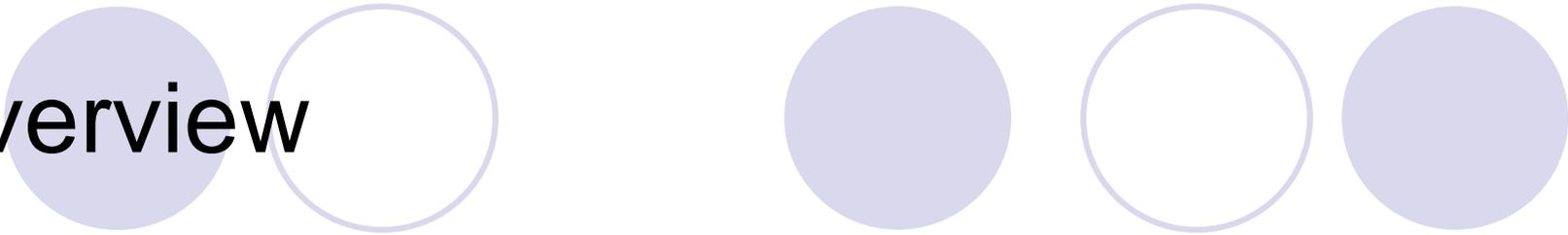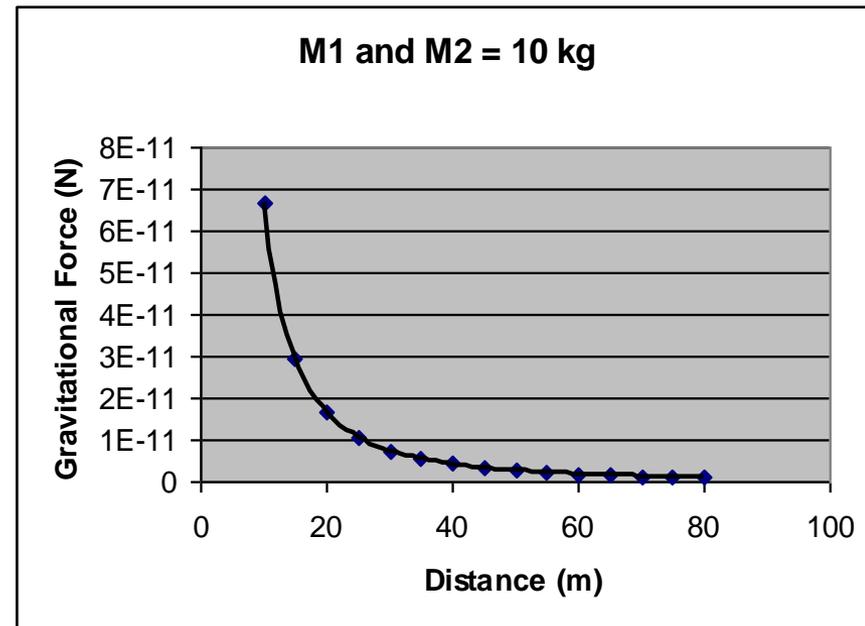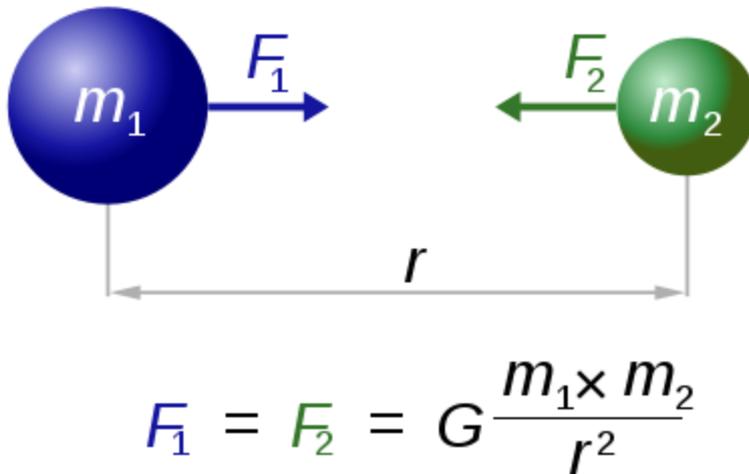# Gravity & Graviton

Abd Elrahman Ahmed Elsaid

Overview

- Newton's Gravity

- General Relativity

- Graviton

- Kaluza – Klien Theory

- Randall-Sundrum Model

- Graviton Production and Di-EM Decay Channel

Gravity

In 1687, Sir Isaac Newton published *Principia*, which hypothesizes the inverse-square law of universal gravitation

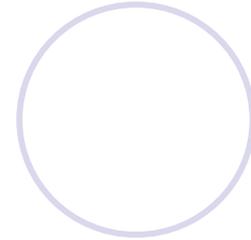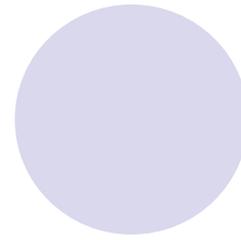$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

M1 and M2 = 10 kg

Defects in Newton theory

•Newton didn't know what *caused* gravity

•One of two objects depend on other at through the distance so it not depend on other masses

•The Instantaneous effect of the force.

