Title:

ApofAll

A Low-Obstruction Newtonian Telescope Using a Relay Lens

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Abstract

This article presents a simple but powerful optical modification for Newtonian telescopes. By drastically reducing the size of the secondary mirror — potentially to 10% of standard sizes or even less — and introducing a single converging (relay) lens, it becomes possible to preserve the full field of view while dramatically improving contrast.

This system, named ApofAll (Apochromatic for All), allows amateur

telescope makers to approach apochromatic-like planetary and lunar performance using a Newtonian reflector. While minor trade-offs exist (e.g., increased collimation difficulty and slight chromatic aberration from the lens), the benefits in flexibility and contrast are substantial. The method is freely available for personal and non-commercial experimentation. Commercial use requires prior written permission from the inventor.

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1. Introduction

Conventional Newtonian reflectors require relatively large secondary mirrors to intercept light and redirect it toward the focuser. This central obstruction introduces diffraction and degrades image contrast, particularly for planetary and lunar observing.

ApofAll introduces a simple but elegant optical solution:

Replace the standard secondary mirror with a significantly smaller one,

Slightly extend the telescope tube (OTA), and

Add a single positive (converging) lens in the diverging light cone after the secondary mirror.

This allows the telescope to maintain a wide field of view and original focal ratio while reducing the central obstruction dramatically — producing high-contrast images comparable to those of apochromatic refractors.

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2. Concept Overview

Core Idea: Reduce the secondary mirror size, allow the beam to diverge, and then reconverge it using a relay lens near the focuser.

The OTA is lengthened slightly to increase the distance between the primary mirror and the secondary.

The smaller secondary mirror is moved forward (closer to the focal point), reducing its required diameter.

After reflection, the light beam naturally converges, passes the focal point, then begins to diverge again.

A positive lens is placed near the focuser to reconverge the light, allowing it to focus properly at the eyepiece.

This results in:

Dramatically reduced central obstruction, improving contrast and resolution,

Retained original focal ratio (f/4, f/5, etc.) — the “speed” of the scope is preserved,

Full field of view — no reduction in light cone or aperture, A Newtonian reflector with performance approaching that of an apochromat.

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3. Optical Geometry & Calculations

We define:

