

Physics 496

Introduction to Research

Lecture 4.1: Using Analogies in Science

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Definition

a-nal-o-gy [*uh-nal-uh-jee*]: A comparison between two things, typically on the basis of their structure and for the purpose of explanation or clarification: *the analogy between the heart and a pump*.

An analogy is different than a simile. A simile is defined as a figure of speech involving the comparison of one thing with another thing of a different kind, (e.g., *as brave as a lion*).

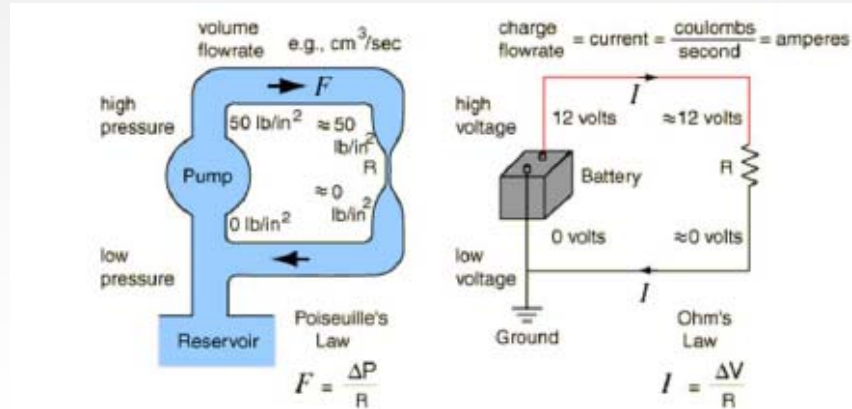
The difference is that a simile just says “this is like that”. Analogies are used to explain one thing by comparison to another thing that is known.

the “heart” is typically more complicated than the “*pump*”

Analogies are helpful for writing, especially outreach.
Analogies are important for discovery.

dc Water Circuit

Classic analogy for plumbers trying to understand electric circuits, or physics majors trying to understand plumbing.



Spontaneous Symmetry Breaking

Minimal Composite Higgs Models at the LHC

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Abstract

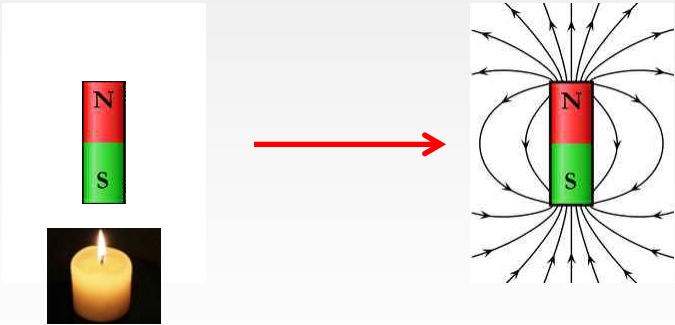
We consider composite Higgs models where the Higgs is a pseudo-Nambu Goldstone boson arising from the spontaneous breaking of an approximate global symmetry by some underlying strong dynamics.

Huh?

[arXiv:1402.2987v1 \[hep-ph\]](https://arxiv.org/abs/1402.2987v1)

Spontaneous Symmetry Breaking

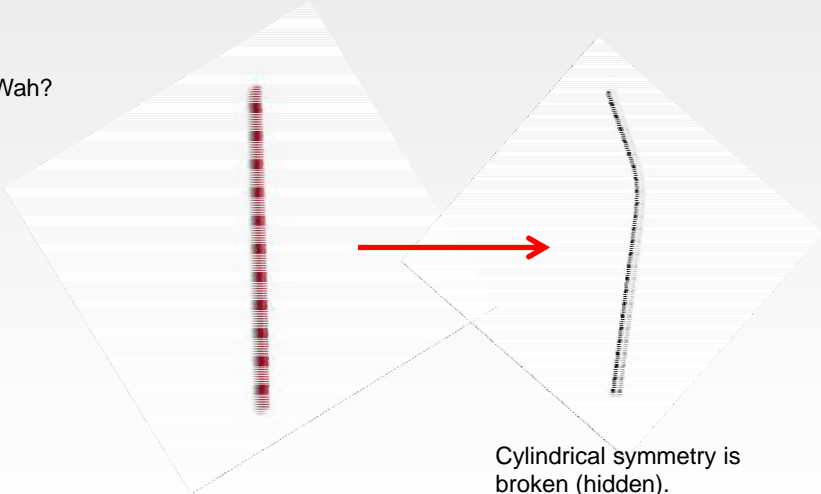
Wah?



