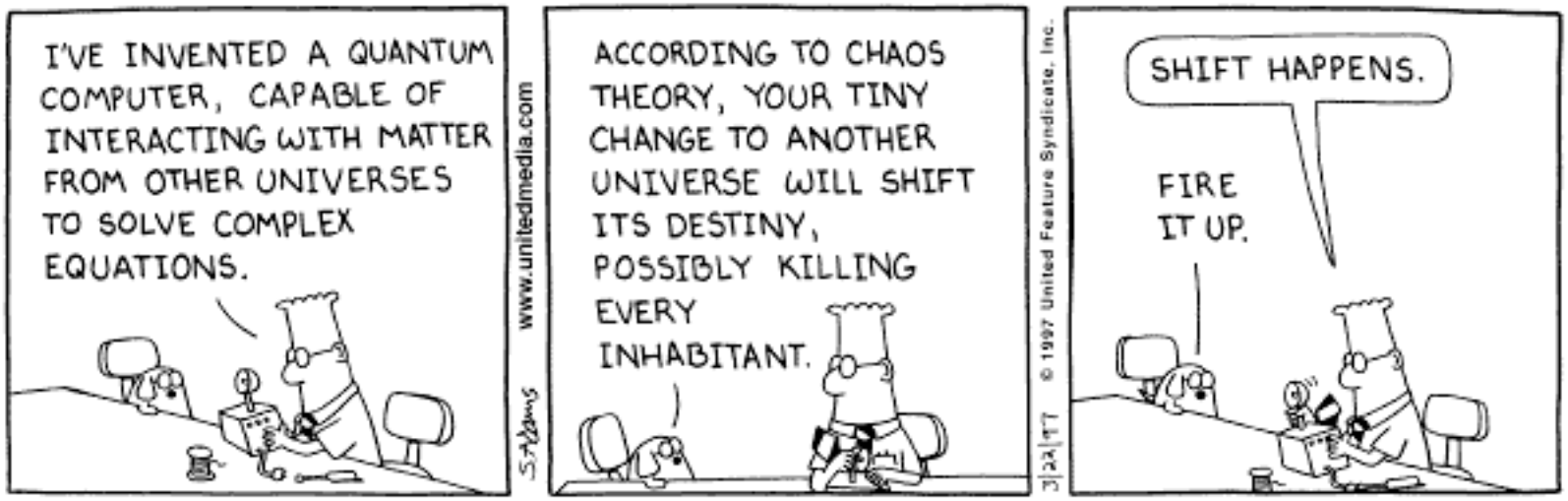
Required comic



Abstract: Quantum computers don't exist yet. But I exist, and I can study anything I want. As a would-be theoretical physicist, quantum computing is a wonderful idea - mainly because it's very cool (= funding) and quite useless at the moment (= good research). There's actually a big group in Madison trying to build a quantum computer. I'd like to tell you a little about it. What's a quantum computer? The real question is: Can I answer this question without causing that glazed over look that usually appears when I start talking about what I actually do? We'll see. (Legal notice: Many trademarks will be violated in this talk.)

What is a Quantum Computer, Charlie?

Charles Tahan
Physics Department
University of Wisconsin-Madison

Introduction

Computing :

= 0's and 1's + simple circuits

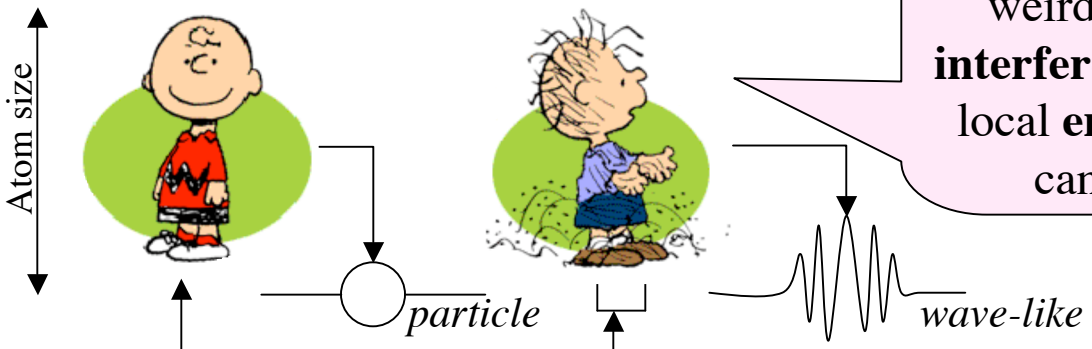
Classical computing takes very simple building blocks and builds something very complex and powerful.

