The cosmic velocities

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INTRODUCTION

The cosmic velocity - the initial velocity which a body must have to be able to overcome the gravity of another object.
We have:

1. The first cosmic velocity
2. Second cosmic velocity (escape velocity)
3. The third cosmic velocity
4. The fourth cosmic velocity

1. The first cosmic velocity

As you know the satellites which were sent by a human are orbiting around the Earth. They are moving in some circles around the Earth. They had to be launched with a very high velocity, namely, with **the first cosmic velocity**.

Figure 1: Satellite [1]

Now we will calculate the value of this velocity. We will use the formula below:

$$V_I = \sqrt{\frac{GM_z}{R_z}} \tag{1}$$

Where:

- V - the value of the first cosmic velocity
- M - the mass of the Earth
- R - the radius of the Earth
- G - the gravitational constant

We put the data into this formula and we obtain:

$$V_I = \sqrt{\frac{3,98 * 10^{14}}{6,37 * 10^6}} = 7900 \tag{2}$$

$$[V_I] = \left[\sqrt{\frac{m^3 * s^{-2}}{m}}\right] = \left[\frac{m}{s}\right] \tag{3}$$

Satellites must have extremely high velocity to orbit around the Earth.
In fact, satellites go around the Earth on the height h = 160 kms in order not to brake into the atmosphere.

2. The second cosmic velocity

In the previous section we calculated the velocity which a body has to have to go around the Earth, which means that we calculated the value of the first cosmic velocity.
Now it is time to give attention to calculating the second cosmic velocity - it is the speed needed to "break free" from the gravitational attraction of the Earth.
In order to understand this issue we should know something about kinetic and potential energy. I will remind you the formulas for calculating the values of kinetic and potential energy:

$$E_k = \frac{mv^2}{2} \tag{4}$$

$$E_p = -G\frac{M_z m}{R_z} \tag{5}$$

As the body moves away from the Earth, the kinetic energy decreases and the potential energy increases. In the infinity both the energies are equal 0, because, as I wrote earlier, when the distance between the body and the Earth increases, the kinetic energy decreases and in the infinity (at the end of its road) has the value of 0.
The potential energy in the infinity has got the highest value but if we put infinity (or for example 1000000) into the previous formula, we will obtain zero (or an extremely small fraction).
Now we could calculate the value of this velocity, putting the data into the formula:

$$V_{II} = \sqrt{2\frac{GM_z}{R_z}} \tag{6}$$

$$V_{II} = \sqrt{2 * 6,67 * 10^{-11}\frac{6 * 10^{24}}{6,37 * 10^6}} = 11200 \tag{7}$$

$$[V_{II}] = \left[\sqrt{\frac{Nm^2}{kg^2} * \frac{kg}{m}}\right] = \left[\frac{m}{s}\right] \tag{8}$$

And finally, the practical curiosity.

$$V_{II} = V_I * \sqrt{2} \tag{9}$$

We can also obtain the value of the second cosmic velocity through the multiplication the value of the first cosmic velocity by the square root of two.

3. The third cosmic velocity

The third cosmic velocity is the initial velocity which a body has to have to leave the Solar System and its value is:

$$V_{III} = 16,7\left[\frac{km}{s}\right] \tag{10}$$

At the surface of the Earth this velocity is about 42 km/s but thanks to the Earth's revolution round The Sun it is enough to launch the body with velocity 16,7 km/s at the direction of this movement.

4. The fourth cosmic velocity

It is the initial velocity which a body has to have to leave the Milky Way.

$$V_{IV} = 130\left[\frac{km}{s}\right] \tag{11}$$

This velocity is about 350 km/s but we know that the Sun is going around the galaxy centre, so it is enough to launch the body with the velocity of 130 km/s at the direction of the Sun's movement.

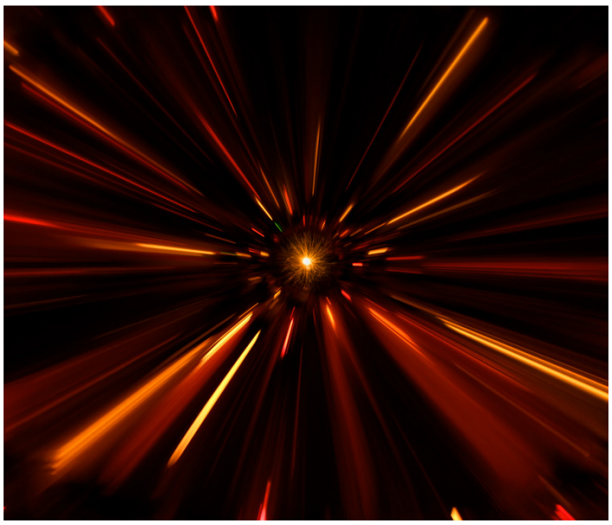

Figure 2: Infinity [2]

In this table below are shown the values of the individual cosmic velocities:

The number of cosmic velocity	The value of cosmic velocity
I	7,9 km/s
II	11,2 km/s
III	16,7 km/s
IV	130 km/s

Bibliography

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