Rotational symmetry of domains is broken (hidden)

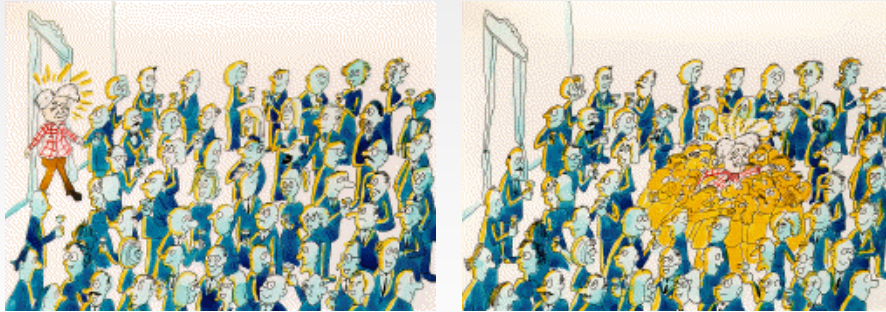
Spontaneous Symmetry Breaking

Wah?



Cylindrical symmetry is broken (hidden).

Analogies are never perfect



An explanation of how the Higgs particle gives mass to other particles. It has some problems.

Another version

<http://www.youtube.com/watch?v=qed3F0mVlbM>

Example

Michigan Tech

It's the Water: Graphene Balloon Yields Unprecedented Images of Hydrated Protein Molecules

A graphene water balloon may soon open up new vistas for scientists seeking to understand health and disease at the most fundamental level.

Electron microscopes already provide amazingly clear images of samples just a few nanometers across. But if you want a good look at living tissue, look again.

"You can't put liquid in an electron microscope," says Tolou Shokuhfar, of Michigan Technological University. "So, if you have a hydrated sample—and all living things are hydrated—you have to freeze it, like a blueberry in an ice cube, and cut it into a million thin pieces, so the electrons can pass through. Only then can you image it to see what's going on."

After such treatment, the blueberry isn't what it was, and neither is human tissue. Shokuhfar, an assistant professor of mechanical engineering-engineering mechanics, wondered if there might be a way to make electron microscopes more friendly to biological samples. That way, you might get a much better view of what's really going on at the sub-cellular level.

<http://www.mtu.edu/news/stories/2014/february/story/02518.html> 20140220

UIC

Graphene 'sandwich' improves imaging of biomolecules

By sandwiching a biological molecule between sheets of graphene, researchers at the University of Illinois at Chicago have obtained atomic-level images of the molecule in its natural watery environment.

The results are published online in advance of print in the journal [Advanced Materials](#).

The molecule, ferritin, is a highly conserved protein that regulates the levels of iron in animals and plants. Ferritin can sequester excess iron, which can be toxic, and release it when it is needed.

"We found a way to encapsulate a liquid sample in two very thin layers of graphene — sheets of carbon that are only one atom thick," said Canhui Wang, UIC graduate student in physics and first author of the study.

Electron microscopes let researchers see at the level of individual atoms. But to do so they must put the samples in a vacuum, making it impossible to image biomolecules in water in their natural, functional state. Biological samples have usually been placed in a container called a "liquid stage," wedged between relatively thick windows of silicon nitrate.

<https://news.uic.edu/graphene-sandwich-improves-imaging-of-biomolecules> 20140220

More Examples

Our own TJ Ha comparing a ribosome to a sewing machine

(http://news.illinois.edu/news/14/0212ribosome_TaekjipHa_ZaidaLuthey-Schulten.html)

Reaction to Stephen Hawking's assertion last month that black holes do not exist, including an analogy in the title of the article

<http://www.newscientist.com/article/mg22129552.400-fiery-black-hole-debate-creates-cosmological-wild-west.html#.Uvj7TLSHT9U>

Several analogies and a cool video from our own Steve Grannick:

http://news.illinois.edu/news/12/1121synchronized_self-assembly_SteveGrannick.html

Michigan Tech

Analogies that are just similes

- Bacterial chromosomes are like spaghetti.
- Blood vessels are like highways.
- The camera is like an eye.
- The cell is like a factory.
- A nuclear reaction is like falling dominoes.
- Electricity is like flowing water.
- The immune system is like a police force.
- The internet is like an information superhighway.
- The muon is like a heavy electron.