•It does *not* predict the precession of Mercury's perihelion, nor does it explain it
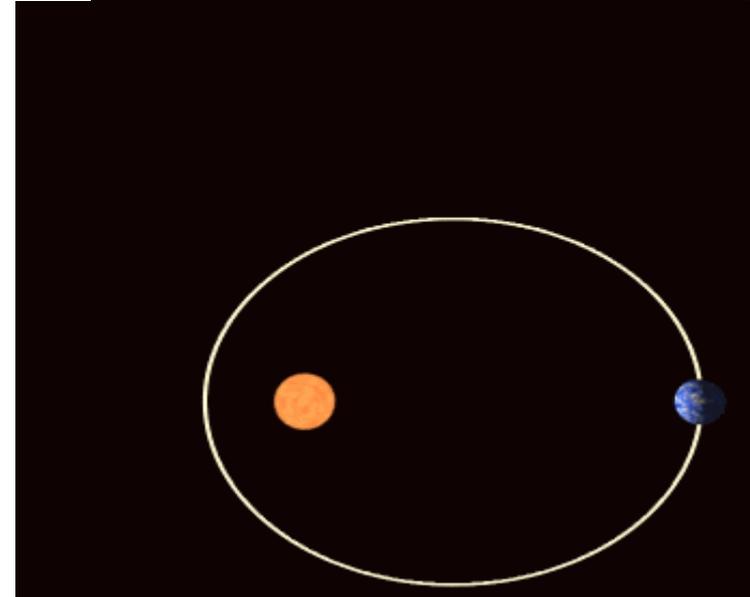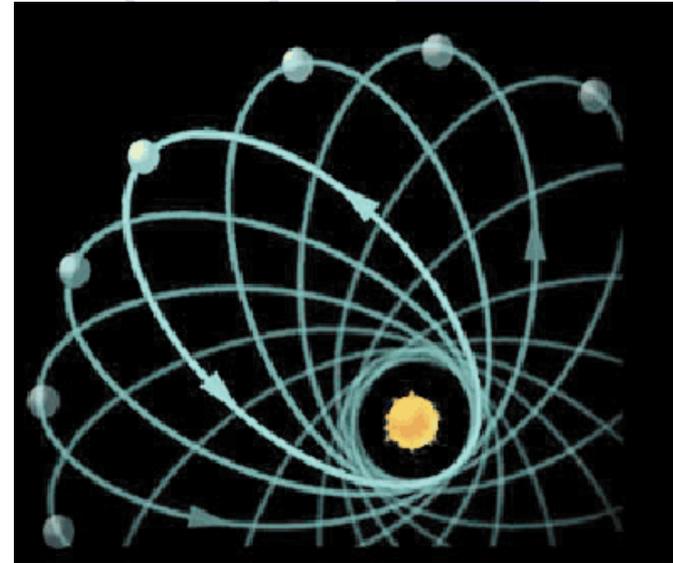
General Relativity
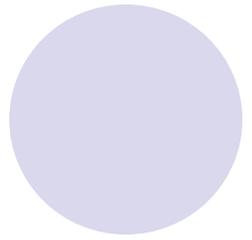
•General relativity is the extension of special relativity

•According to Einstein, massive bodies cause a curvature in space-time, Gravity feels strongest where space time is most curved so
"matter tells space-time how to curve, and curved space-time tells matter how to move"

