ANALYZING THE AGREEMENT OF THE THIN LENS EQUATION WITH CONVEX LENSES USING THE CHI-SQUARED TEST

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INTRODUCTION

LENSES

- refracting optical devices that focuses or disperses light
- usually made with glass and normally has a spherical surface

Thin lenses

thickness of the lens appears to be negligible in comparison to the radius of curvature of the lens

THIN LENS EQUATION

$$\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$$

f - the focal length of the lens used

s_o - distance of the object from the lens

s_i - distance of the image formed from the lens

CHI-SQUARED TEST

To determine whether there is a significant association between the two variables

CHI-SQUARED TEST

The value of chi-squared is obtained by comparing the experimental value (E_n) and the theoretical value (T_n)

$$\chi^2 = \sum_{n=1}^{N} \frac{[E_n - T_n]^2}{T_n}$$

MAGNIFICATION

There are two ways to measure magnification consistent with the thin lens equation

$$M = -\frac{q}{p} \tag{1}$$

$$M = \frac{d'}{d} \tag{2}$$

$p =$ object distance	$d =$ object height
$q =$ image distance	$d' =$ image height

OBJECTIVES

1. To be able to show the agreement of experimental data with the theoretical model using χ^2 test.
2. To be able to show the agreement between the two definitions of magnification (1), (2)

