P2 9 The Lack of Colour from Outer Space

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Abstract

In this paper, we investigate the properties of the *Outer Ones* from the H.P. Lovecraft short story *The Whisperer from the Darkness*, specifically their apparent invisibility in photographs. We derive a simple optical model considering the dependence of reflectance on the wavelength of incident light. We find that for photographs taken with a 1930s-style camera, the *Outer Ones* must have a refractive index that increases with wavelength, controlled by a dispersion coefficient of $B = -0.59\,\mathrm{\mu m}^2$.

Introduction

In his 1931 horror short story *The Whisperer from the Darkness*, first published in the weird tales pulp magazine, H.P. Lovecraft introduces the extraterrestrial species known as the *Outer Ones* [1]. Heralding from their colony of *Yuggoth*, known to us as the then newly discovered planet of Pluto, the *Outer Ones* are depicted as an alien and technologically advanced species. They frequently travel between Earth and Pluto on short timescales and utilise electric guns. They are also said to be made of an unearthly material, which renders them invisible to photography. In this paper, we investigate the optical properties of the *Outer Ones* as described by Lovecraft to determine if it is truly possible for them to be invisible in photographs.

Theory

The most striking feature of the *Outer Ones* is their physical form, which is said to appear as a mixture between a crustacean and a fungus and consists of a material which reflects light in such a way as to render them invisible in photographs [1] [2].

A method of photography common at the time employed the use of a silver halide-based film, which could later be developed [3]. An interesting property of these silver halide films is that they are very sensitive to light in the blue to ultraviolet range but insensitive to red light [4]. We propose that the *Outer Ones* consist of a material which is highly reflective to red light but not to blue light, rendering them invisible in the photographs of the time but still visible to the human eye.

We start by considering the truncated form of the Cauchy formula for refractive index [5]:

$$n(\lambda) = A + \frac{B}{\lambda^2} \tag{1}$$

where A and B are material constants, and λ is the wavelength measured, by convention, in microns. We then consider the Fresnel reflectance, R, of the *Outer Ones* hide assuming light rays travelling at normal incidence [6]:

$$R = \left(\frac{n_{air} - n(\lambda)}{n_{air} + n(\lambda)} \right)^2 \tag{2}$$

where n_{air} is the refractive index of air and $n(\lambda)$ is the refractive index of our material. Combining Equations 1 and 2 allows us to determine the reflectance as a function of the incident wavelength:

$$R(\lambda) = \left(\frac{\lambda^2(n_{air} - A) - B}{\lambda^2(n_{air} + A) + B} \right)^2 \qquad (3)$$

where for the *Outer Ones* to not appear in photographs we require the ratio $r = \frac{R(\lambda_R)}{R(\lambda_B)} \gg 1$. Where we define $\lambda_R = 0.65\,\mu\text{m}$ as red light and $\lambda_B = 0.45\,\mu\text{m}$ as blue light [7].

Using these conditions, we can then find estimates for our material constants A and B of the *Outer Ones* by applying Nelder-Mead optimisation [8]. This is a derivative-free optimisation scheme which defines a simplex in our parameter space and manipulates the geometry over a series of iterations to converge the simplex towards our desired point. From common values of the Cauchy constants [9] we define our initial assumptions as $A = 1.5$ and $B = 0.1\,\mu\text{m}^2$ and take $r = 100$ as the minimum required ratio so the simplex converges to the point at which $r = 100$.

This procedure was run over 224 iterations and resulted in optimised constants of $A = 4.02$ and $B = -0.59\,\mu\text{m}^2$ corresponding to reflectances of $R(\lambda_R) \approx 0.2$ and $R(\lambda_B) \approx 0.002$.

Discussion & Conclusion

When interpreting our Cauchy coefficients, it is clear that A represents the refractive index in the limit of a long wavelength, such that $\lim_{\lambda \to \infty} n(\lambda) = A$. Of more interest in our case is the B coefficient, which can be shown to control the rate of dispersion, seen by taking the derivative of Equation 1:

$$\frac{dn(\lambda)}{d\lambda} = -\frac{B}{\lambda^3} \qquad (4)$$

This shows that for $B > 0$ the refractive index decreases for an increasing wavelength and normal dispersion occurs [5]. We find the *Outer Ones* to have $B < 0$ and so the refractive index increases as the wavelength does, displaying
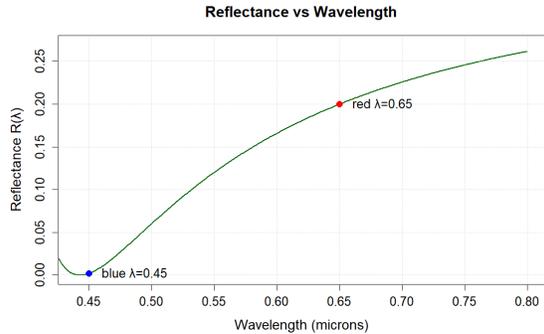

Figure 1: Plot showing how the reflectance of the *Outer Ones* varies with incident wavelength in the visible range. The reflectance $R(\lambda)$ is determined using our optimised coefficients and, following convention, the wavelength is measured in microns. The representative blue and red wavelengths used in this study are highlighted as coloured dots on the curve.

a behaviour different to most Earth-based materials, which is consistent with their lore [2].

The consequence of this can be seen in Fig. 1, where, due to the increase in refractive index, the red light has a much greater reflectance on our modelled *Outer One* than blue light. With $R(\lambda_R) \approx 0.2$ and the reflectance of blue light 100 times smaller, we can safely conclude that a sufficient amount of light is reflected that the *Outer Ones* would be visible to the human eye, but an insufficient amount of blue light is reflected for them to appear in photographs taken using a common 1930s camera.

This model uses some simple assumptions to produce results that are consistent with how the *Outer Ones* are described in the short story. The key assumption that we have made is that the refractive index can be described using the two-term Cauchy formula. In most cases, this is a good first-order approximation, and higher-order terms can be neglected as small compared to the first two. This has the additional benefit of simplifying the computation as we only have to account for two free parameters.

We also note that this model works only for silver halide-based photography, and further work must be done to generalise this phenomenon to all types of cameras.

References

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