•According to Einstein, gravity It's an effect caused by the curvature of space-time by massive bodies.
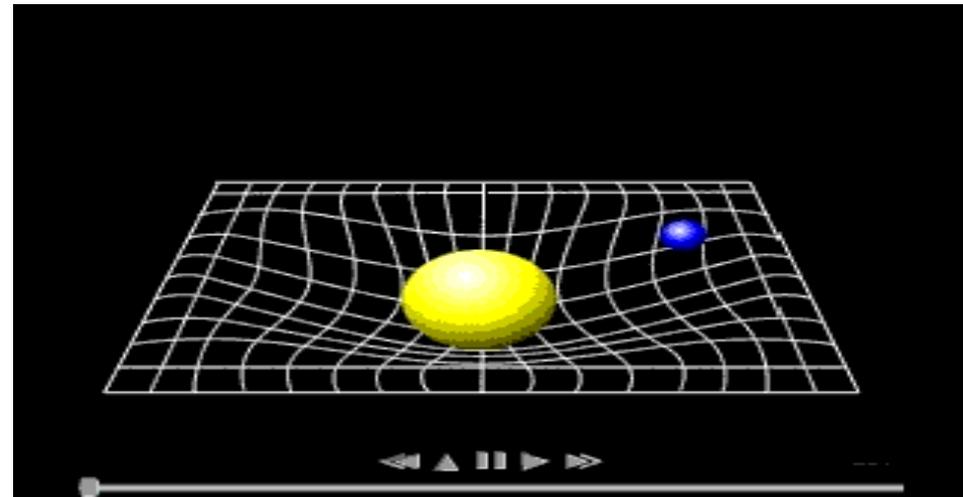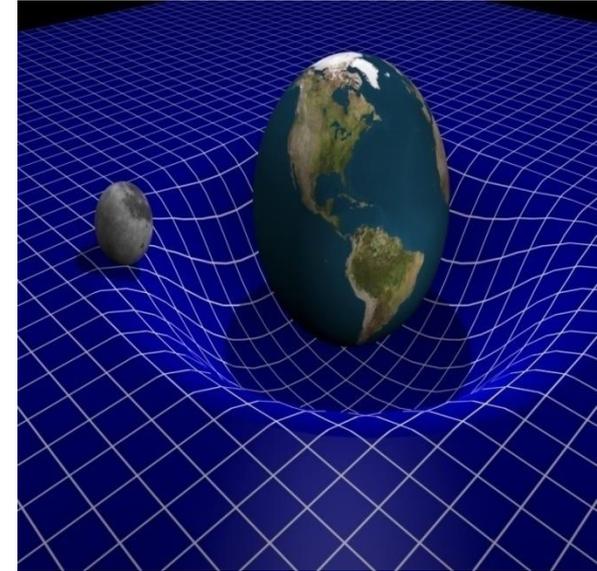
Testing relativity

Real   Observed
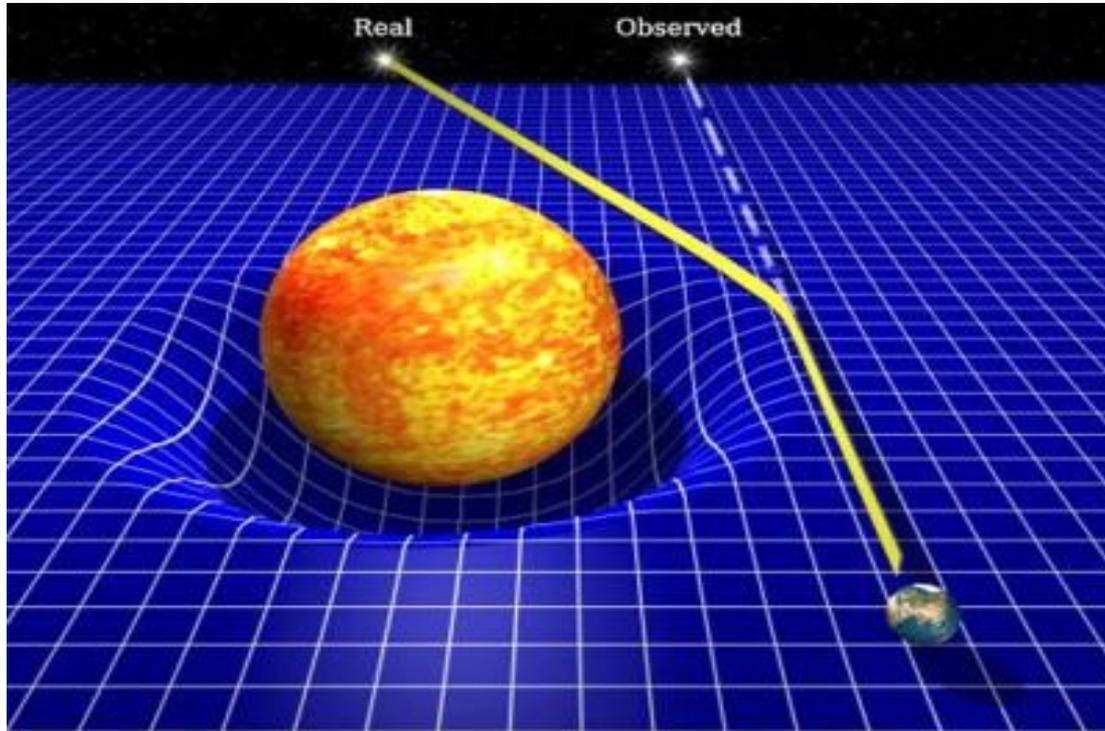
Arthur Stanley Eddington (1882–1944). In 1919 Eddington