METHODOLOGY

EXPERIMENTAL SETUP & PARAMETERS

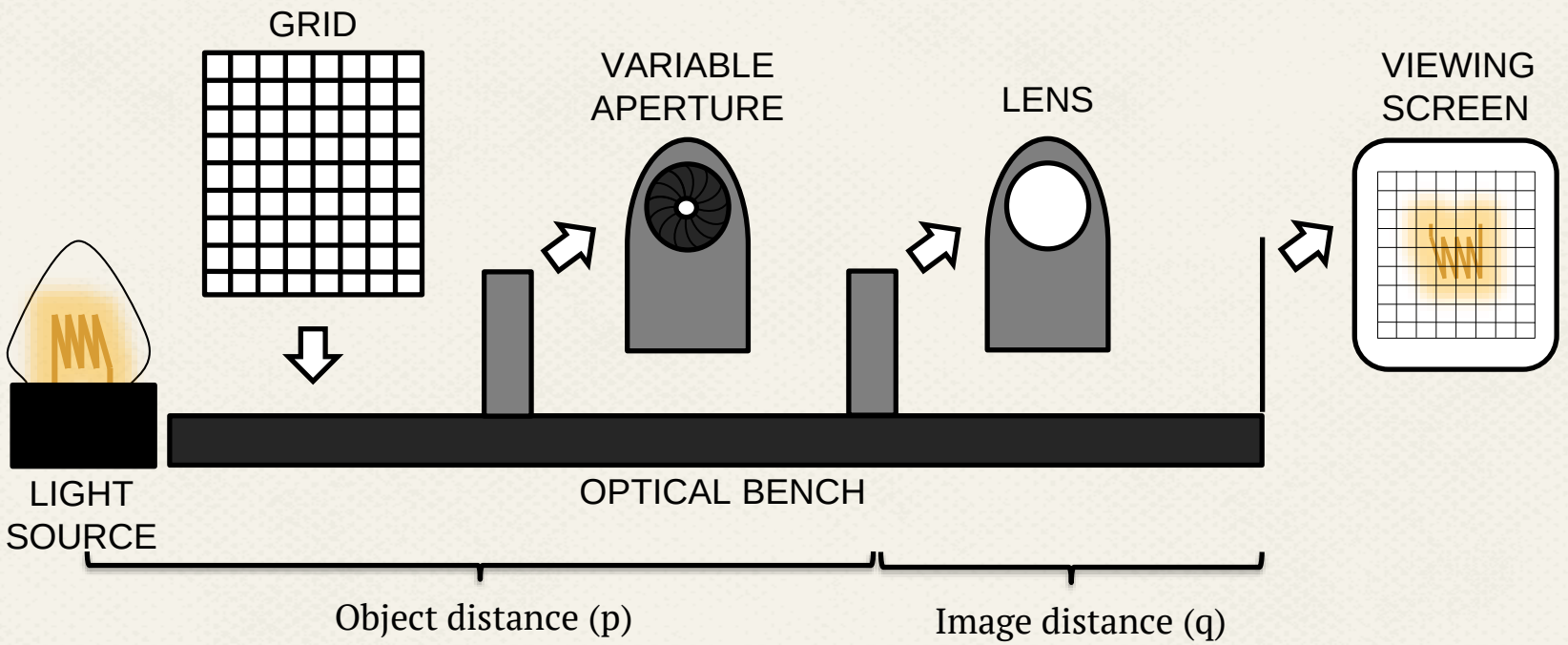
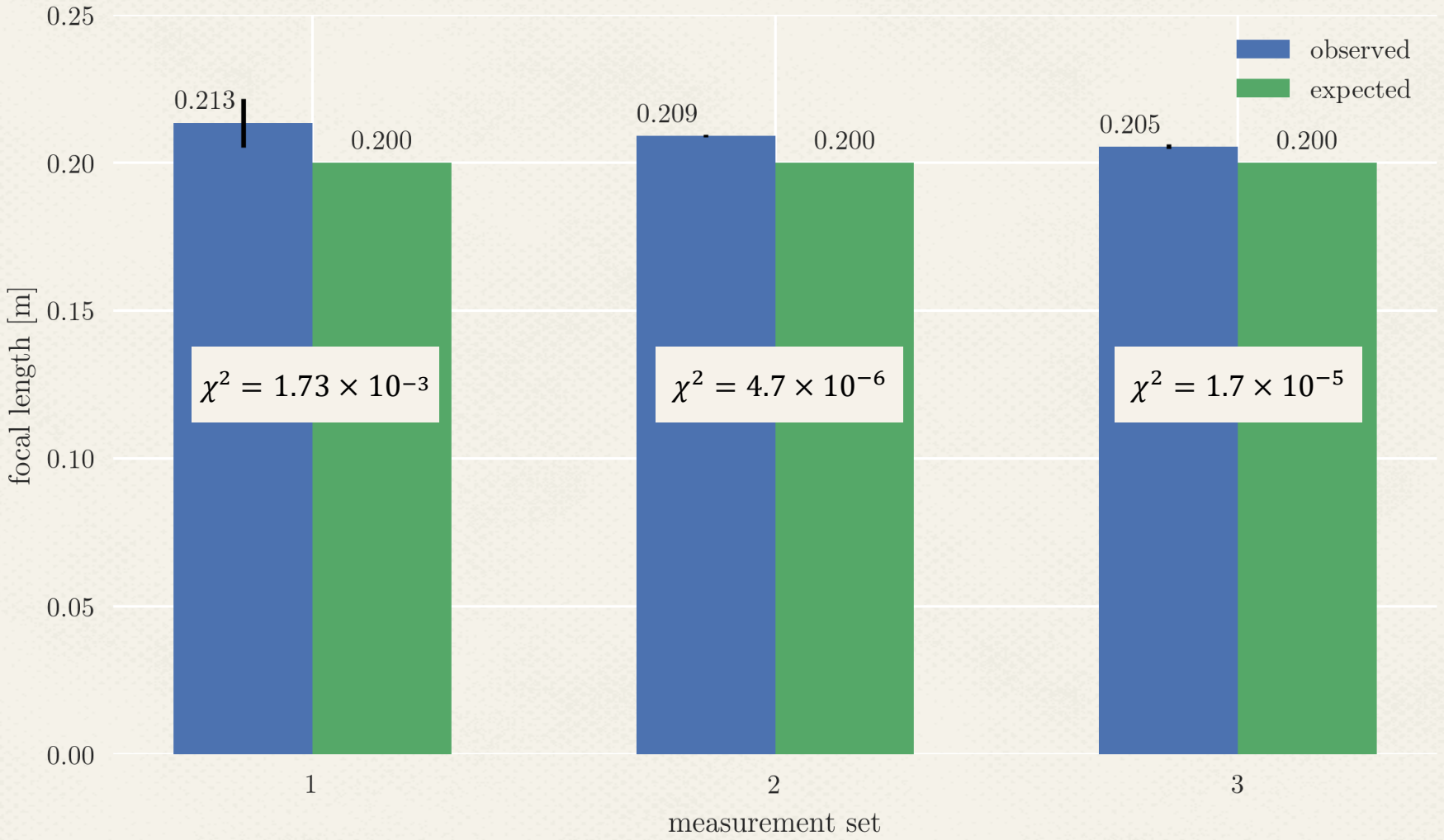


Figure 1. Thin Lens Setup consisting of an incandescent bulb as a light source projected onto a viewing screen with a variable aperture and a converging thin lens placed in between.

