Steve Smith Tuition: Maths Notes

$e^{i\pi} + 1 = 0$ $a^2 + b^2 = c^2$ $z_{n+1} = z_n^2 + c$ $V - E + F = 2$

Astronomical Telescope in Normal Adjustment

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Prerequisites

Read "Drawing Ray Diagrams for Converging Lenses".

Notes

None.

Document History

Date	Version	Comments
7 June 2012	1.0	Initial creation of the document.

1 Introduction

An astronomical telescope consists of two lenses: an "eyepiece" that you look through, and an "objective". It's called the objective lens because that's the lens that is closest to the object that you are looking at.

The objective lens has a very long focal length (f_o), and the eyepiece has a very short focal length (f_e). It turns out that the magnification (m) of the telescope is the ratio of these focal lengths:

$$m = \frac{f_o}{f_e}$$

so in designing a telescope, you want to try and make this ratio as large as possible.

2 The Objective

When we use a telscope, the thing we're looking at is a long way away. In astronomy, it's a *very* long way away. It can be considered to be at infinity.

So, let's have a look at what happens to the light from an object an infinite distance away, as it goes through our objective lens. See Figure 1. Remember that if the object is at infinity, rays from the top of the object will be parallel as they arrive at the objective lens.

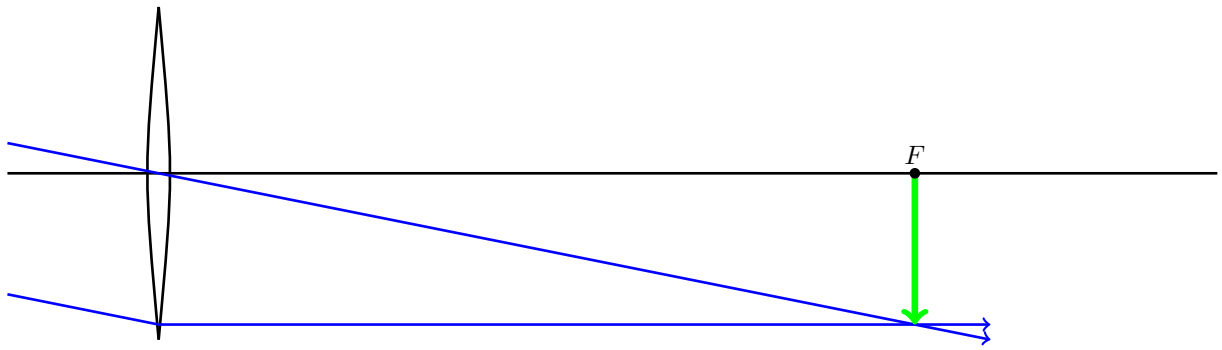

Figure 1: Light from a distant object going through our objective lens

The image of the distant object will appear at the focal point on the other side of the lens (that is, inside the telescope tube). The image of the distant object appears inverted and diminished.

3 The Eyepiece

The eyepiece is used to allow us to see an image of the distant object by actually using the image of the distant object (that was produced by the objective lens inside the telescope tube) as its object.