Force In Nature

According standard model

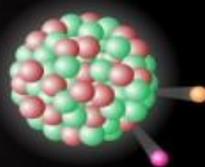## Weak Nuclear Force

Converting protons into neutrons
When two protons collide and fuse, a disruption in the weak nuclear force emits a positron and neutrino, which converts one of the positively charged proton to a neutrally charged Nuetron. Without the weak nuclear force converting protons into nuetrons, certain complex nuclei cannot form.

Releasing radiation
Heavy atoms have an imbalance of protons and nuetrons, so the weak nuclear force converts protons to nuetrons releasing radiation.

Gravity

Center of Mass

The Sun and the planets all orbit a shared center of mass
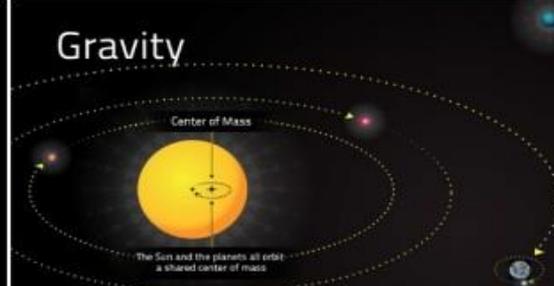
Adding motion to the Universe
Gravity forms stars, planets, and moons, and forces these objects to spin on an axis and move along an orbital path. The planets appear to be orbiting the center of the Sun, but the Sun and planets all orbit a shared center of mass. Planets with enough mass can develop orbiting moons or rings of debris.
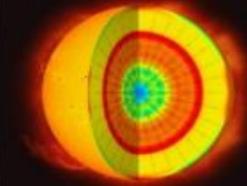
Creating energy
Gravity is the force that creates pressure and fusion energy in the core of stars allowing them to burn for millions of years.

## Electromagnetic Force
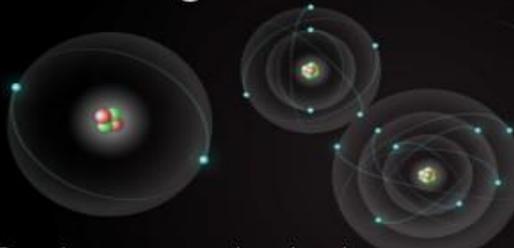
Forming atoms and molecules
The electromagnetic force pulls negatively charged electrons into bound orbits around positively charged nuclei to form atoms and molecules. As a gas cools, electrons will find their way into the presence of atomic nuclei. Larger nuclei with a greater positive charge pull in more electrons until atoms and molecules have a balance of charges.

Generating light
When a negative electron interacts with a positive proton, the electromagnetic force adds energy to the electron generating a photon.

Strong Nuclear Force
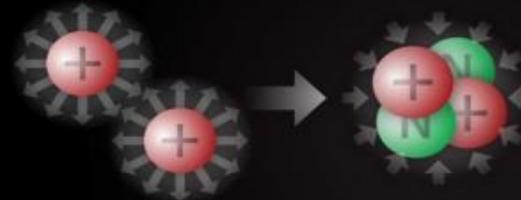
Binding protons in atomic nuclei
Positively charged particles naturally repel each other, it takes an extreme amount of force to hold protons together. The strong nuclear force overcomes the repulsion between protons to hold together atomic nuclei. Without the strong nuclear force, complex nuclei cannot form.
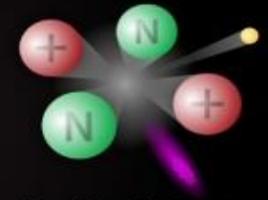
Breaking the bond
Enormous energy is released as gamma rays and nuetrinos when the strong nuclear force is broken between protons and neutrons.
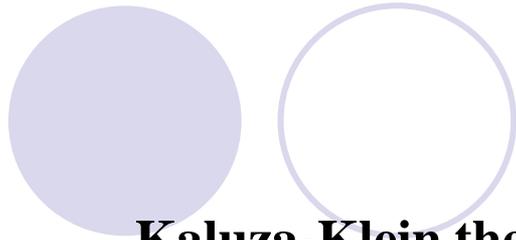
Graviton
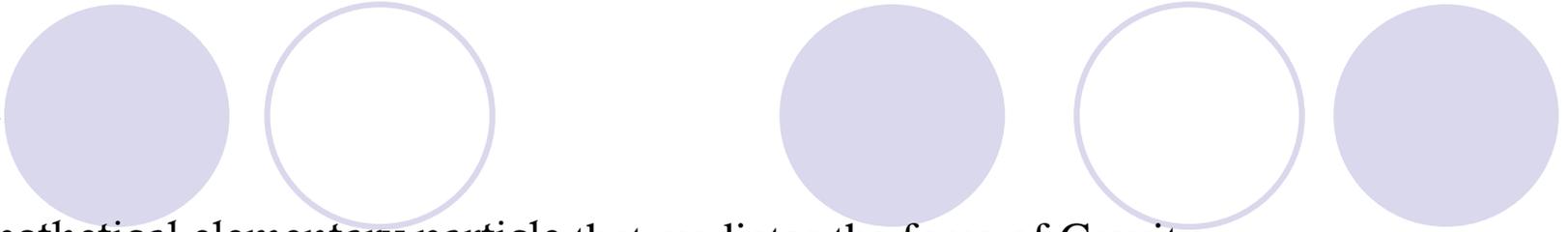
Is a hypothetical elementary particle that mediates the force of Gravity

