Theory of Relativity

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Theory of Relativity – Special relativity

1.The principle of relativity:

The laws of physics are the same for all observers in uniform motion relative to one another.

2. The principle of the constancy of the speed of light:

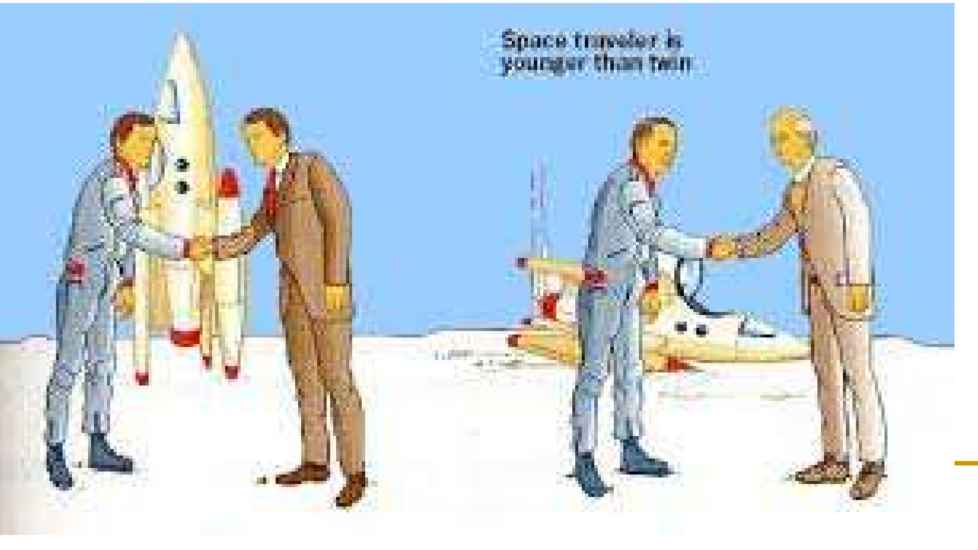
The speed of light in a vacuum is the same for all observers, regardless of their relative motion or of the motion of the light source.

Dilation of time:

("in reference frames in relative motion, time passes more slowly")

$$\Delta t = \frac{\Delta t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Δt – the time interval measured in a reference frame in relative motion ("a clock in a rocket"),
Δt_0 – the time interval measured in a reference frame at relative rest ("a clock on the Earth"),
v – relative velocity of the moving reference frame,
c – speed of light in vacuum.

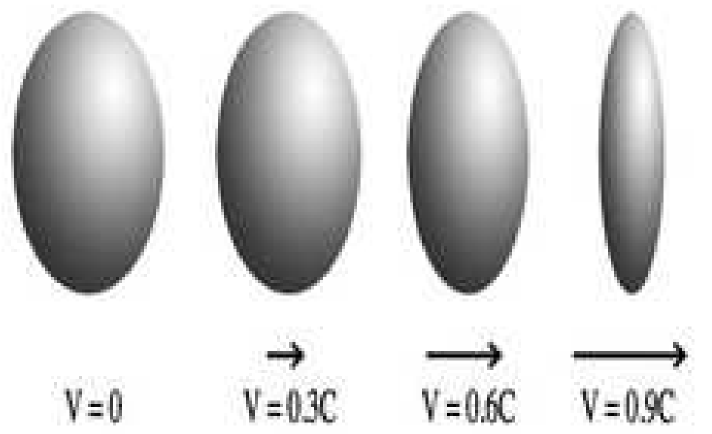


Contraction of length:

("The length of a body measured by an observer who is at rest with respect to the object being measured is called the rest length. All observers in motion relative to the first observer measure a shorter length but only for dimensions along the direction of motion.")