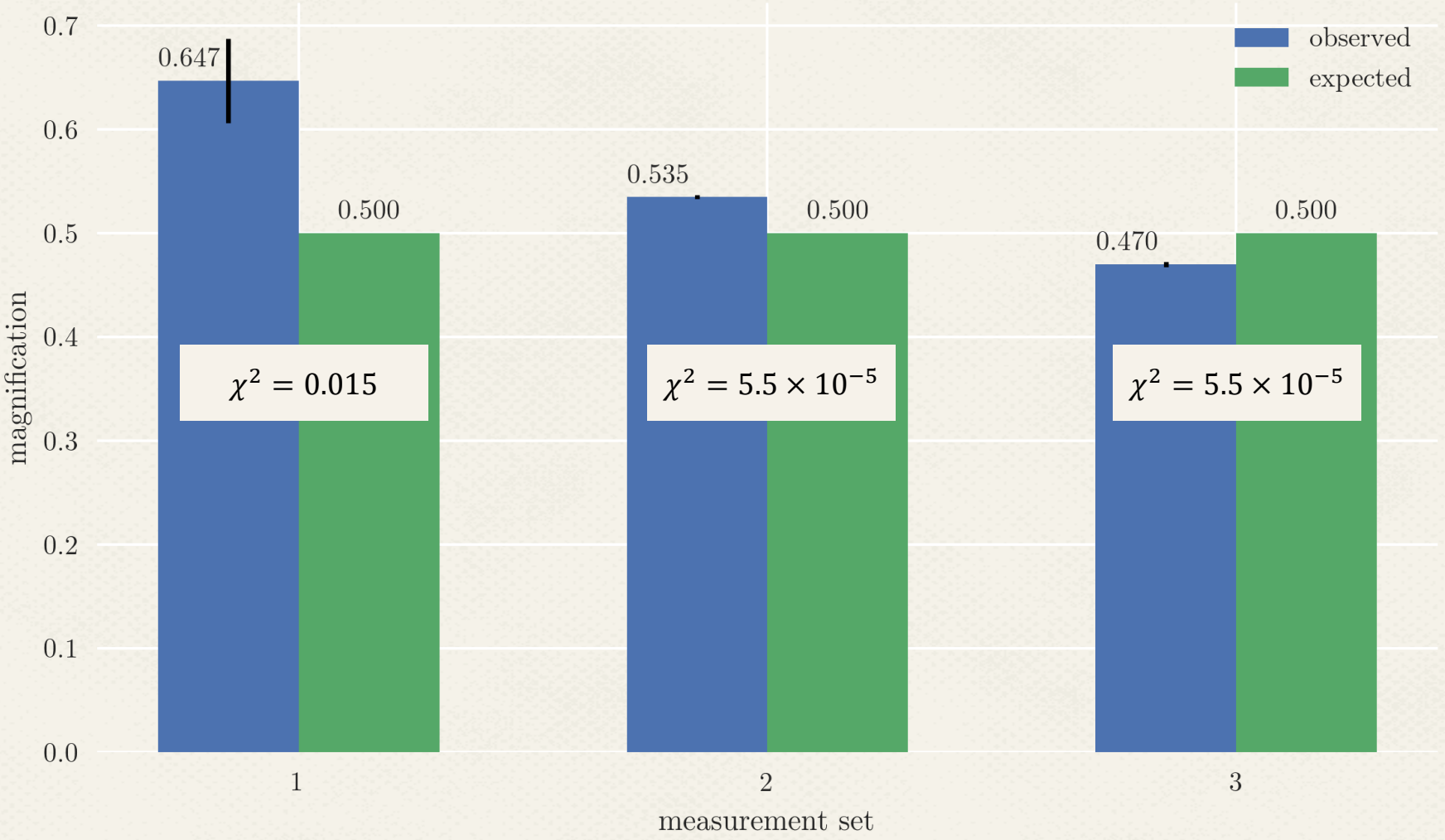
- Light source: incandescent lamp
- Lens: +200 mm
- Grid spacing: 2.00 mm x 2.00 mm
- No. of trials per p: 5
- Object distance was varied 3x

