Journal of Physics Special Topics

An undergraduate physics journal

P5_5 Hidden in Plain Sight

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November 30, 2017

Abstract

In the opening episode of Star Trek Discovery; A Vulcan Hello, the USS Shenzhou detected an unknown object. Upon further investigation it was unable to be identified due to a scattering field. In this paper we calculate the angular resolution of the ships optical systems without electronic assistance and therefore the diameter of aperture that would give this resolution. We found the diameter of the aperture to be 6.51 mm and using the image produced found the focal length of the lens to be 7.55 x 10^{-5} m, much smaller than that expected for a futuristic ship.

Introduction

In the Star Trek Discovery episode; The Vulcan Hello, the science officer states that an unknown object is 2000 km away and has an approximate length of 150 m. It is also stated that the object is at a bearing of 358 with respect to the Shenzhou [1]. An interference described as a 'scattering field' prevents the object being identified by minimising the resolution of the image. We assumed that the scattering field interfered with the electronic field of the ships systems, meaning the image produced was solely due to the lens and was not assisted by electronic enhancement in any way.

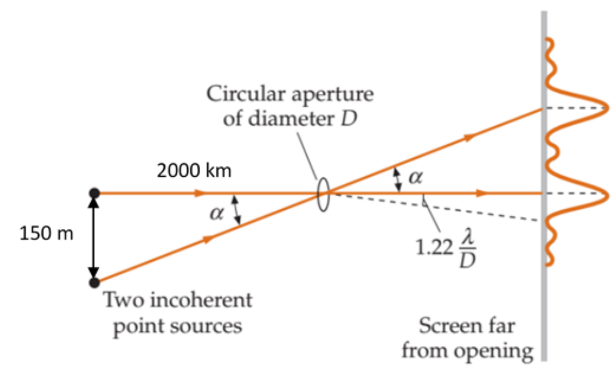

Figure 1: This figure shows how resolution of an aperture is affected by two different sources of light. [3]

Theory and Results

Starships are designed with multiple optical lenses to maintain a wide field of view. The exact dimensions of the Shenzhou are not known however the width of a Galaxy-Class Explorer is known to be 464 m [2] . From this we can calculate the angular resolution of the system using trigonometry as shown in Figure 1. We have considered the point sources to be at opposite sides of the unknown object and therefore 150 m apart. The distance to the aperture is the distance to the object; 2000 km. The angular resolution of the ship at this distance is found to be 7.50 x 10^{-5} rad. We use this value in Equation 1 to calculate the diameter of aperture that would correspond to this angular resolution.

$$\alpha_c = \frac{1.22\lambda}{D} \tag{1}$$

α_c is the critical angular separation (angular resolution) in radians, λ is the wavelength of visible light, taken to be 400 nm in this calculation, and D is the diameter of aperture. It was found that the aperture for the Starship Shenzhou at this distance would be 6.51 mm. This is a much smaller value than expected as current military satellites can have an optical lens with a diameter of up to 20 m [4] and technology can be expected to develop before 2255, when the show takes place [5]. The magnification of the lens is the length of the image, seen in the episode as 1 m, divided by the length of the object; 150 m. As we know the image is produced on the opposite side of the lens to the object, the magnification m of the system is -1/150, meaning it is also inverted. Using the magnification equation, Equation 2, we can calculate the distance away from the lens that the image is produced.

$$m = \frac{-s'}{s} \tag{2}$$

Where s' is the image distance away from the lens and s is the object distance away from the lens. s is known to be 2000 km, therefore s' is calculated as 13.3 km away. Using Equation 3, the thin-lens equation, we calculate the focal length f of the lens and determine at what distance it would be possible to observe the object clearly.

$$\frac{1}{f} = \frac{1}{s} + \frac{1}{s'} \tag{3}$$

For the values calculated we have found this distance to be 7.55 x 10^{-5} m. This is an extremely small distance and suggests that the interference caused by the object does not simply remove the electronic assistance of the Starship but hinders its existing optical lenses.

Discussion

There is a main sensor in the centre of the ship and multiple sensors are located around the rim of the entire Starship meaning the field of view should be wider than that described in our single lens model [6]. This lack of resolution could be explained by a lens being present in front of the object refracting light, causing aberrations due to the different points of refraction and the index of refraction at different points of the lens. In order to calculate these aberrations more information is required, such as the material of the lens as well as its index of refraction.

A loss of communication near the object suggests that an electromagnetic field is present that is destructively interfering with the ships systems. Electromagnetic interference occurs when a source produces an electromagnetic field that adversely affects nearby electromagnetic devices [7].

Conclusion

In this report we calculated the angular resolution of the USS Shenzhou's optical systems and found this to be 7.50 x 10^{-5} rad. From this we calculated the diameter of the lens that corresponds to this resolution. We found this to be 6.51 mm. The corresponding lens was found to have a focal length of 7.55 x 10^{-5} m. This is much smaller than todays values and therefore it can be assumed that with technical advances a lens would have a longer focal length in the future, meaning the object is causing electromagnetic interference.

References

[1] "A Vulcan Hello", *Star Trek Discovery*, Netflix, 25 September 2017

[2] `http://techspecs.acalltoduty.com/federation.html` [Accessed 13 November 2017]

[3] P. A. Tipler and G. Mosca, *(Physics for Scientists. 6th edition)*, W. H. Freeman (2007).

[4] `https://defence.pk/pdf/threads/gaofen-4-worlds-most-powerful-geospy-satellite-continues-chinas-leap-in-space.436720/` [Accessed 13 November 2017]

[5] `http://time.com/4952491/star-trek-discovery-timeline/` [Accessed 13 November 2017]

[6] `http://techspecs.acalltoduty.com/galaxy.html#7.1` [Accessed 13 November 2017]

[7] `http://www.hsr.ca.gov/docs/programs/merced-fresno-eir/final_EIR_MerFres3_5Electromag.pdf` [Accessed 13 November 2017]