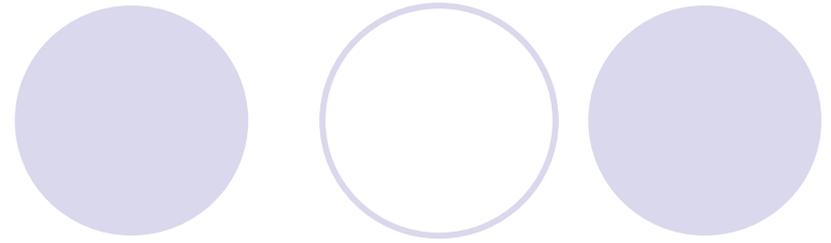If it exists, the graviton is expected properties to be according standard model
1. massless
2. Spin = 2
3. charge = 0 e

In the SM, there is a so-called **"Hierarchy Problem"** about different energy scales , namely the question why the weak force is stronger than gravity by large scale

•Possible explanations: SUSY, Extra Dimensions or Randall–Sundrum models

Kaluza-Klein theory

It added a fifth dimension to the general relativity

Kaluza & Klein tried to unify gravity and electromagnetism in five-dimensional general relativity that contains both Einstein's four-dimensional theory of gravity and Maxwell's theory of electromagnetism

The problem in this theory that it suppose gravity only could propagate in the 5th-dimension

Figure 1: *The founders of original KK theory, Theodor Kaluza (left) and Oskar Klein (right)* [1]

The Randall-Sundrum Model

A five-dimensional geometry is assumed, in which the fifth dimension is compactified with length of the Extra dimension
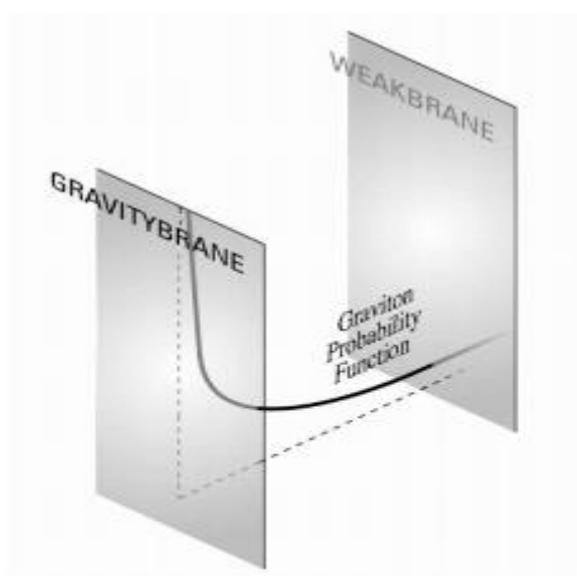
There is two branes WeakBrane and GravityBrane

Figure 2.1: Schematic view of Randall-Sundrum model where the graviton is the only particle propagating in the extra dimension.

