

CHAPTER 2

THE EVOLUTION OF THE CONCEPT OF A FIELD (or: Reality is a Concept)

- Our concept of physical reality is still changing.
- early views were primarily mechanistic.
- by ~1800's, this approach peaked out.
- the mechanical view works well for most things but does not work well for E+M.
- here we will briefly discuss the rise & fall of the mechanical view and the rise of the contemporary way of looking at things in E+M: field theory.
- first a look at the mechanistic view.....

Aristotle:

conceived of force as a physical substance added to a body. This substance imparted to a forced body (say, a rock) gradually left the body as the rock came to rest.

This was wrong.

Galileo

This was considered correct until Galileo changed people's view of reality.

Galileo separated out the concept of force and resistance to motion (friction).

Newton

Soon after Newton codified this new view in his LAW OF INERTIA:

"apathy reigns supreme."

These early investigators and their contemporaries struggled with these abstract concepts of inertia, force, energy, mass, etc. They formulated their conclusions only after extensive experimental study.

Thus: These fundamental concepts are experimentally based. Therefore they are subject to constant revision!

Define mass

Define force

TOOLS

- These "laws" implied precision.
- Tools were developed to supply the needed precision in language:
 - vectors
 - Calculus

MASS

- 2 types of mass
 - gravitational
 - inertial
- experimentally identical!
- classical physics assumed this identity to be accidental.
- Modern physics says that this is fundamental
gen. thr. of relativity

HEAT

- It wasn't till ~ 1800's that heat was discovered to be a form of energy, not a substance!
(motion)

Conclusions of physicists of the 1800's :

1) $\Delta M = 0$

2) $\Delta E = 0$

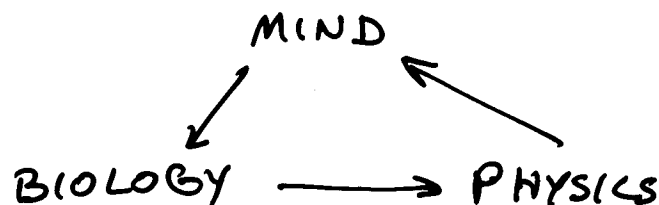
Philosophical Basis of Scientific Inquiry:

It was assumed that a unified ^(mechanical) theory (which could explain everything) did exist.

Implicit in this was the belief that the concept of reality was (and is) unique.

E & M investigations blew the cover on that theory. A revised set of laws resulted, in which the old mechanical are a subset.

The search continues. Indications are that there is no unique reality.



THE DECLINE OF THE MECHANICAL VIEW

- electrostatic forces found to exist.
- Force $\sim \frac{1}{r^2}$ like gravity.
- +ve & -ve charges.
- magnetic forces^(static) found to exist
- Force $\sim \frac{1}{r^2}$ also.
- can deal with all this under conventional view even though new particles had to be invented.

But ~1800's Oersted related magnetism to a current.

Problem: Force perpendicular to current direction & to magnetic direction.

- This was a new phenomenon.

~1880 Rowland got same effect by spinning a charge.

So we have a force not parallel to initiating forces & not $\sim \frac{1}{r^2}$. Depends on velocity of charge. This was the first shake of the mechanistic view.

Another problem area

- The mechanical view of light required "particles" or corpuscles to be invented.
- Can explain reflection
refraction
rectilinear motion.
- Colour in white light (Newton + prism) explained by more corpuscles.
- The concept of waves was introduced to explain interference patterns.
- Still mechanistic: compare to water waves which are transverse and air waves which are longitudinal.
- but need a medium for the waves

ether. ← another new substance.

ETHER

Paradox:

- 1, Planets travel thru space without resistance
- 2, Ether is everywhere
- 3, \therefore ether does not interact with matter
- 4, Velocity of light different in different media. \therefore ether does interact.

ie CONTRADICTION

All this points to a flaw in the fundamental assumption:

THE MECHANICAL VIEW

Problems so far:

- 1, Unnoticed clue of grav. mass = inertial mass
- 2, Artificial character of electric & magnetic fluids
- 3, Perpendicular forces
- 4, Ether

CONCLUDED THAT THE SOURCE OF THE FIELD IS NOT IMPORTANT IN DETERMINING HOW FIELDS INTERACT.

BUT THE FIELD IS IMPORTANT.

THE DYNAMICS OF THE FIELD ARE IMPORTANT:

changing magnetic field \Rightarrow electric field
(Faraday)

changing electric field \Rightarrow magnetic field
(Rowland & Øersted)

Energy stored in fields (can get sparks)



CONSERVATION OF ENERGY.

MORE "CONCEPTS"

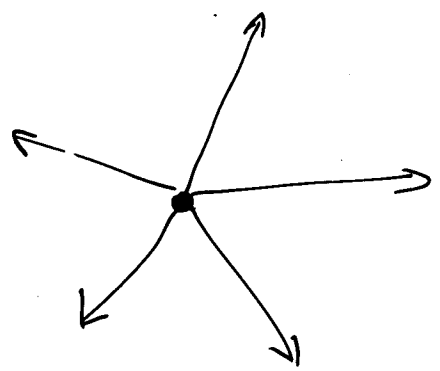
LESS "SUBSTANCES"

FIELD THEORY

1850 \rightarrow 1900 : field theory emerges.

- Faraday
- Maxwell
- Hertz

Graphical concept : LINES

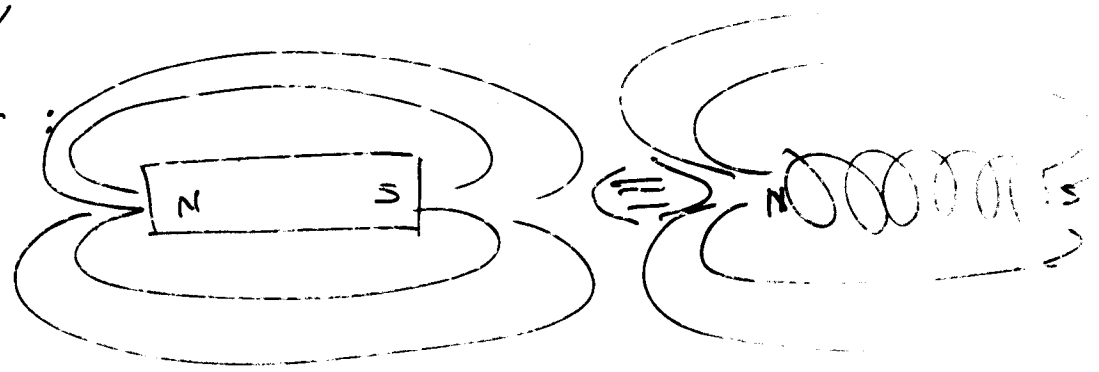


$\frac{1}{r^2}$ behaviour

- NO MATTER
- PROPERTY OF SPACE ONLY
- NO TIME



1ST FRUIT :



SAME LINES

MAXWELL'S LAWS \Leftrightarrow FIELD LAWS

- REPRESENT THE STRUCTURE OF THE FIELD
- DESCRIBE A CONNECTION BETWEEN ELECTRIC + MAGNETIC FIELDS
- DON'T NEED SUBSTANCES

UNEXPECTED RESULTS

- Prediction of electromagnetic waves from oscillating charges.



radiation of energy as transverse waves.



speed of light !

LIGHT + ELECTROMAGNETIC WAVES ARE LINKED ; SAME EXCEPT FOR λ .

EXPERIMENTAL RESULTS ARE NOW FULLY EXPLAINED

IF WE ONLY KNEW WHAT A FIELD WAS !