Journal of Physics Special Topics
An undergraduate physics journal

A6_6 Lunar-tising

R. Lindon, J. Mayes, C. Wallis, M. Favaro-Bedford, E. Day

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH

December 12, 2018

Abstract

Lunar advertising, although a Sci-Fi concept, has caught the attention of company executives before. In this paper, the authors examine the feasibility of Moon advertising using lasers, and examine the mechanics behind this. The paper finds that the power required to beam a visible message onto the Moon's surface is of order of magnitude of 10^{12} W, and any combination of normal optical lasers can be used as there is no special wavelength requirements.

Introduction

Figure 1: The Author's impression of a lunar advertisement.

In 1998, a marketing executive at Coca-Cola decided that using lasers to beam the company's logo onto the Moon was a good idea. After over $100,000 was put into this project, the FAA (Federal Aviation Authority) stopped the plans, on the grounds that the power of the lasers would likely melt planes out of the sky [1].

However, what was not considered was if instead of one huge laser bank, a network of many thousands of diffuse lasers were pointed at the Moon that were spread over continental US. In this paper, we examine the feasibility of of using commercially available lasers to project an image onto the lunar surface.

Analysis

First, the intensity of the laser light at the Moon to be visible from Earth is defined. We assume the laser must be as bright as the solar illuminated Moon to be seen easily from Earth. As visible light is 40% of the Sun's total solar flux [2], the total solar flux in the visible region hitting the Moon per square meter is shown in Eq.(1).

$$F_{v,\odot} = 0.4\frac{L_{\odot}}{4\pi D^2} = 544.5 \text{ Wm}^{-2} \quad (1)$$

Where $F_{v,\odot}$ is the total visible solar flux per square meter, $L_{\odot}$ is the luminosity of the Sun and D is the average Moon-Sun distance (taken as 1 AU). However, as the Moon has an albedo of roughly 0.12, the lunar radiant flux per square meter ($F_{v,☾}$) is shown in Eq.(2).

$$F_{v,\leftmoon} = 0.12 F_{v,\odot} = 65.33 \text{ Wm}^{-2} \quad (2)$$

To have any chance of being visible, our lasers need to illuminate the Moon with an intensity at the Moon's surface of this. Assuming 1% of the Moon's surface needs to be illuminated for the advertisement, the total laser power at the Moon ($P_{v,\leftmoon}$) is calculated in Eq.(3).

$$P_{v,\leftmoon} = 0.01(\pi R_{\leftmoon}^2) F_{v,\leftmoon} = 6.193 \times 10^{12} \text{ W} \quad (3)$$

Where $R_{\leftmoon}$ is the lunar radius. Assuming an optical depth (τ) of 0.043 [3], the power of the laser at the surface of the Earth ($P_{v,\earth}$) is defined by Eq.(4).

$$P_{v,\earth} = P_{v,\leftmoon} e^{\tau} = 6.47 \times 10^{12} \text{ W} \quad (4)$$

This power is equivalent to over 6 million of the most powerful continuous wave laser in existence (MIRACL) firing simultaneously [4].

However, in order to create a message or picture, the lasers must be collimated enough to not appear as vague smudges on the Moon's surface. Assuming one hundredth of the Moons diameter needs to be the effective width of a pixel in order to have a clear image, Eq.(5), the Raleigh Criterion, can be used to determine this.

$$\theta = \frac{1.22\lambda}{D} \quad (5)$$

$$\frac{\theta}{2} = \arctan \frac{0.5 S_p}{D_{E-M}} \quad (6)$$

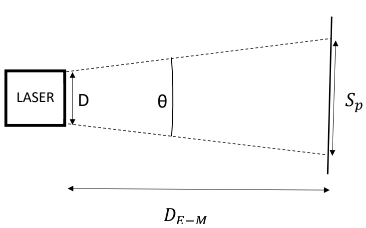

Figure 2: Schematic illustrating Eq. 5 and 6 parameters.

Where λ is the wavelength of light (500 nm for a green laser), θ is the angular spread of the laser and D is the diameter of an individual laser's aperture. Taking the angle of θ to be defined in Eq.(6), this gives a minimum laser aperture diameter of 1.178×10^{-4}m. Where S_p is the pixel size at the Moon and D_{E-M} is the Earth-Moon distance. As this is smaller then the vast majority of commercial lasers, it implies most lasers could be used for this project.

Conclusion

To advertise on the Moon is almost impossible. The power requirements are huge, and it would be a huge waste of money. However, in the future, as the lasers that are needed to do this are cheap and plentiful, it might not be science fiction forever.

References

[1] Lacey Rose. The Guy Who Got Conan. *Forbes.* https://www.forbes.com/2010/06/22/steve-koonin-conan-business-entertainment-celeb-100-10-koonin.html, Accessed 2018-12-11.

[2] Qiang Fu. *Encyclopedia of Atmospheric Sciences: Vol 5.* Academic Press Inc.,U.S., 2001. pg. 1859.

[3] G.A. Ban-Weiss and W.D. Collins. Aerosols — role in radiative transfer. In *Encyclopedia of Atmospheric Sciences (Second Edition)*, pages 66 – 75. Academic Press, Oxford, second edition edition, 2015.

[4] John R Albertine. History of navy hel technology development and systems testing. In *Laser and Beam Control Technologies*, volume 4632, pages 32–38. International Society for Optics and Photonics, 2002.