Collider Signals

The KK excitations of the gravitons are strongly coupled at the weak
scale with a mass gap of ~ TeV size. They can be produced resonantly
at the Tevatron through quark-antiquark annihilation or gluon-gluon
fusion, and would subsequently decay to pairs of SM fermions or
bosons. For example, the Feynman diagrams for virtual graviton
exchange in the Dielectron and Diphoton channels considered in this
analysis
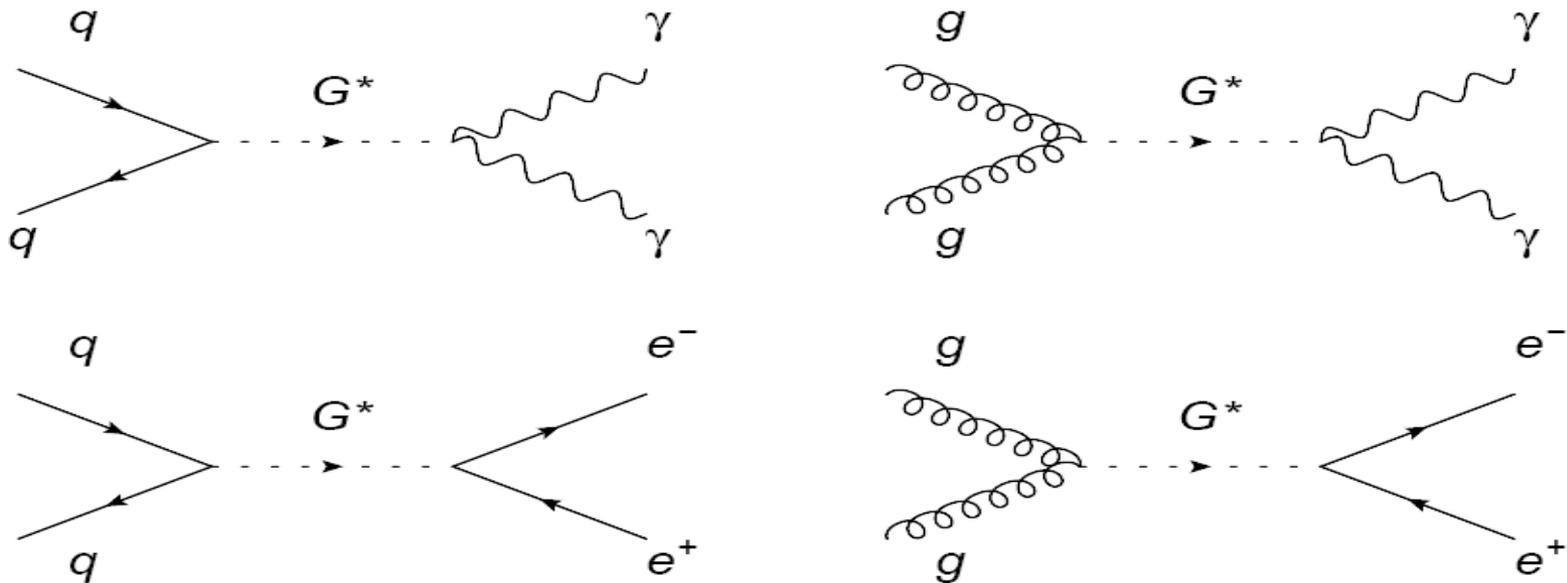
Tevatron