$$l = l_0 \cdot \sqrt{1 - \frac{v^2}{c^2}}$$

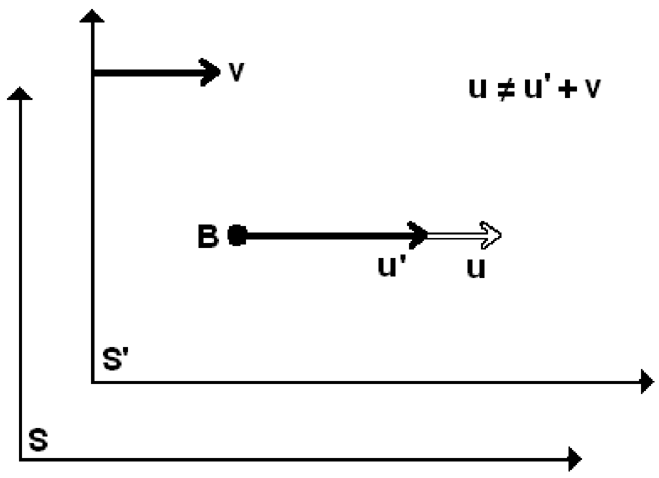
,
l – length of a body measured by the observer in motion with respect to the body,
l_0 – length of a body measured by the observer at rest with respect to the body,
v – relative velocity of the observer with respect to the observed body,
c – speed of light in vacuum.



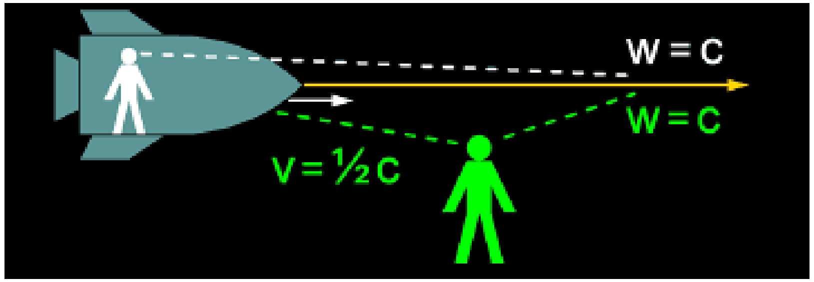
Relativistic addition of velocities:

When a body B moves with a velocity *u’* in the direction of the x-axis with respect to the reference frame S’, and this frame simultaneously moves with respect to the reference frame S at velocity *v* in the same direction, the body B then moves with respect to S at velocity *u*:

$$u = \frac{u' + v}{1 + \frac{v.u'}{c^2}}$$



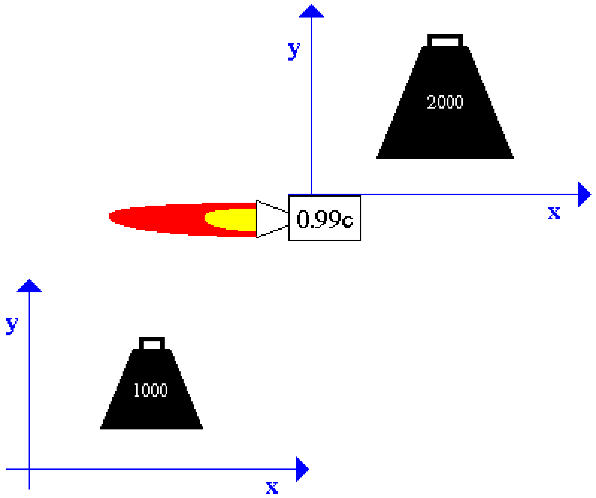
$u \neq u' + v$



Relativistic mass:

("the mass of a body increases with its velocity")

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$



an objects mass increases as it approaches the speed of light

where m_0 is the rest mass of the body, and m is its mass at the speed v.

Energy and mass equivalence principle (Einstein energy equation):

Under certain circumstances, energy can be transformed into mass or mass can be transformed into energy. The following formulas belong to the general theory of relativity (contrary to the previous formulas which are involved in the special theory of relativity).

