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THE MOVEMENT OF SATELLITES AND COSMIC SPEEDS

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ABSTRACT

Newton guessed the possibility of sending bodies into space. The bodies whose speed is lower than the first cosmic speed will fall on the Earth, and if the speed is higher the vehicle will leave the Earth for good.

Key words: satellites, cosmic speed

Introduction

Newton realized that a vehicle launched at a sufficiently high speed would be able to rotate around the Earth in a geostationary orbit. If the speed grows even more, the vehicle could finally leave the Earth (fig. 1)

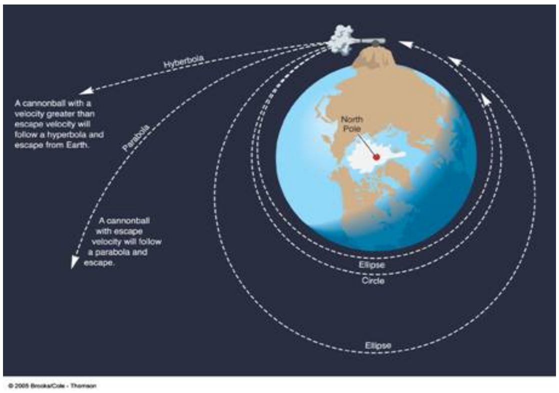

Fig. 1 - A projectile may describe different trajectories depending on the launch speed

According to the Principle II of classical mechanics, a force acting on a body imparts an acceleration, that is: F = m·a.

In the case of a rotating body, acceleration is given by mathematical expression

$$a=\frac{v^2}{R}\text{, so } F=\frac{mv^2}{R}.$$

This force is due to the gravitational pull between the Earth and the satellite ($F = \gamma \frac{mM}{R^2}$).

Drawing the two forces results:

$$\frac{mv^2}{R} = \gamma \frac{mM}{R^2}. \quad (1)$$

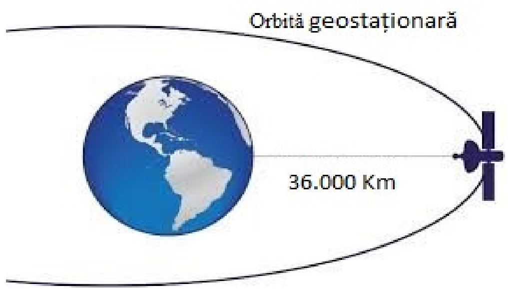

Fig. 2 - Moving a satellite on a geostationary orbit

The relationship is valid for a satellite very close to Earth (r = R). In this case, from (1) we obtain:

$v = \sqrt{\frac{\gamma M}{R}} = \sqrt{g \cdot R} = 7{,}91\ Km/s$, which represents the **first cosmic speed.**

Let us observe: the determination of the first cosmic speed has neglected the strength of the air resistance.

Tab. 1 - The value of the first cosmic speed decreases with the height

H (km)	0	250	500	750	1.000	1.500	1.690	2.000	5.000
V^1_o	7,91	7,76	7,62	7,48	7,35	7,12	7,03	6,90	5,92
T (ore)	1,41	1,49	1,58	1,66	1,75	1,93	2,00	2,10	3,35

There are a variety of different orbits that can be adopted by satellites. The choice of one depends

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on the service that the satellite needs to provide and the area it needs to serve.

In some cases, the orbit may be low, only 160 km, while others can be over 36 000 km. Satellites rotate around the Earth, so they are attracted to gravitational force. If you do not have one his own movement, would fall back on Earth, igniting in the upper atmosphere. But the centrifugal force pushes the satellite away from the Earth.

For any given orbit there is a speed for which these two forces balance. Obviously, as the orbit is lower, the gravitational attraction is higher and the satellite has to rotate around the Earth faster to offset this attraction. At high heights the gravitational pull is smaller and therefore the angular velocity must be less. For a very low orbit, at 160 km, a speed of 21,160 km / h = 5,877 km / s is required, so the satellite will surround the Earth in 90 minutes. At an altitude of 36 000 km, a speed of nearly 11,265 km / h = 3,129 km / s is required, giving a 24-hour rotation period (geostationary satellite).

A satellite can surround the Earth on two types of orbits. The first is the circular orbit, at which distance from Earth remains constant. The second type of orbit is the elliptical (Figure 3). When a satellite surrounds the Earth, the orbit describes a plan that passes through the geocentre.

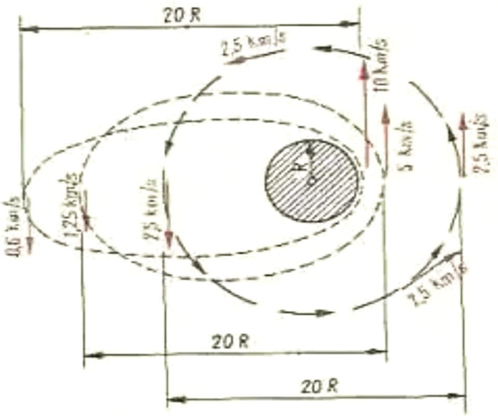

Fig. 3 - The satellite orbits

In the case of an elliptical orbit, the velocity changes according to the position in orbit. The maximum speed is when the satellite is closest to the Earth (perigeus) and must overcome the greatest gravitational force and is minimal at the highest apogee distance.

