International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 06 | June 2020 www.irjet.net p-ISSN: 2395-0072

Asteroid Deflection using a Solar-Sailed Electromagnetic Gravity Tractor

Parvati Rajesh

Student, Department of Mechanical Engineering, Presidency University, Itgalpur, Rajanakunte, Yelahanka, Bengaluru, Karnataka, Pin Code- 560064, India

---

Abstract – *An asteroid threat is one of the topics in science which gets less coverage. If an asteroid as small as 200m were to collide with earth, that would annihilate modern infrastructure and cause significant losses in biodiversity. One such theoretical solution developed to prevent this from occurring is a Gravity Tractor. A Gravity Tractor is a theoretical spacecraft which aims to alter the trajectory of an asteroid which is on the course to collide with earth. Although there have been numerous anticipated designs and alterations in this subject matter, this paper intends to suggest an idea of a gravity tractor integrated with a solar sail for solar-electric propulsion coupled with a feature of electromagnetism to exert a stronger attraction force on the asteroid if it is made out of a metallic core.*

***Key Words*: Asteroid, Gravity tractor, Threat mitigation, asteroid collision, space craft, Gravitational towing, Near Earth Objects, electromagnetic spacecraft**

1. INTRODUCTION

The idea of a spacecraft for altering the course of an asteroid by employing gravity alone was first proposed by Edward T. Lu and Stanley G. Love from the *NASA Johnson Space Centre* (Sep 21, 2005) .The idea was straightforward; to make a spacecraft hover above an asteroid with its thrusters directed towards the opposite direction and to use gravity as a "towline" to alter the asteroids course by slightly deflecting it off its main course. This method is independent of the structure, surface, and rotational properties of the asteroid. To surmount such a threat and to alter the course of an asteroid, we would have to send a spacecraft around 1-2 decades before the estimated date of collision due to the restrictions of our existing technology. A small angular change in the asteroid's trajectory millions of miles away from earth, in the long- term can make it entirely forgo earth. This is visualized in the figure shown:

Figure 1

Assuming the asteroid shown in the figure above is at least a 100 light years away and has been detected by planetary defenses of various space agencies ,other private industries or any other means, if a tractor is sent on time and the deflection is made at a safe distance, a small deflection (α) will cause a significant amount of change in course for the asteroid to completely omit earth.

Now one such problem that arises is, we require fuel to send the spacecraft that far and to pull away from the asteroids gravitational force, and how do we recognize what the asteroid is made of? An asteroid with a metallic core (iron/nickel) would be much tricky to divert off course compared to an asteroid made of ice or rock. Possible solutions to the above problems are given below.

2. STUDIES AND FINDINGS

According to NASA, asteroids can be broadly classified into three main categories:

- The C-type (chondrite) asteroids are most common, almost certainly consist of clay and silicate rocks, and are dark in appearance.

- The S-types ("stony") are rendered of silicate materials and nickel-iron.
- The M-types are metallic (nickel-iron).

Some asteroids are made of ice, which should not be a threat as they would burn out while entering the earth's orbit. The major threats are the C, S and M type asteroids. Well a simple gravity tractor should be enough as these tractors, theoretically would simply use gravity and do not depend on the structure or composition of the asteroid. But what happens when gravity alone is not adequate to make a significant amount of course alteration for an asteroid to completely miss earth? Gravitational force would be enough for a rocky asteroid but what about the ones with an iron-nickel core? Or what if the asteroid is too close to earth and a large deflection is mandatory?

3. SOLUTIONS

Introduction of an infrared camera and an X-ray spectrometer into the gravity tractor would work as a module for asteroid core detection and could help us discover if the asteroid is metallic or non-metallic.

CASE1: Asteroid is non metallic

In this case, a simple tractor which hovers above an asteroid, which is independent of the structure and composition of the asteroid can use gravity and thrusters pointing in opposite directions alone to deflect it off course, as explained by Edward T Lu and Stanley G Love.

CASE 2:

Asteroid is metallic

A Gravity tractor can be made magnetic by the phenomenon of electromagnetism by simply giving it an iron core wound by copper wires. The tractor turns into a magnet when electricity is provided to the wounding's by means of a battery which is charged by solar power. The advantage of this method is that there would be three forces acting against the asteroid: gravity, thrusters, and magnetism. Even if it causes a small deflection, if this is done 10-20 decades before, the metallic asteroid would completely miss earth.

The benefit of doing this as soon as we can and as far from earth as we can is that even a small deflection at a long distance is sufficient, but the nearer the asteroid gets, the more thrust we need as we need more deflection, Besides more thrust requires more fuel and this would be a challenge as fuel storing capacity is one of the biggest hurdles.

3.1 SOLAR SAIL

Even if we had to send a spacecraft that far, where would we get that much fuel from? Yet if we did, the bigger problem would be as to where we would store that much fuel? We cannot eliminate the use of fuel entirely, but one way to compensate would be to establish a solar sail. A method of spacecraft propulsion using radiation pressure exerted by sunlight on large mirrors which can double up as sails. Based on the physics, several spaceflight missions to test solar propulsion and celestial navigation have been proposed since the 1980s. in simple words, we propel the spacecraft using solar radiation and pressure.

Advantages

- Conserves fuel
- Longer space life
- Low mass
- A solar sail can also act as a solar cell by providing electricity to onboard sensors
- Using origami techniques, it can be placed in a small volume for the same mass

Disadvantages

- Sail operation depends upon solar distance, sail angle, reflectivity, and front and back emissivity.
- Further the distance from the sun, lesser the propulsion
- Large and delicate

4. CONCLUSIONS

The main motive of this paper is to convey an effective idea of an asteroid towing gravity tractor whose function depends on the material out of which the asteroid's core is made and to improve the chances and reliability of sending a tractor far from home and it being capable of carrying out the desired result of changing the course.

REFERENCES

[1] Hovering control of a solar sail gravity tractor spacecraft for asteroid deflection. Bong Wie

[2] Dynamical Characterization and Stabilization of Gravity Tractor Designs for NEO Impact Risk Mitigation Eugene G. Fahnestock_ and Daniel J. Scheeres University of Michigan, Ann Arbor, Michigan, USA

[3] Electrostatic Tractor for Near Earth Object Deflection Naomi Murdoch, Dario Izzo, Claudio Bombardelli, Ian Carnelli†, Alain Hilgers_ and David Rodgers_ESA, Advanced Concepts Team, ESTEC, Keplerlaan 1, Postbus 299,2200 AG, Noordwijk_ESA, ESTEC, Keplerlaan 1, Postbus 299,2200 AG, Noordwijk

[4] Enhanced Gravity Tractor Technique For Planetary Defense Daniel D. Mazanek(1), David M. Reeves(2), Joshua B. Hopkins(3), Darren W. Wade(4), Marco Tantardini(5), and Haijun Shen

[5] The Gravitational Spacecraft -Fran De Aquino

[6] Threat Mitigation: The Gravity Tractor Russell Schweickart, Clark Chapman, Dan Durda, Piet Hut

[7] A Gravitational Tractor for Towing Asteroids Edward T. Lu and Stanley G. Love NASA Johnson Space Center