$$\Delta E = \Delta m c^2$$

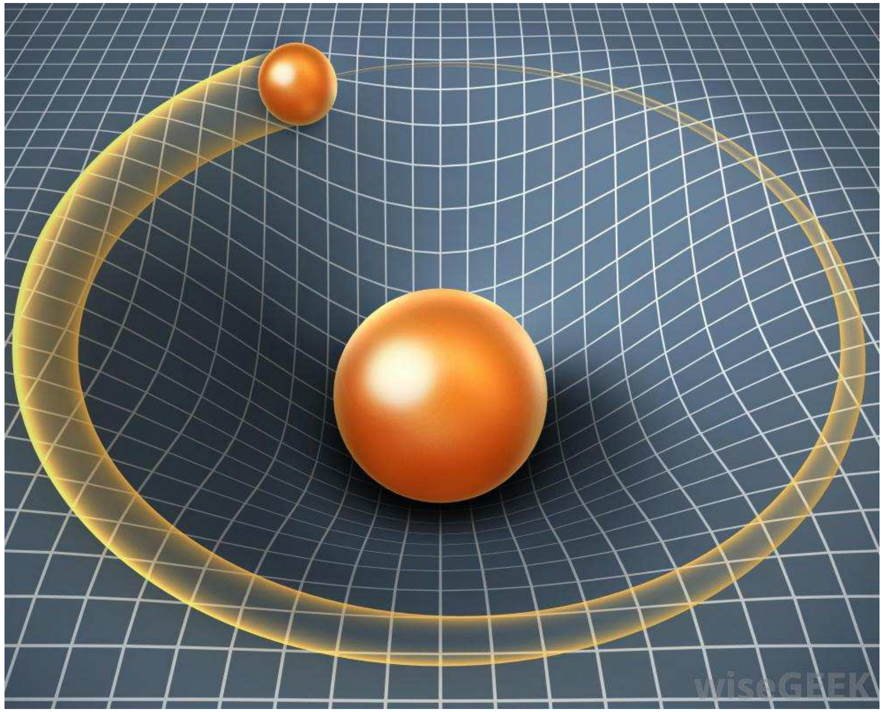
$$E = m.c^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \quad \text{(in motion)}$$

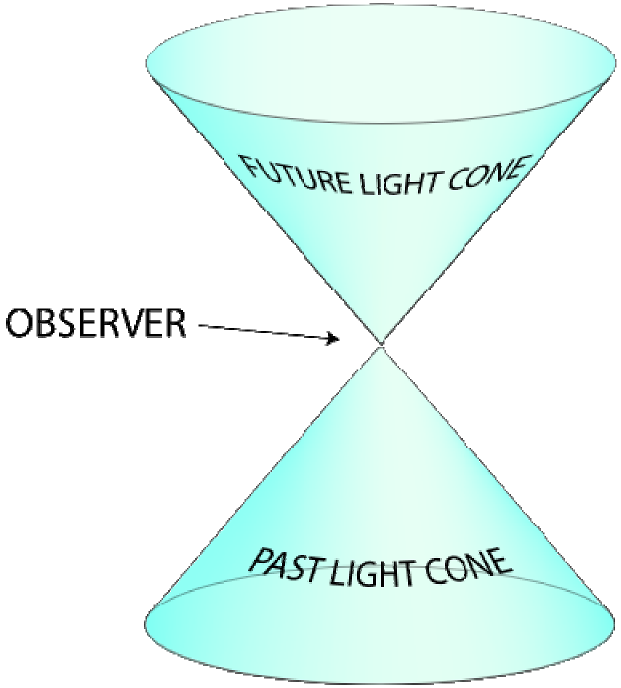
$$E_0 = m_0 c^2 \quad \text{(in rest)}$$