Example program:

```
010   "2"
011   "3"
ADD
101   "5"
```

Quantum Physics :

"classical object" "quantum object"



Since I act like a wave, weird things like **interference** and non-local **entanglement** can happen.

Can we use this craziness to our advantage?

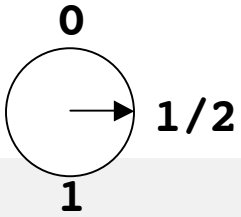
Charlie Brown is definitely here.

Whereas Pigpen is in here somewhere. → probability

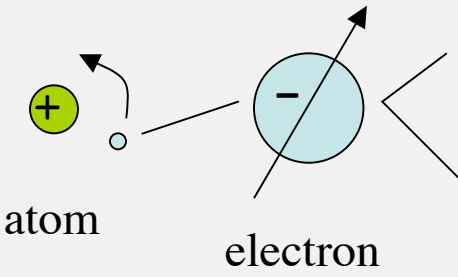
Classical **bit** vs. quantum **qubit**

Qubits and Spin

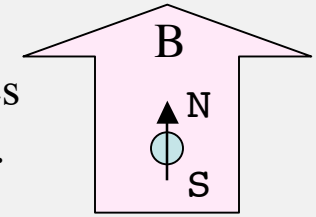
- One **bit** of classical information: 0 or 1 and that's it.
- A **qubit** can be in a *superposition* of the two:



Physical example of a qubit: spin of an electron



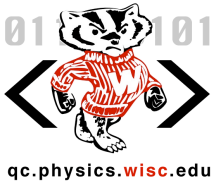
Like a magnet, the spin lines up with a magnetic field B.



But, when *measured*, will only be **up** or **down**.

#	**bits**		**qubits**	"info" stored
1	0 or 1	***1***	a|0>+b|1>	***2***
2	00 or 01 or 10 or 11	***2***	a|00>+b|01>+c|10>+d|11>	***4***
3	000 or 001 or 010 or …	***3***	a|000>+b|001>+c|010>+d|011> +e|100>+f|101>+g|110>+h|111>	***8***
				2^n

- Much more information can be stored in qubits, although it can't be directly accessed.
- I've ignored phase which causes interference and non-local interactions.



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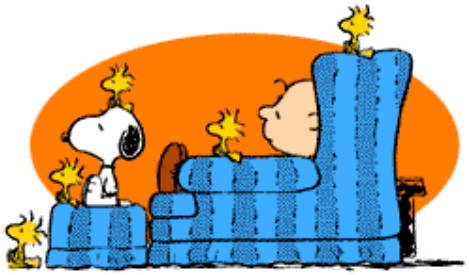
Motivation

Why build a quantum computer?



Quantum Algorithms

Quantum Factoring Algorithm:
Breaking RSA encryption
Quantum Sorting Algorithm
What is the nature of computation?

