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S E N in evening sky

Regarding Sputnik

by

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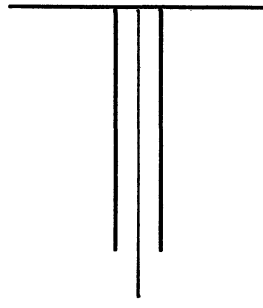

Since the launching of the first artificial earth satellite by Russian scientists on October 4, 1957, there have been endless reports in the press concerning its progress on its repeated journeys about the earth. Some of these have been contradictory, and it must have been next to impossible for most people to keep track of what has been going on. The purpose of this note is to give, as concisely as possible, what information we have been able to obtain from radio and visual observations made at the University of Toronto. The radio observations have been made by Messrs. Bosco Loncaravic and Gordon West of the Geophysics Laboratory and by Mr. Wallace Russell, a student in the Department of Astronomy; the visual observations were made by various groups observing at the David Dunlap Observatory.

The Satellite and the Rocket

The launching of the satellite resulted in two (and possibly three) bodies being placed in orbital motion about the earth. These were the satellite itself and the third stage of the launching rocket (and possibly also the nose-cone of the rocket). The satellite began immediately to transmit signals on frequencies of 20 megacycles and 40 megacycles in the form of "beeps," about two per second. Later the transmission became continuous on the 40 megacycle frequency. As long as this transmission could be received it was possible, with special equipment, to locate the satellite with a fair degree of accuracy every time it passed within about a thousand miles of Toronto. The launching rocket could be located only by visual observation, and this was possible only when the rocket was passing nearly over Toronto just before sunrise or just after sunset that is, at times when the rocket was in the sunlight and yet the sky was dark for the observer. The rocket, being so much larger was more easily visible than the satellite. There have been reports of sightings of the satellite itself, but there is some uncertainty as to whether or not some or all of these may refer to the nose-cone.

The Period of Revolution and the Height

Immediately after the launching it is presumed that both rocket and satellite were in the same orbit, that is to say, travelling close together in space. From the earliest radio observations the period of revolution (that is, the time for one complete circuit) was found to be just over 96 minutes (probably it was 96.2 minutes as reported in the press). From the laws governing orbital motion this meant that the average height of the bodies was 350 miles. Actually the height ranged from 140 miles to 560 miles, being lowest when the bodies were passing over the northern hemisphere, highest when over the southern. The average speed of both bodies was about 17,000 miles per hour.

The Orbit Nearly Stationary—But Not Quite

The orbit, or path, of the two bodies might be expected to be nearly fixed in space like a hoop surrounding the earth and tilted at 65 degrees to the equator. Within this orbit the earth rotated once in 24 hours, and on the orbit the bodies circled once every 96 minutes. The rotation of the earth would thus carry any locality under the orbit twice in every day. Thus on

October 5th, at 12.10 a.m. EST, less than 12 hours after the launching, the satellite was heard passing nearly over Toronto going northward, and it passed again nearly over Toronto at 8.32 a.m., EST, on the same day, going southward. Now, since fifteen cycles of the satellite (15 x 96 minutes) was exactly 24 hours, one might have expected successive daily passages to be at the same time of day. For a few days this appeared to be almost exactly the case, but as time went on it was apparent that two changes were taking place: firstly the passages were heard a little earlier each day, and secondly the successive passages appeared to be working gradually westward from Toronto. These effects were interpreted as being due to two changes in the orbit—firstly the satellite was speeding up, and secondly the orbit was swinging slowly westward.

The Rocket Beats the Satellite

Both of the foregoing effects were verified when the rocket became visible in the Toronto area in the pre-dawn sky each morning between October 13th and October 16th—but with this difference: the speed-up was more marked for the rocket than for the satellite. On October 13th the rocket was about 4 minutes (or more than 1,000 miles) ahead of the satellite. Two weeks later when the rocket had widened its lead to more than an hour; it was nearly a full lap ahead. At the time of writing (November 1st) the satellite is doing each lap in about 95 minutes and the rocket in about 94 minutes. Why is each speeding up and why is the rocket speeding up more than the satellite?

Rocket and Satellite are Falling to Earth

The answer lies in the fact that both rocket and satellite are encountering a little air resistance—even at such great heights. The effect of air resistance is to make each body spiral in closer to the earth and at the same time to go faster. The satellite has now fallen by 40 miles to an average height of 310 miles and the rocket by 70 miles to an average height of 280 miles. The reason that the rocket is more affected by air resistance lies in its larger size and non-spherical shape. It is easy to understand that as each body falls into denser atmosphere this falling and speeding will be accelerated. Soon—perhaps in a few weeks—the rocket will encounter enough air resistance to make it plummet to earth, glowing like a meteorite with the heat engendered by the friction. Later — perhaps months later—the satellite will encounter the same fate.

Why the Orbits are Swinging Westward

Let us return to the point which we noted earlier that the orbits of both satellite and rocket are swinging slowly westward. What is the reason for this? If the earth were spherical the orbits would act like gyroscopes and maintain a fixed direction in space. However, as we all learned at school, the earth bulges slightly at the equator. The effect of this bulge on the orbits is to produce what physicists call a "couple" which in turn causes a "precession" of the orbits—the slow westward swing which we have noted.

What Scientists Hope to Learn

Perhaps the satellite carries instruments which were signalling back to earth information about the upper atmosphere, cosmic rays and micrometeorites. If so, it seems reasonable to suppose that only the Russian scientists have this information. However, apart from this altogether, there are at least two ways in which observations of the satellite and its rocket may be used to calculate valuable information. In the first place the rates at which the satellite and the rocket have been falling earthward will yield values of the density of the atmosphere—and, in turn, its temperature—at the various levels. Secondly the rate of the westward swing of the orbits carried by the earth's equatorial bulge may give us new information regarding the way the earth's density increases below the surface. It is a remarkable thing that the movements of a tiny sphere hundreds of miles above the earth may be expected to teach us more about the depths of the earth than we have been able to learn with all our delicate instruments right here on the surface!

Will the Rocket be Seen in the Toronto Area Again?

The rocket was seen in the morning twilight in the Toronto area between October 13th and 16th. A week later it was so placed that it should have been visible here in the evening twilight. Clouds prevented its being seen except on one evening, October 25th, when it was seen in the northwestern sky travelling northward. From our analysis, it appears unlikely that it will be seen here again for a few weeks to come. However, it must be realized that in some part of the world it is visible every day. As for the satellite, the radio transmission failed on or about October 24th and has not been heard since. Because of the small size it will be difficult to track the silent satellite by either visual or radar means. It is to be hoped that the Russian and American scientists who are best equipped to follow it will be able to do so and that its spiral path to earth will be fruitful for scientific research.

David Dunlap Observatory, University of Toronto, Nov. 1, 1957

The November 2 Satellite

As this account is being completed an announcement has come that a second much larger, satellite has been launched by the Russians. It is higher than the first and circles the earth more slowly. No doubt it will still be orbiting after the first satellite has crashed.

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