Fermilab Accelerators
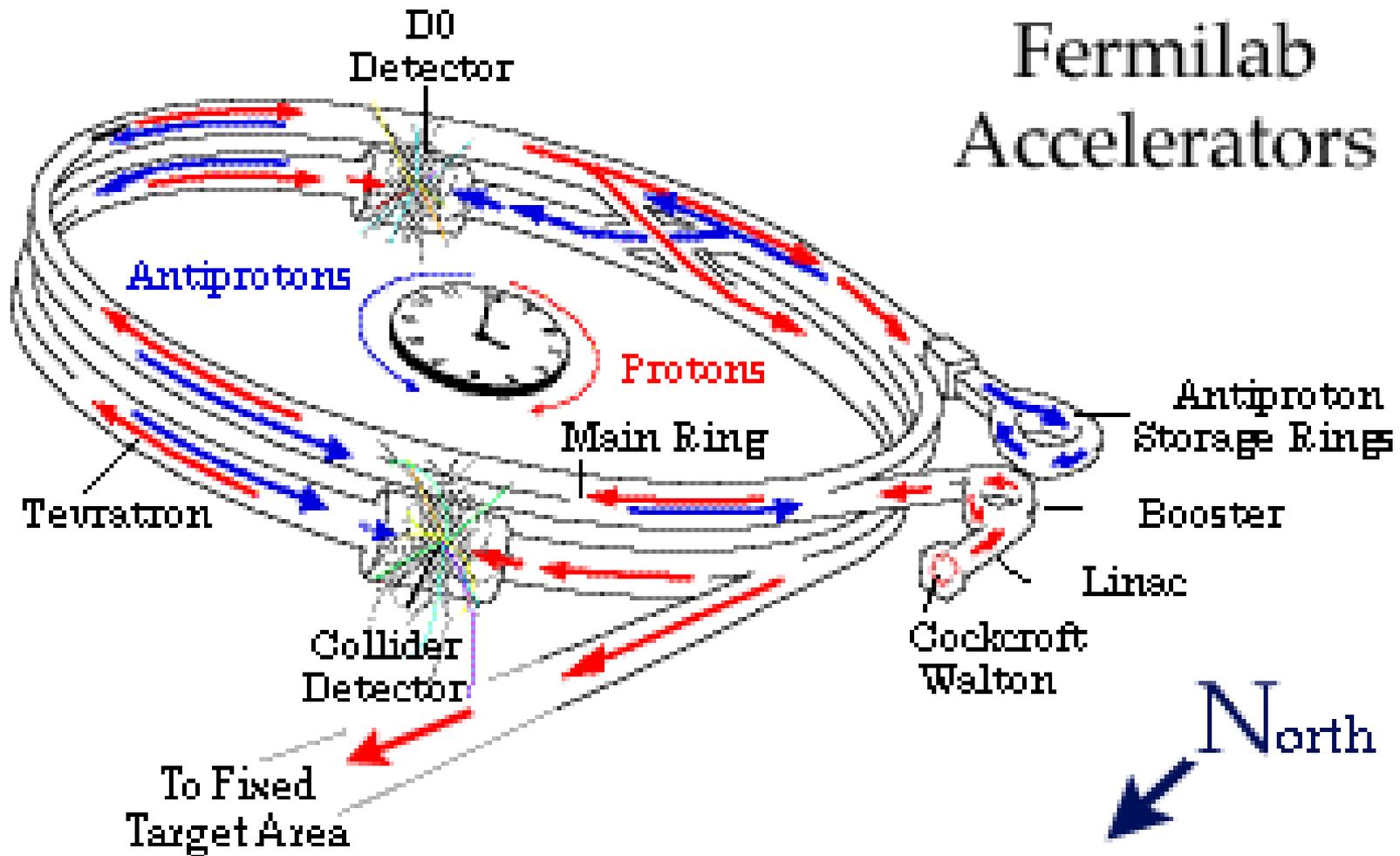
The contributions from quark-antiquark annihilation and gluon-gluon fusion at the Tevatron proton-antiproton collider

Quark-antiquark annihilation dominates the cross section for graviton masses above 200 GeV, since the gluon-parton distribution function f(x) is smaller than that of the valence quarks for the larger values of the momentum fraction x that are required to produce heavy gravitons.
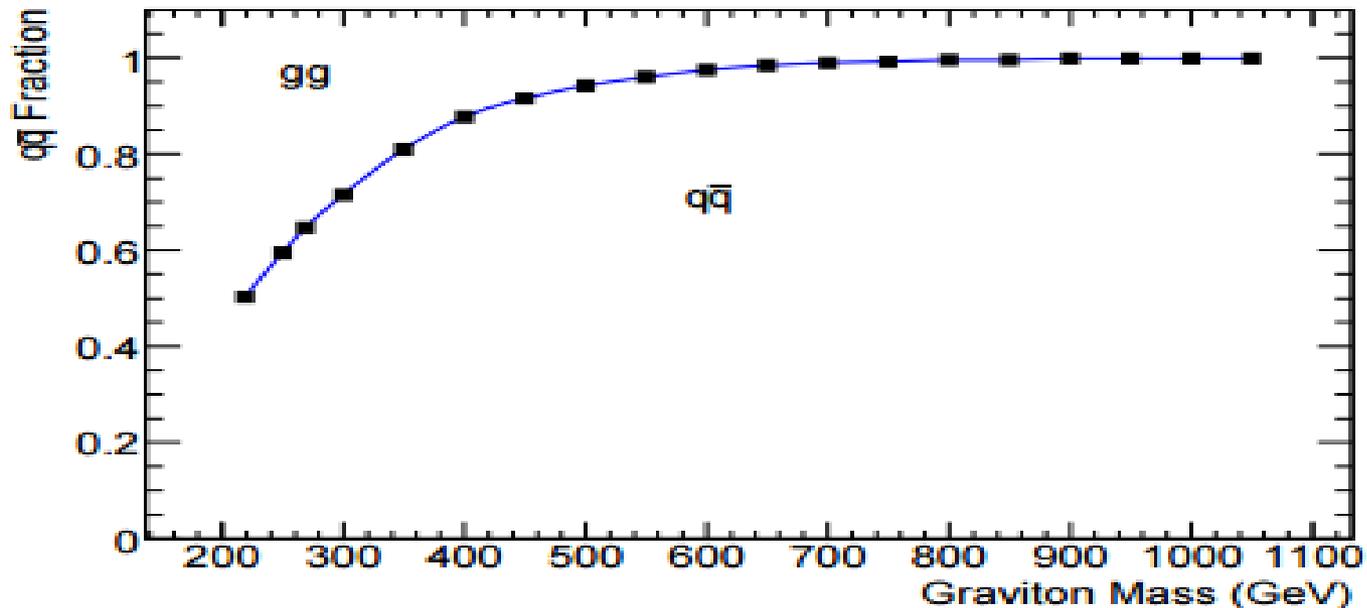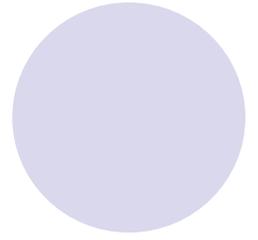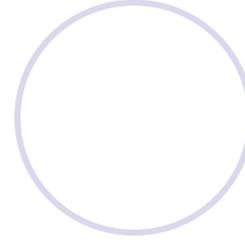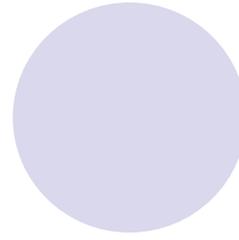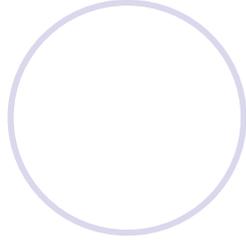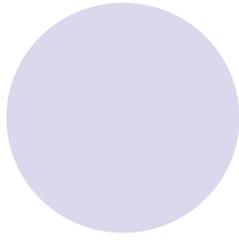
Graviton at Tevatron

