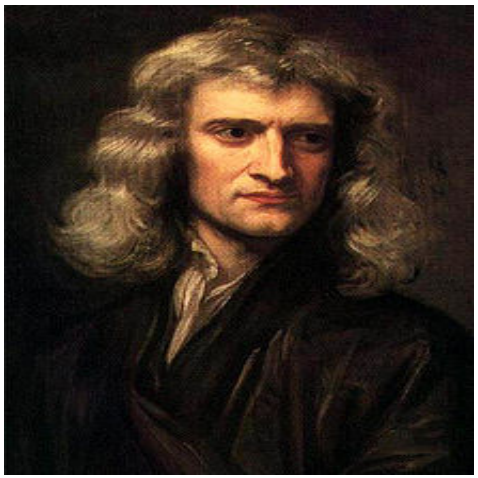
Do we live in eleven dimensions?

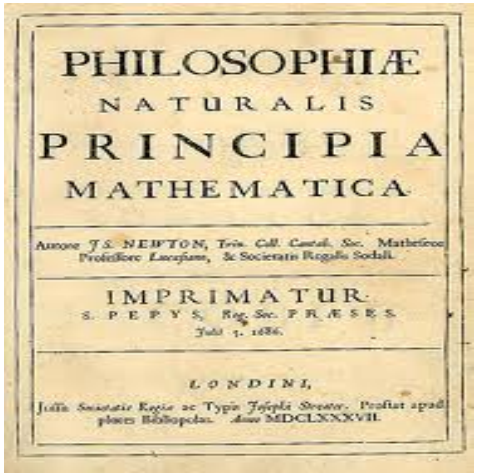
Maciej Dunajski

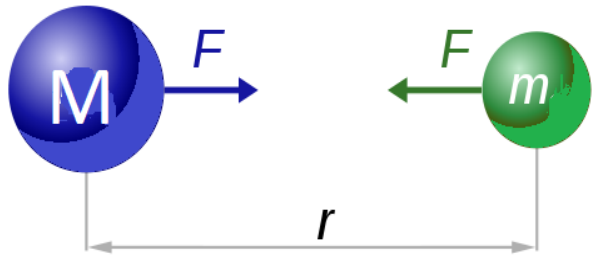
Clare College
and
Department of Applied Mathematics and Theoretical Physics
University of Cambridge

Newton's law of gravitation

- Isaac Newton, 1687. Gravitational force is proportional to the product two masses, and inverse proportional to the square of the distance







,

$$\text{Force} = G\frac{M \times m}{r^2}.$$

$$r = \text{distance}, \quad M = \text{Mass}_1, \quad m = \text{mass}_2,$$

$$G = 6.67 \times 10^{-11} = 0.00000000000667$$

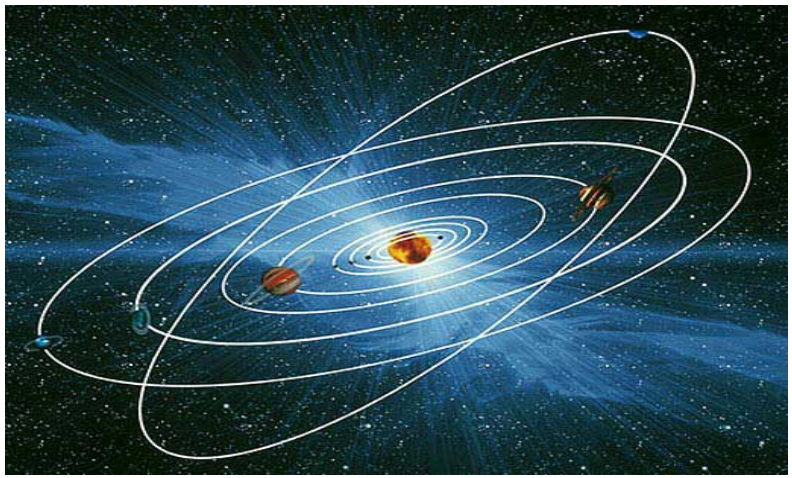
- Newton - physicist, mathematician, astronomer, alchemist, theologian, . . . , Fellow of Trinity College in Cambridge.