D: Diameter of the primary mirror

F: Focal length of the primary mirror

K: Focal ratio = F / D

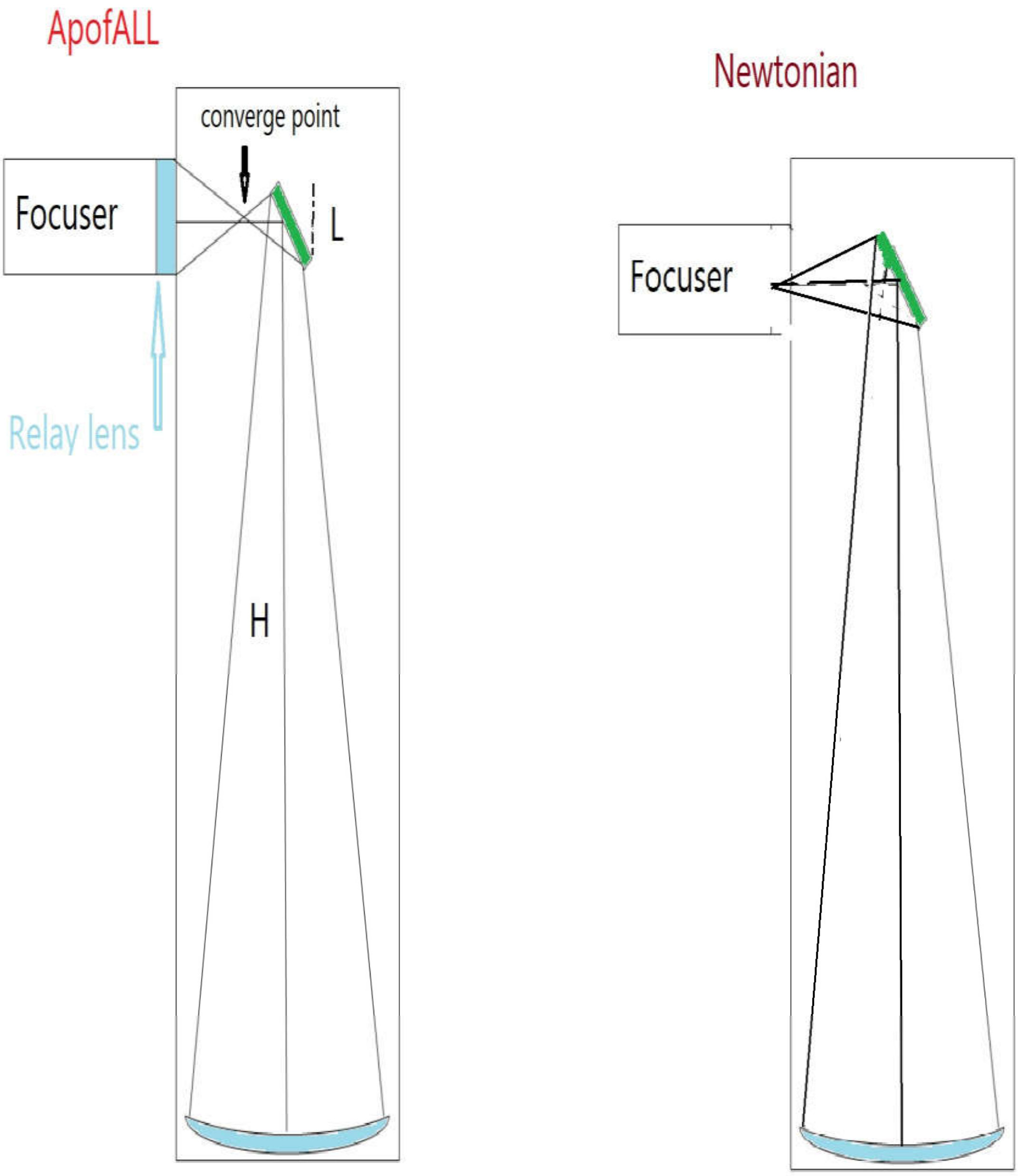
W: Inner width of the OTA

H: Distance from primary to secondary mirror

L: Length of the secondary mirror (as projected from focuser)

Focus: Effective diameter of the focuser (typically 46 mm for 2" or 27 mm for 1.25")

Cnvex: Focal length of the relay lens



Key Geometry

By similar triangles, we can relate these quantities:

(Distance from secondary mirror to converge point)/L = F/D = K

Solving for H, the mirror spacing:

H = F – (Distance of converge point from secondary mirror)

So

H = F – (F/D) x L = F(1-L/D) = KD(1-L/D) = K(D-L)

This allows us to:

Calculate the mirror spacing based on how small we want L (the secondary),

Evaluate how close to the focal point the secondary can be moved without losing the light cone.

Avoiding Vignetting:

To ensure that all diverging rays after the focal point still pass through the focuser:

(Distance of converge point from entrance of focuser) = (W/2) -

(Distance of converge point from secondary mirror) = (W/2) – KL

We ensure this divergence does not exceed the focuser diameter:

$$(W/2) - KL \le \text{Focus} \times K$$

Which can be rearranged to solve for L:

$$L \ge (W/2) - \text{Focus}$$

This defines how small L (the secondary size) can be, without losing light — even when the beam diverges.

Your Example — 150/750 Newtonian

Given:

$D = 150$ mm

$F = 750$ mm $\Rightarrow K = 5$

$W = 180$ mm

Focus = 46 mm

Applying the inequality:

$L \geq (W/2K) - \text{Focus}$

$L \geq (180/(2x5)) - 46 = -28$ (So for this telescope you have not limitation at all.)

This tells us: you can move the secondary closer to the primary mirror and reduce its size dramatically, without violating optical limits. In fact, it shows that there's room for optimization far beyond standard Newtonian design, even on a compact OTA.

Later I add formula to calculate relay lens focal length if it is needed.For now it is good to say that the cone of diverged light on convex lens is little. For example for above telescope(150/750) it is about 8 mm. So much color aberration is not expected and it is possible to use better glass for lens or even ED if you like.

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