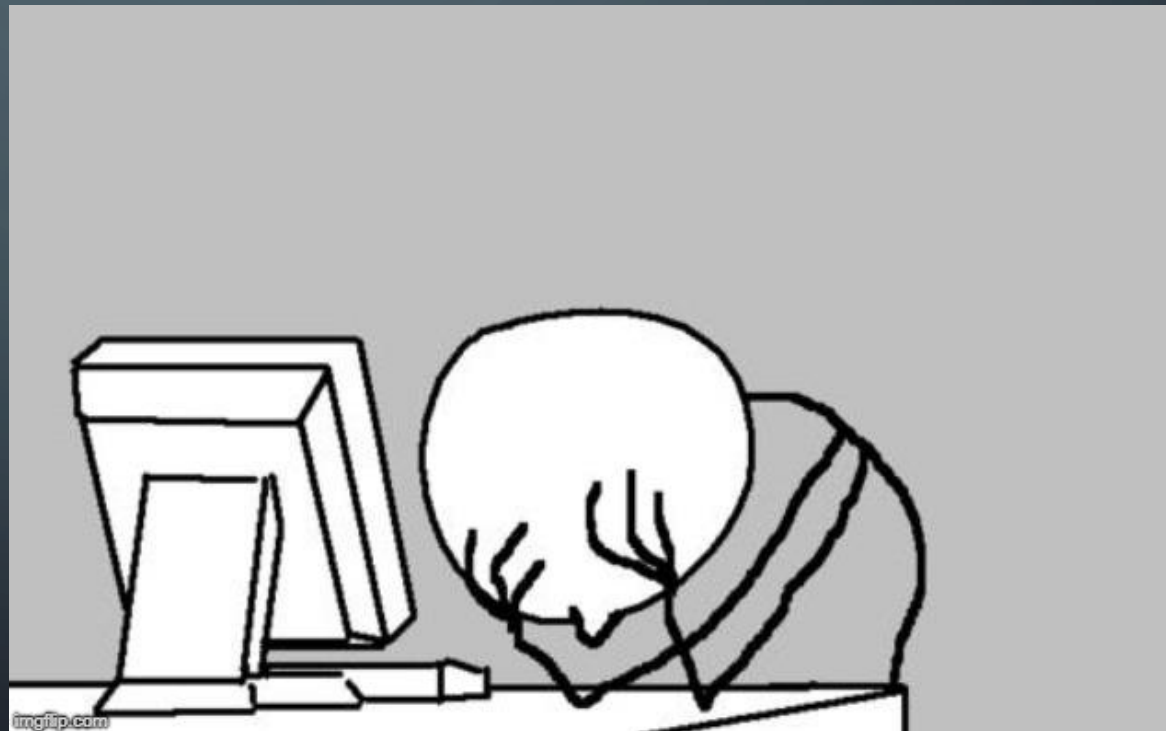
- BPP (Bounded-Error Probabilistic Polynomial-Time)
  - Accept computation  $2/3$  if answer is YES
  - Accept computation  $1/3$  if answer is NO
- $P \stackrel{?}{=} BPP \stackrel{?}{=} NP$ 
  - BPP is it's own monster





# OKAY OKAY... QUANTUM COMPUTING!

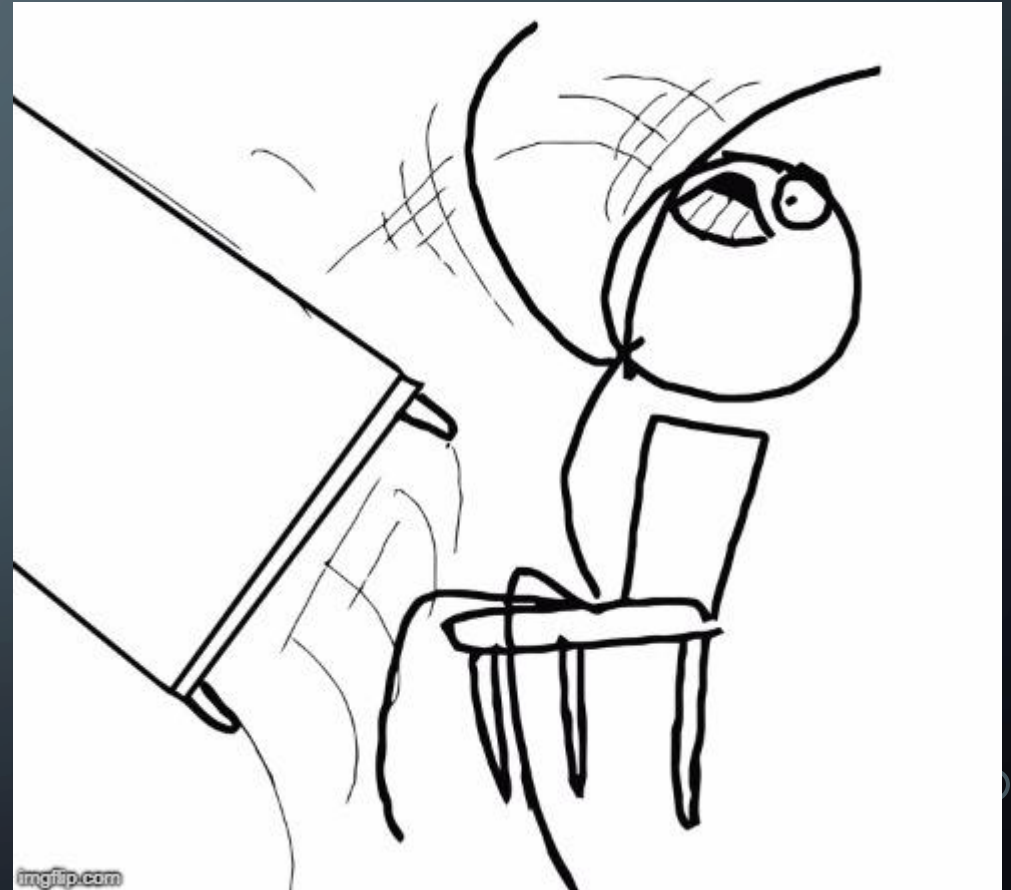
- BQP (Bounded-Error Quantum Polynomial-Time)
  - BPP on Quantum Computer
- Just try everything!
  - Not how QC work!
- Probably  $BQP \neq NP$