The graviton signature is a series of heavy resonances, Kaluza-Klein excitations with separation among each other of order TeV the first excitation of 700 GeV as would be seen at the Tevatron
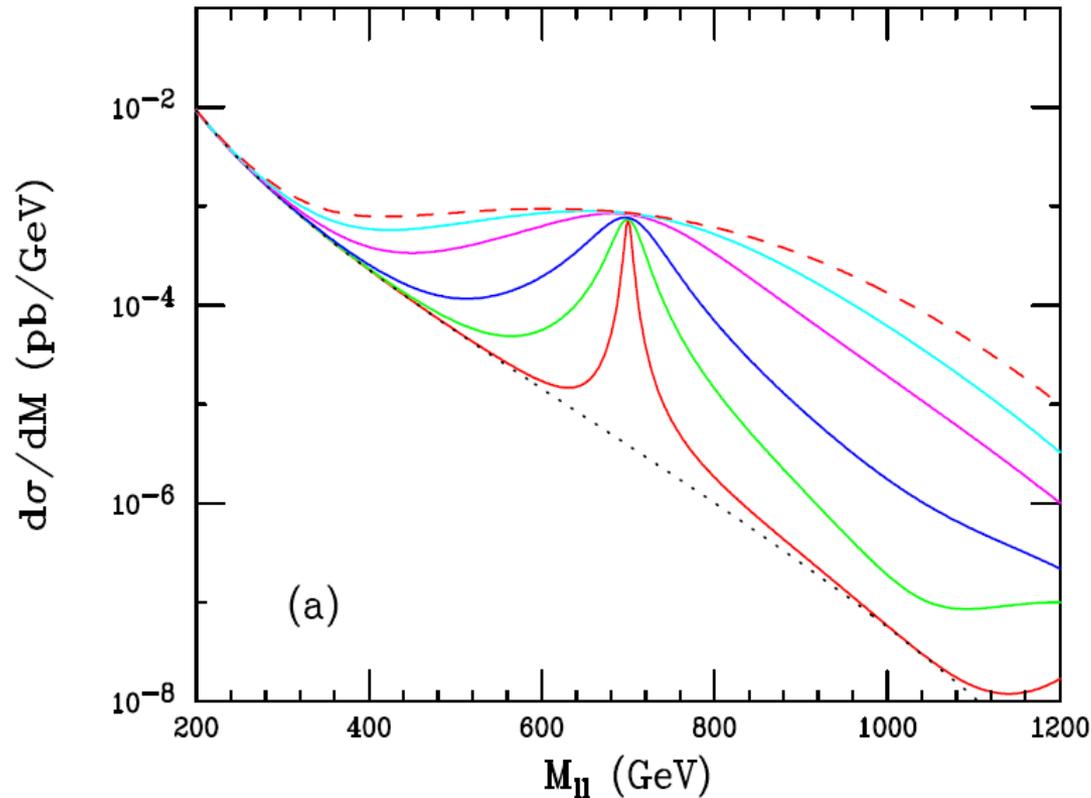
Production cross-section for 700 GeV RS graviton at the Tevatron with coupling constant 1, 0.7, 0.5, 0.3 and 0.1, from top to bottom.

Thank you ☺