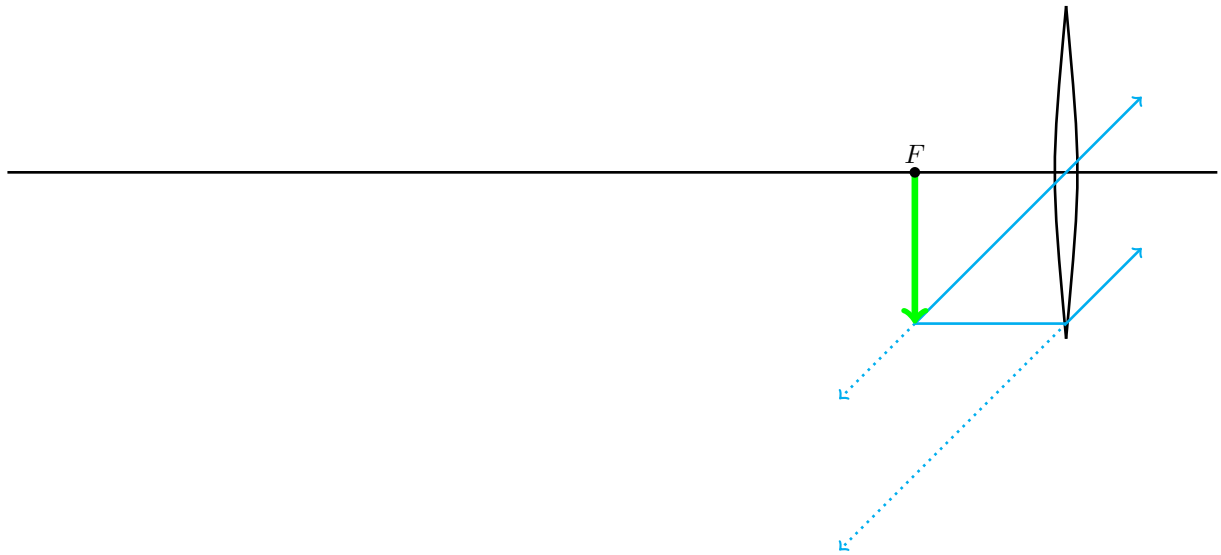

Figure 2: Looking through the eyepiece at the image of a distant object

The observer looks through the eyepiece lens from the right at the (eyepiece-) image of the (objective-) image of the distant object. Because of the geometry of the ray tracing, this (eyepiece-) image is at infinity.

4 Putting it all Together

So when we use an astronomical telescope in normal adjustment, we just put the two lenses in the telescope together in such a way that we are achieving both situations shown in the previous two sections:

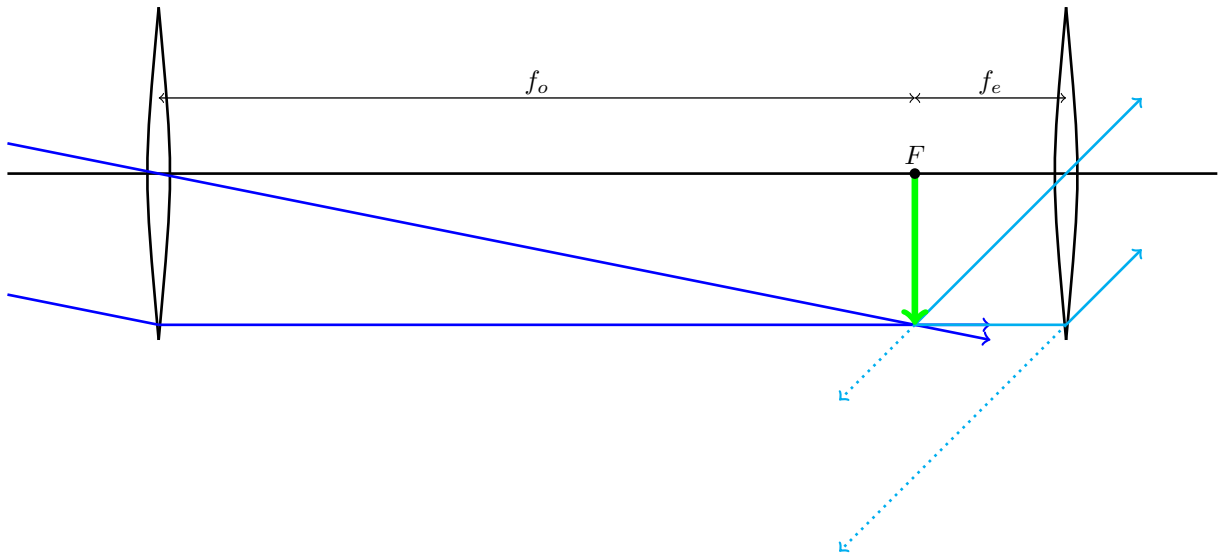

Figure 3: The telescope in normal adjustment

In this case, the point F represents the focal point of *both* lenses. The focal length of the objective lens (f_o), which is the distance from F to the objective lens, is much longer than the focal length of the eyepiece

lens (f_e), which is the distance from F to the eyepiece lens. The total distance between the lenses will consequently be $f_o + f_e$, and the magnification of the telescope can be shown to be $\frac{f_o}{f_e}$.