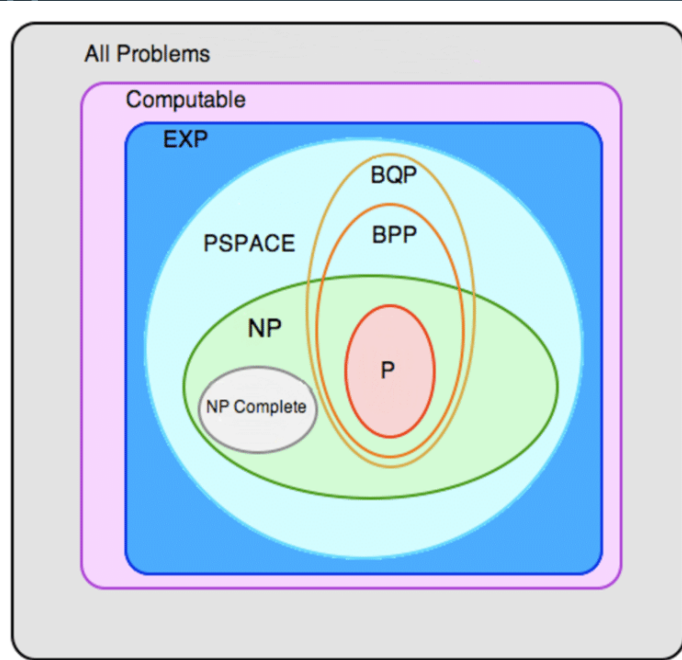
# SCREW THIS: LET'S TRY ORACLES!

- Let's pretend we have an Oracle
  - Knows answer to P or to NP or EXP or ...