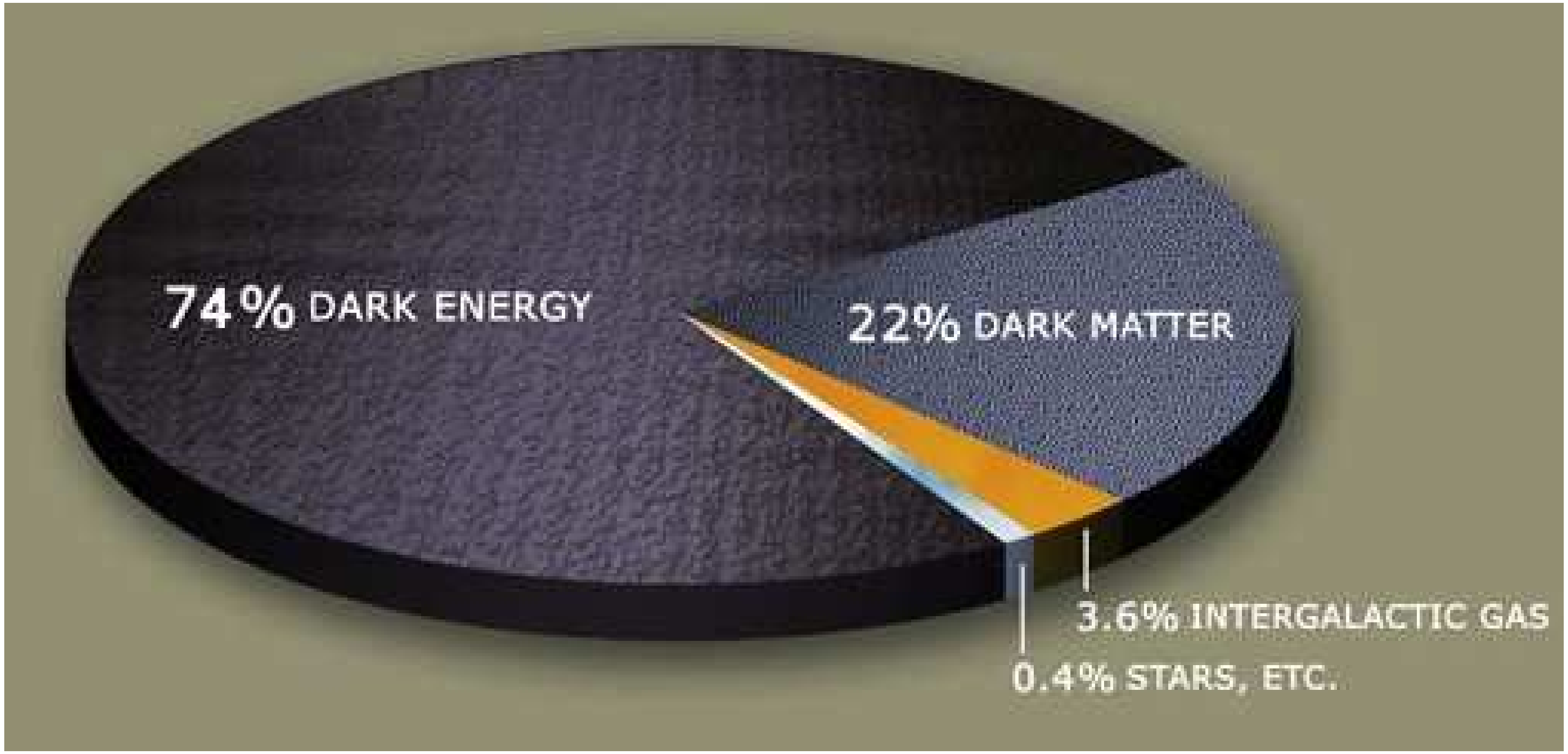
All the relativistic phenomena are well manifested when the velocities are comparable with the speed of light. They are scarcely observed in everyday life. The theory of relativity is of special importance in physic of elementary particles and in cosmology.

Theory of Relativity – General relativity

General relativity is a theory of gravitation whose defining feature is its use of the Einstein field equations. The solutions of the field equations are metric tensors which define the topology of the spacetime and how objects move inertially.






74% DARK ENERGY
22% DARK MATTER
3.6% INTERGALACTIC GAS
0.4% STARS, ETC.

Quantum Mechanics: Heisenberg uncertainty relations

$$\delta r . \delta p \geq h/2\pi$$

$$\delta E . \delta t \geq h/2\pi$$

The position *r* and momentum *p* of a particle cannot be simultaneously measured with independent precision (if the uncertainty of particle position – δr – is made smaller, the uncertainty of particle momentum – δp – automatically increases). The same holds for the simultaneous measurement of energy change δE and the time δt necessary for this change.