Successes of Newtonian Theory

Galileo's Leaning Tower of Pisa. Acceleration a does not depend on mass.

$$a = \text{Force} \div \text{mass} = G\frac{M \times m}{r^2} \div m = G\frac{M}{r^2}.$$

Planetary orbits



Problem with singularity

- Newton's Law

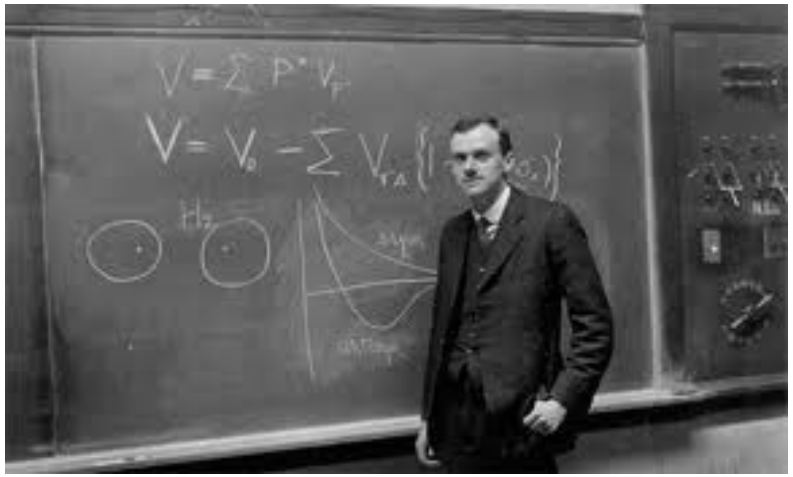
$$\text{Force} = G\frac{M \times m}{r^2}.$$

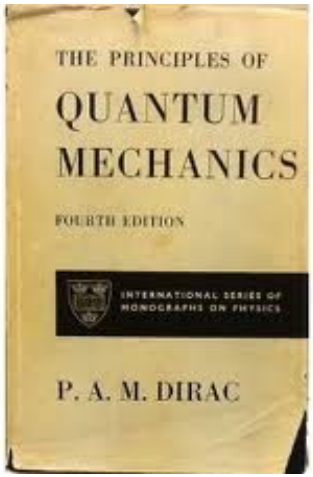
- Some maths

$$10^{-3} = 0.001, \quad \frac{1}{10^{-3}} = 10^3 = 1000.$$

- Small distance=big force.
- Small and dense objects exert huge gravitational force.
- . . . very dense objects become black holes - everything, including light is sucked inside a black hole by its gravitational force.
- Squeeze the Earth into a size of a peanut $\rightarrow$ Black hole!

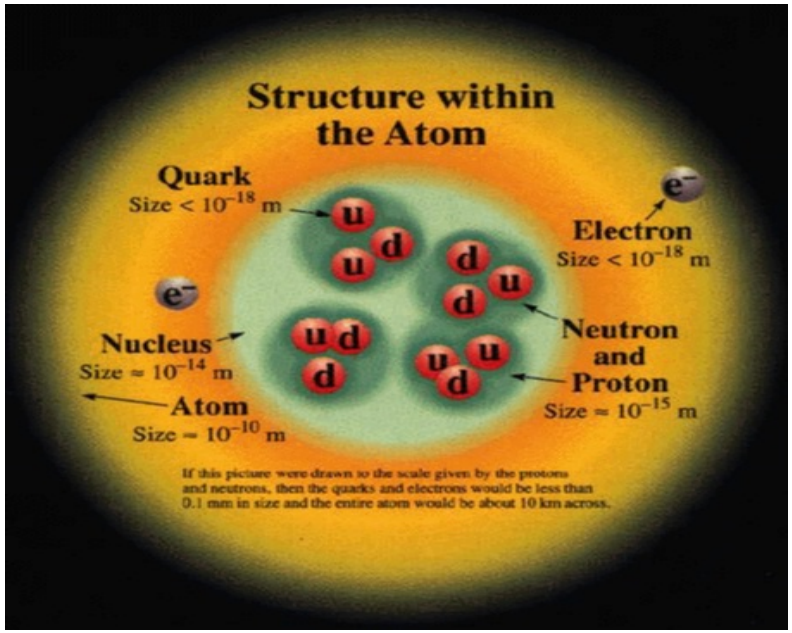
Quantum Physics





- Paul Dirac – Fellow of St Johns College in Cambridge.
- Dirac on poetry: *The aim of science is to make difficult things understandable in a simpler way; the aim of poetry is to state simple things in an incomprehensible way. The two are incompatible.*

Quantum Physics - physics of small things



Δ =uncertainty.

$$\Delta(position) \times \Delta(velocity) > 0.0000001 \frac{meter^2}{second}.$$

The more precisely the position of a particle is determined, the less precisely the velocity is known (and vice versa).

