Behaviour of a pitiable rocket flying near to the Earth

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Abstract

Nowadays many people know that if one jumps thoughtlesly high, he can get a bump. But they all have never thought that tiny rockets feel the same! Imagine that you're a tiny ricket and you want to change your direction using our planet. Everything goes well until you meet our skrewdy atmosphere: it slows you down and you fall and explode! That's a pity. In this study we will discuss what tiny rockets can do in such situations.

Introduction

The process of turning around our rocket is explored in this research. The theoretical model includes **Newton's law of universal gravitation** and **Barometric formula**. This is enough because other things are left as self-evident. This was implemented in **Python** program which calculates what would happen under initial conditions like coordinate, velocity and impact parameter.

Theoretical model

As it was already mentioned, was used **Newton's law of universal gravitation**:

$$\mathbf{F} = G \cdot \frac{m_1 \cdot m_2}{r^3} \cdot \mathbf{r} \tag{1}$$

Where F is Newton force, m_1 is the rocket mass, m_2 is the Earth mass and r is a distance between the rocket and the Earth.
And **Barometric formula** (used when the rocket is in the atmosphere):

$$\rho = \rho_0 \cdot exp\left[\frac{-g \cdot m \cdot H}{k \cdot T}\right] \tag{2}$$

Where ρ is the density of atmosphere, ρ_0 is the density near the surface, g is the gravitational acceleration, m is mass of an air molecule, H is the height above the Earth, k is Boltzmann constant and T is temperature.
Also the **friction force** acts upon the rocket (when the rocket is in the atmpsphere):

$$\mathbf{F} = -\frac{1}{2} \cdot c \cdot S \cdot v^2 \cdot \frac{\mathbf{v}}{v} \tag{3}$$

Where F is the friction force, c is the drag coefficient, S is the effective square and v is the velocity of the rocket.

Methods

To model such situation **Python** code was written. You should use `main.py`. There are two functions to use: `sign_graph.show()` and `sign_graph.test()`. They take two arguments. The first one `impact_parameter` is a required positional argument representing the impact parameter (it is measured in the Earth radius), another one which represents the absolute value of the initial velocity is a optional keyword argument with the default value 15 pixel per second and is referred to as `speed`. Function `sign_graph.show()` shows how it happens, function `sign_graph.test()` finds the optimal *impact parameter* in $O_{0.1}(impact\_parameter)$.

Results

Here are the findings of the study. The optimal value if $speed = 0.1$ of the *impact parameter* is $1.3962 \cdot R_{Earth}$ if the influence of the atmosphere is taken into account and $1.3947 \cdot R_{Earth}$ otherwise.
Below you can see a plot of the inflection agnle of the trajectory as a function of the impact parameter for $speed = 0.1$.

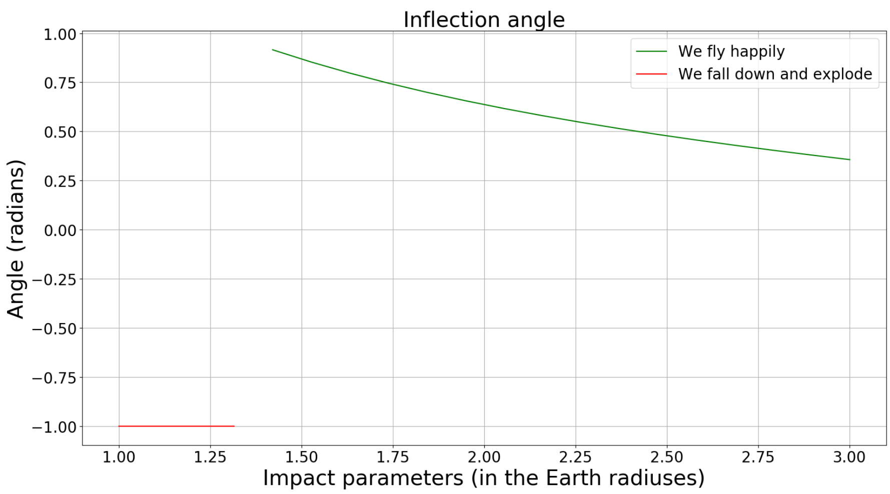

Figure 1: The inflection angle as a function of the impact parameter

Conclusion

As it can be seen, the influence of the atmosphere is not that significant ($\approx 0.1\%$). Nevertheless, since that moment all tiny rockets can use this project to fly happily and not be confused.

