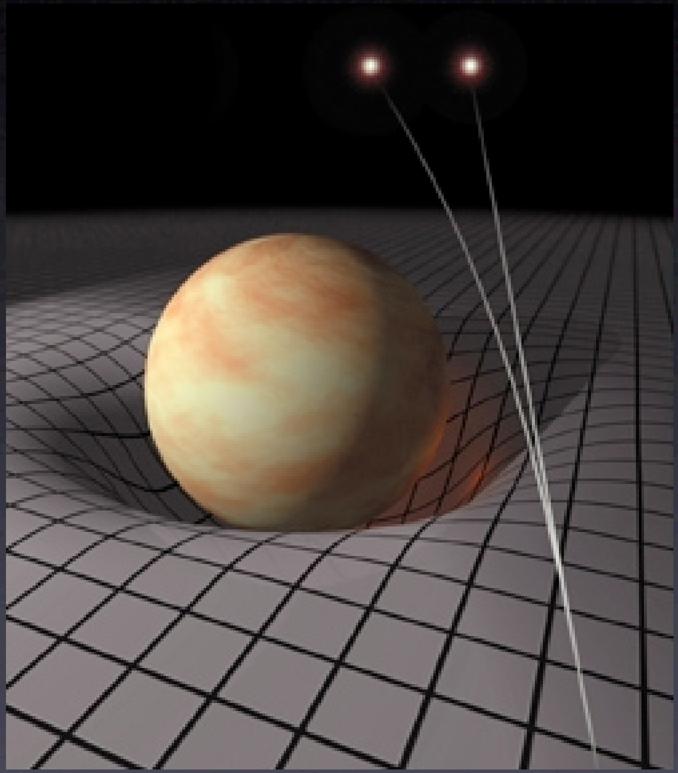
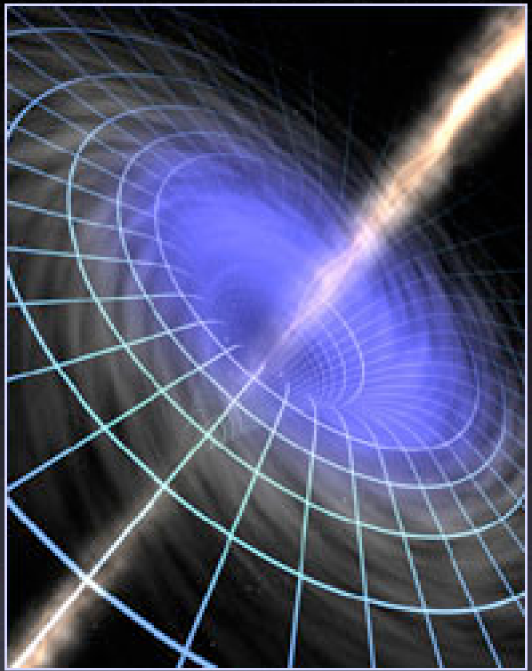
General Relativity



Lecture 1: Introduction to Concepts in GR

1.0 What is General Relativity?



- a relativistic theory of gravity
- the generalisation of Special Relativity to include gravity

1.1 Newtonian Gravity vs. Relativistic Gravity

Newtonian gravity:

- requires *inertial reference frames*, but do non-accelerating reference frames actually exist, when gravity is *everywhere*?
- requires that gravity is felt instantaneously at a distance, but we know from Special Relativity that nothing can propagate faster than c
- requires $g \propto r^{-2}$ but Special Relativity says distance is not absolute; also, since g is the same for all objects, then *gravity is locally undetectable*

1.2 Einstein's Equivalence Principle (EP)

$$m_i \equiv m_g$$

inertial mass equivalent to gravitational mass

- ➡ locally, cannot distinguish between an accelerated reference frame and a reference frame in a gravitational field, so Special Relativity applies
- ➡ locally, free-fall in a gravitational field must be equivalent to constant (i.e. straight-line) motion
- ➡ non-constant motion must be due to the curvature of spacetime!

1.3 Consequences of EP

- concept of a gravitational force disappears in a locally intertial reference frame (LIF), so Special Relativity holds

- LIFs are simply any freely-falling frames

$$E = mc^2 \Rightarrow$$

1. light bends in a grav. field
2. photons are redshifted

1.4 Einstein's Field Equations

$$G_{\mu\nu} = 8\pi T_{\mu\nu}$$

spacetime geometry = mass-energy distribution

(Einstein tensor) (stress-energy tensor)

mass curves spacetime geometry

spacetime geometry determines how mass moves