Quantum Communication

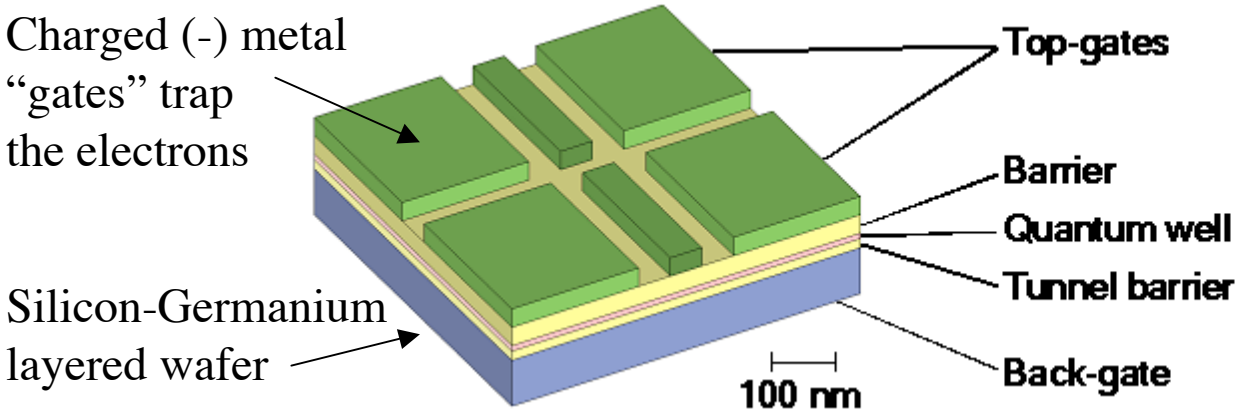
Cryptography/Secure Communication
Quantum Information Channels
Utilizing entanglement to transmit information.

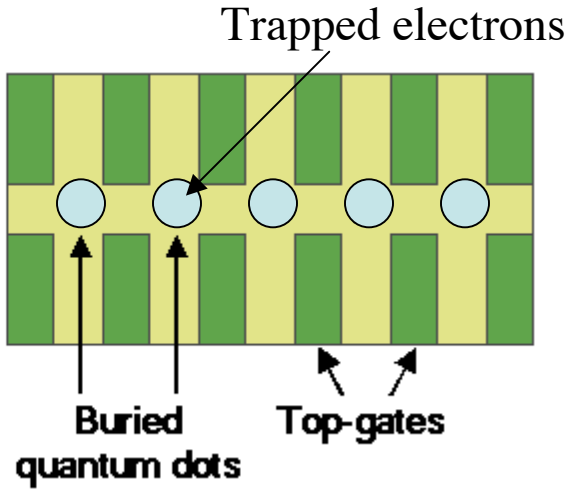
Theoretical and Applied Physics

Quantum simulations:
solids, molecules, drugs, etc.
The nature of entanglement
Further exploration of quantum mechanics

Building a Quantum Computer

The Wisconsin design:





Challenges:

1) Decoherence

Quantum states are very delicate!

2) Manipulation of quantum states

And they're very hard to control!

3) Scalability

And it gets much harder when you have many qubits!

HARD!

"What's Quantum Computing Charlie?" -Charles Tahan, Physics Dept., Madison WI

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The End

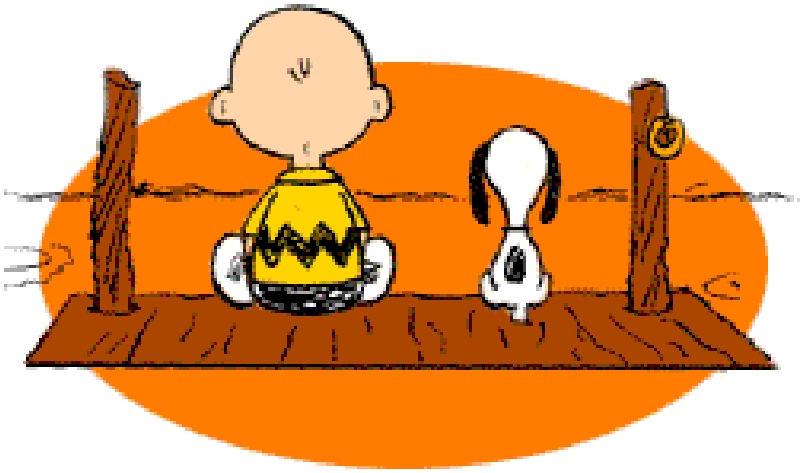
Quantum Computing at Madison

Physics: Bob Joynt, Sue Coppersmith, Mark Eriksson, Mark Freisen, Charles Tahan, Marcel Goldschen, Daniel Shumow, Will Williams

ECE: Dan van der Weide, Jim Truitt, Chris Brace

Materials Science: Max Legally, Don Savage, Paul Rugeimer

Computer Science: Eric Bach, Dieter van Melkebeek



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