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What if from now on, we start shooting all waste produced worldwide into space?

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Abstract
This article explores the difficulties and the consequences of shooting all waste produced on Earth into space. It is found that if we do not want the waste to orbit Earth, the energy required to shoot one years' worth of garbage into space would be one third of the total yearly energy consumption of humanity. If it is brought into orbit instead, in 50 years it will be massive enough to have a gravitational field strong enough to let people walk around on it as long as they do not go faster than 8 kmh^{-1}.

Introduction

Waste management is one of the great global challenges of this age. With wealth comes consumption, and with consumption comes waste. Despite rising efforts to reduce waste production and recycle more, a 2018 study found that globally, a staggering amount of 2.01×10^{12} kg of waste was produced in 2016 alone [1]. This article explores some of the possible consequences that could arise if this amount of garbage was shot into space annually.

Into the void

Ideally, we never want to see the waste shot into space ever again. This means that it cannot go into orbit, but has to fully escape Earth's gravity. How much energy is needed for that can be calculated by considering the gravitational potential U_g:

$$U_g = -\frac{GMm}{r}, \tag{1}$$

where G is the gravitational constant, M the mass of the Earth, m the mass of whatever you want to shoot into outer space and r the distance to the centre of the Earth of the place from where you shoot it (in our case, r equals the radius of the Earth since we shoot from the surface).

Filling in the values, it is found that shooting one year's amount of global garbage into outer space would cost around 1.2×10^{20} joules. To compare: an average UK household uses about 14.4×10^{9} joules per year [2], so that means that shooting one years' worth of global garbage into space would minimally cost as much energy as 9 billion UK households use in a year, or about 338 years' worth of energy used by all 27.2 million households in the UK [3]. An even more illustrative comparison would be to look at the World Total Final Energy Consumption: in 2015, that was 3.9×10^{20} joules [4]. The rocket would thus use one third of all energy used by humanity world-wide. And that is even without taking this hypothetical rocket's efficiency into account.

Into orbit

Bringing the garbage into orbit will still cost a lot of energy, depending of course on the radius of the orbit. However, for the sake of having something to do further calculations on, we will assume that humanity has succeeded in doing this and from this point on we will instead of examining the energy costs focus on the effects of having the garbage in orbit.

It would be very undesirable to have all garbage fly around the Earth in loose pieces, as that might be dangerous for other space related activities such as the operation of satellites or missions to the moon or other planets. Instead, we will assume that all garbage is somehow held together in one giant flying garbage disposal-site, which we will call the Trash-Satellite, or TS. The TS will grow by 2.01×10^{12} kg annually, which might have an impact on its orbit. If we assume that the TS will be in a circular orbit around the Earth, gravity acts as the centripetal force pulling the TS around in circles. This gives us the following equation which relates the centripetal force on the left-hand side to the force of gravity on the right-hand side:

$$\frac{mv^2}{r} = \frac{GMm}{r^2}, \tag{2}$$

which gives us the equation for radius of orbit r:

$$r = \frac{GM}{v^2}. \tag{3}$$

From equation 3, it becomes clear that the mass of the TS does not have an impact on the orbital radius as long as the orbital velocity remains unchanged. This means that as long it is made sure that v stays the same (which might be difficult but we will assume future generations have found a solution), we do not have to care about adding mass to the TS.

Space-garbage workers

If the TS is maintained for 50 years, and in those 50 years the amount of globally produced garbage stays the same as it was in 2007 (because, for example, people have realised they need to combat the now expected increase in waste production), in the year 2069 it will have accumulated a mass of over 10^{14} kg. If we assume that the TS consists of compressed plastic garbage and has an average density of 1150 kgm^{-3} [5], its volume would be around 8.7×10^{10} m^3, which would make its radius (if we assume the TS to be spherical) around 2.7 km. The TS would be massive enough to have its own (significant) gravitational field, with an escape velocity on its surface that can be calculated through:

$$v_{esc} = \sqrt{\frac{2GM_{TS}}{r_{TS}}}, \tag{4}$$

which, upon filling in the values, gives an escape velocity of slightly over 8 kmh^{-1}. That means that the gravity of the TS would be strong enough to keep space-garbage workers firmly enough on its surface to prevent them floating off into space, as long as they do not run or jump faster than 8 kmh^{-1}.

Conclusion

Shooting all waste produced on Earth into the infinity of space would be energetically unfeasible. A giant garbage-disposal site in orbit around the Earth, on which all annually produced waste is dumped will over 50 years become so massive that it will have its own gravity that is strong enough to let space-garbage workers walk around on it as long as they do not exceed the escape velocity of 8 kmh^{-1}. The annual addition of mass does not necessarily alter the orbit of this Trash-Satellite if we find a way to keep the orbital velocity of the TS constant.

References

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