RESULTS & DISCUSSION

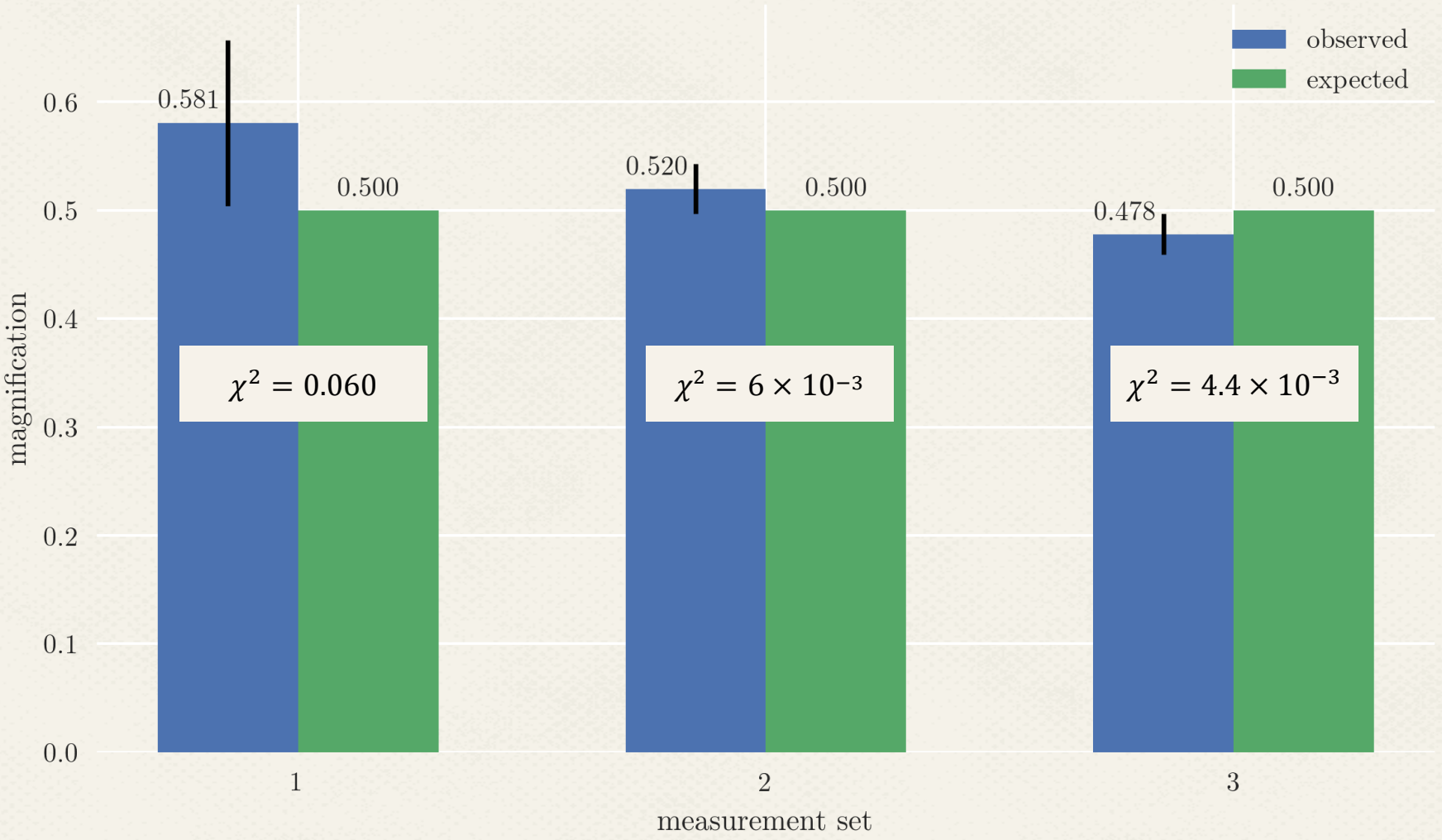
χ^2 TEST: FOCAL LENGTH



χ^2 TEST: MAGNIFICATION (1)



χ^2 TEST: MAGNIFICATION (2)



χ^2 TEST

- All of the calculated $\chi^2 \ll 5$, where 5 is the total number of trials. We can therefore say that the data is highly consistent with the thin lens equation.
- The two definitions of the magnification has a very low χ^2 value that we can practically consider that these two give equal values for the magnification.
- The precision of measurement and the imperfect alignment of the apparatus are possible sources of error.

CONCLUSIONS

The χ^2 test that was performed on the focal lengths expressed a close agreement between the theoretical and experimental measurements.

Measurements of the magnitude of magnification from the ratio of object and image distance, and ratio of object and image height also showed no significant difference.

The experimental data using the convex lens followed the thin lens equation, as confirmed by the χ^2 test.

REFERENCES

1. J. Taylor, An Introduction to Error Analysis: The study of Uncertainties in Physical Measurements (University Science Books, Sausalito, California, 1997), 2nd ed.