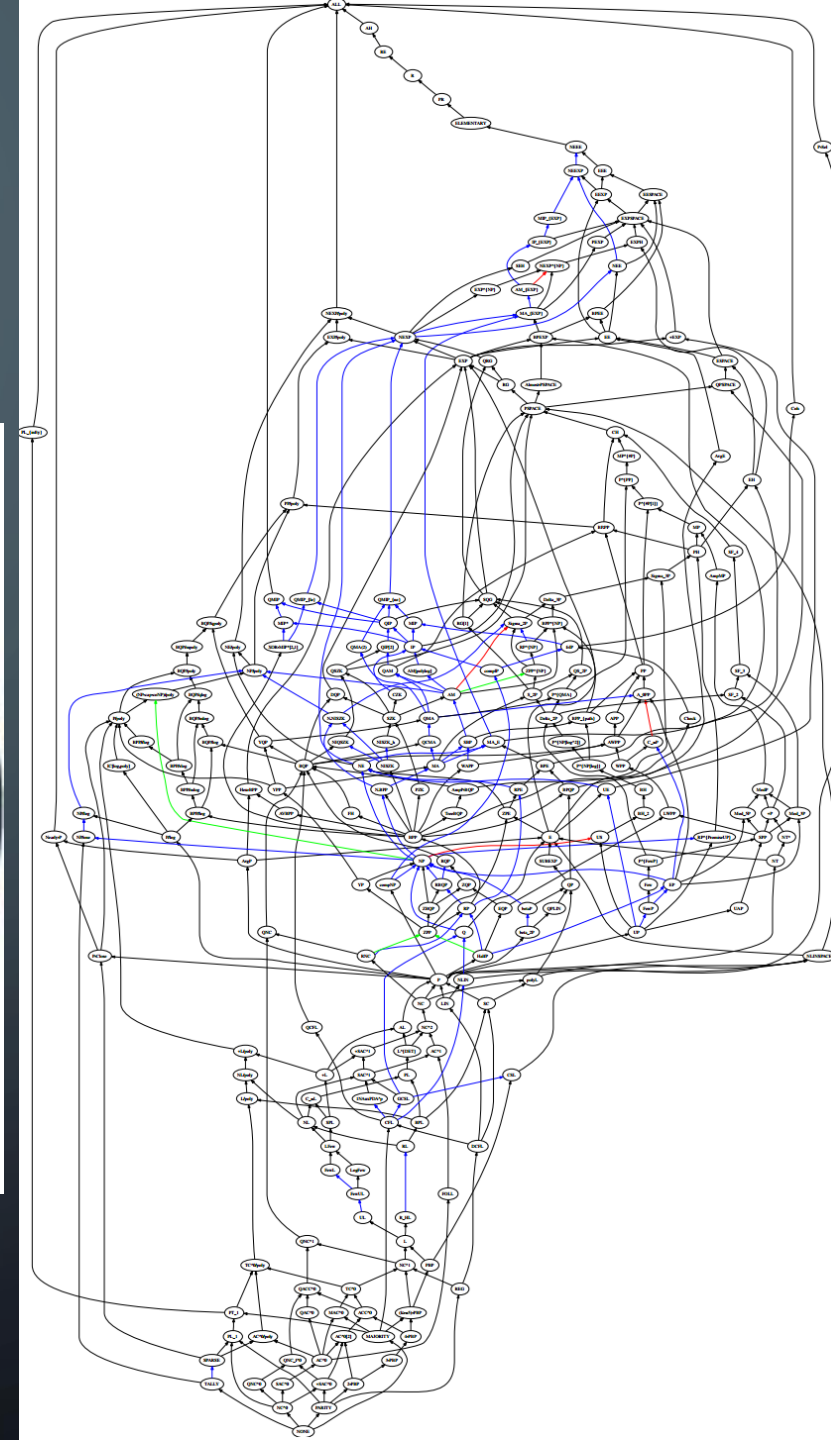
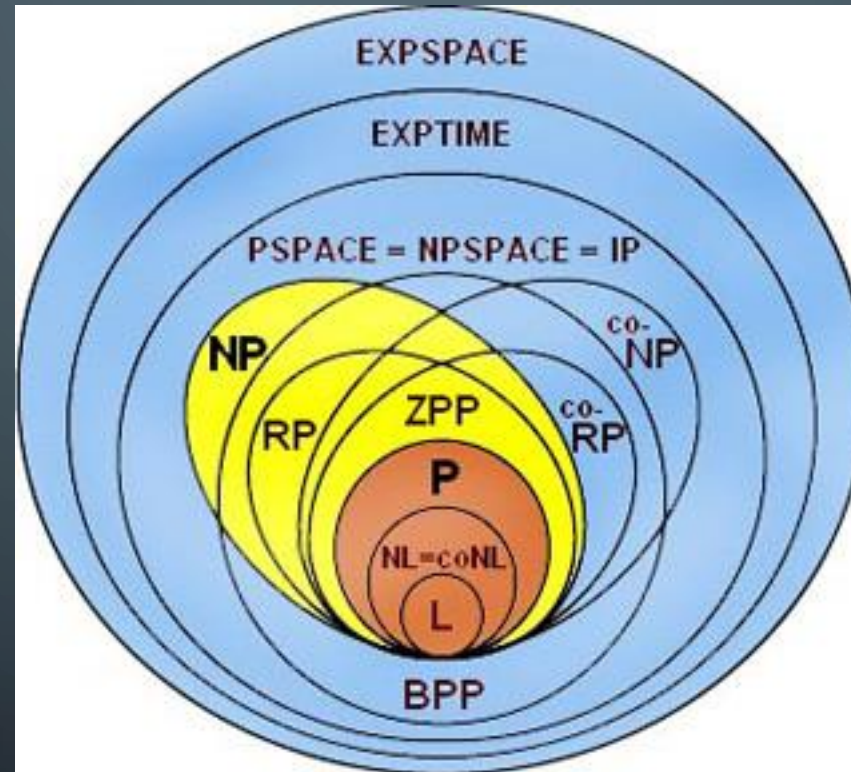
„...the relativized  $P \stackrel{?}{=} NP$  question has a positive answer for some oracles and a negative answer for other oracles. We feel that this is further evidence of the difficulty of the  $P \stackrel{?}{=} NP$  question.“ Baker, Gill, Solvay



# AND THAT WAS JUST A GLIMPSE!



**P** solution can be found in time polynomial in the size (number of bits)  
**NP** solution can be checked in polynomial time  
**NP COMPLETE** any NP problem can be reduced to one of these  
**BPP** solution in polynomial time at probability  $p > 1/2$   
**BQP** solution in polynomial time at probability  $p > 1/2$  on quantum computer  
**PSPACE** solution requires a polynomial amount of memory  
**EXP** solution can be found in exponential time  
**COMPUTABLE** solution can be found eventually





The image features a dark blue gradient background with faint, stylized circuit board traces in the corners. These traces consist of thin white lines forming right angles, with small white circles at various points, resembling electronic components or connection nodes. The traces are located in the top-left, top-right, bottom-left, and bottom-right corners, framing the central text.

THANKS YOU FOR LISTENING