References

Author's own physics knowledge and very strange picture on the next pagen take from
http://meteoinfo.ru/about/glossary/4806-2012-03-11-20-40-41

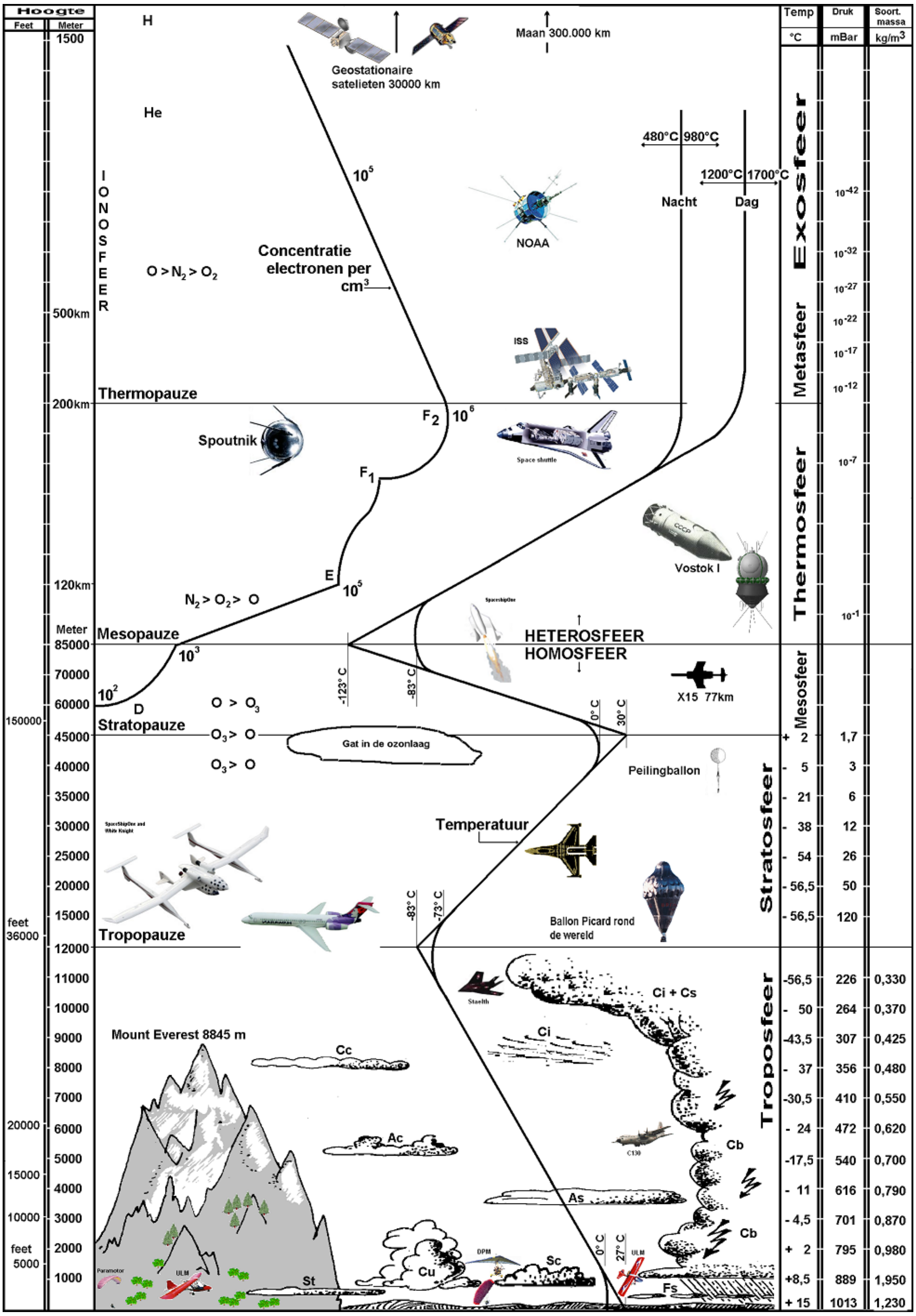

Figure 2: Temperature as a function of the height