Quest for the Theory of Everything

- Biology

↓

- Chemistry

↓

- Physics

↙ ↘

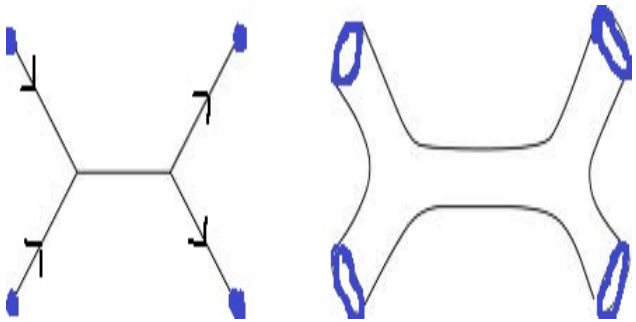
Gravitation Quantum

↘ ↙

- *One ring to rule them all*

Quantum physics meets gravitation

- Quantum Mechanics - physics of small things: electrons, protons, quarks,. . . , lasers, electronics.
- Gravitation - physics of big things: planets, stars, black holes, . . . , GPS, space travel.
- Idea - microscopic strings are more elementary than particles. Different particles - vibration modes of one string.
- Particle collisions vs String collisions



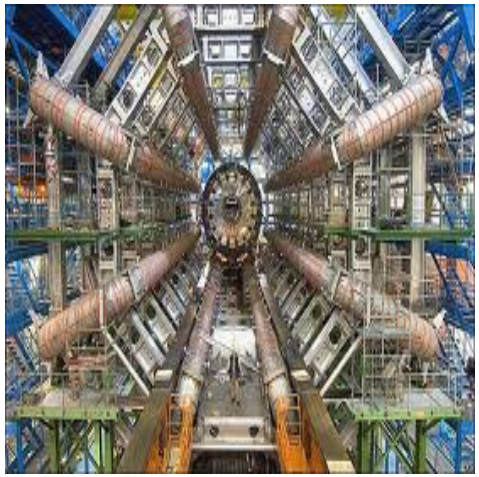
- Mathematics - string theory requires eleven dimensions - ten space + one time! M Theory.

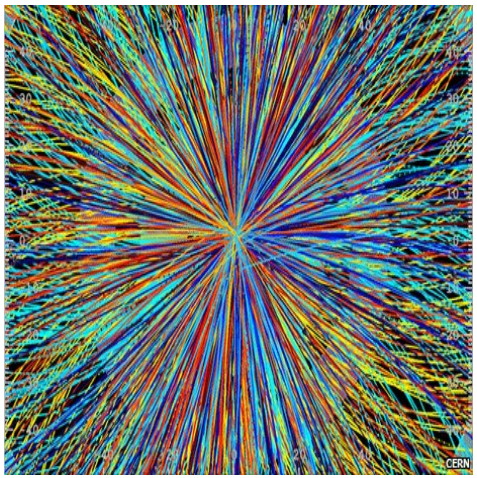
How to look for higher dimensions?

Look closer!

How to look for higher dimensions?

Large Hadron Collider (CERN, Geneva)



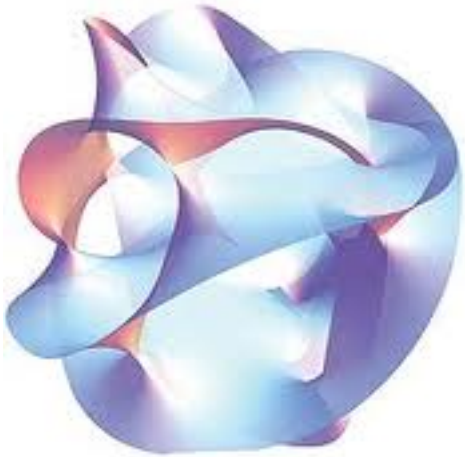


Higher dimensions predict new particles. *'Look closer'* - particle collisions.

11–dimensional world

Space–time=Time $\times$ Space $\times$ Hyperspace

$$11 = 1 + 3 + 7$$



Finale

- Question with no practical consequences.
- Intriguing nevertheless . . .
- No definitive answer so far.
- Needs new ideas, new mathematical tools.

Thank You !!!