For an elliptical orbit, the center of the Earth is in one of the outbreaks of the ellipse (Figure 3). A satellite can rotate around the Earth in different planes. The angle of inclination of the orbit is the angle between a straight line perpendicular to the plane of the orbit and the right that passes through the Earth's poles. The orbits that pass over the equator are called equatorial orbit and those that cross the poles are called polar orbits.

The artificial satellites used are classified as follows:

1. By their nature:
- Passive satellites that do not have onboard equipment; they are a simple reflective medium of the radio waves transmitted from the ground;
- Active satellites, which are equipped with signal processing, space-guiding and execution of commands received from the ground.

2. By way of transmitting information:
- Real-time response satellites, when ground stations ensure continuous satellite visibility;
- Memory satellites (delayed response), when on certain portions of the trajectory it is not visible from the ground and it is necessary to record all the information to be transmitted later

3. In the form of the trajectory, the satellites may have:
- Circular orbit;
- Elliptical orbit.

4. After the angle of inclination of the satellite orbit (i) to the terrestrial equator:
-for i = 0 degrees, equatorial satellites;
-for i = 90 degrees, polar satellites;
-for tilt values between 10 - 80 degrees, ordinary satellites.

5. In terms of altitude:
- Low altitude satellites for altitudes between 1000 and 5000 km;
- Medium altitude satellites, placed between 5000 and 20 000 km;
- High altitude satellites, between 20 000 and 35 800 km.

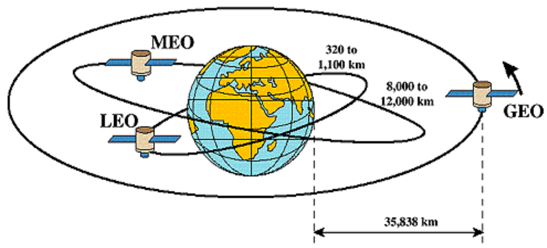

Fig. 4 - The satellites LEO, MEO, GEO

The main issues of Earth's artificial satellites are:
- launching and placing on orbit;
- satellite operation;
- to maintain connections with the ground control panel;
- their use for solving problems of sea or air navigation, communications, scientific research, exploration of alien space, etc.

After placing it on orbit, it is very important to study the undisturbed motion of the satellite, as well as the perturbations of the orbital elements of the satellite.

Depending on the cosmic velocity, the object can be:
- Satellite, with movement on a circle or ellipse;
- Interplanetary ship with movement on the parabola or hyperbolic.

The second cosmic speed, also called the speed of release, is the speed that a body must initially have to get out of the gravitational field of the Earth. Its value is 11.2 km / s.

The third cosmic speed is the initial speed that a body must have to leave the solar system and has a value of 16.7 km / s.

Artificial satellites have helped solve some issues related to:
- Management of seagoing and spacecraft on sea or air communications;
- Determination of their position and movement elements (such as: speed, acceleration, travel direction);
- Warning of ships on crash situations, catastrophes, determining where it happened and triggering rescue operations;
- Extension of long-distance communications and transmissions, transmission of permanent meteorological information, prevention of crews from the occurrence of dangerous meteorological or hydrological phenomena;

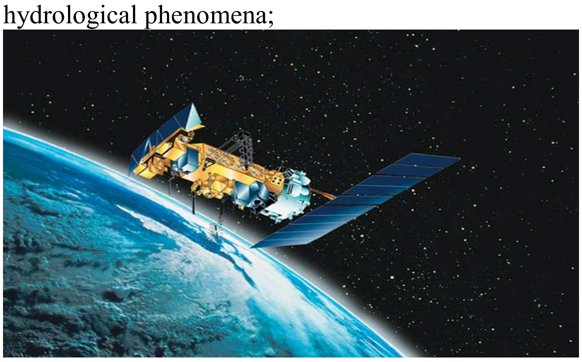

Fig. 5 - Meteo satellite

- Design of land surface;
- Exploring large areas.

The use of artificial satellites starts from a number of their properties, such as:
- global coverage;
- fast action;
- high probability of determining low- navigation parameters in any terrestrial area irrespective of the position and timing of motion of the sea going vessels or aircraft;
- resolving navigation problems in any kind of meteorological conditions, day and night, with great precision and in very short time.

Conclusions

Ever since the establishment of the expression of gravitational force, Newton intuited the possibility of sending bodies into space. If a body is launched horizontally, at the top of a mountain, with higher speeds, there will be a speed at which will not fall on Earth, managing to make a complete rotation around it.

Bodies that print at a speed lower than the first cosmic speed will fall on Earth. At higher speeds, the vehicle will finally leave the Earth.

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