Photometric Reductions of Asteroids to the Standard Magnitude System

Kayla Lorenzen
Faculty: Dr. George Stecher & Dr. Lyle Ford

University of Wisconsin-Eau Claire
Department of Physics and Astronomy

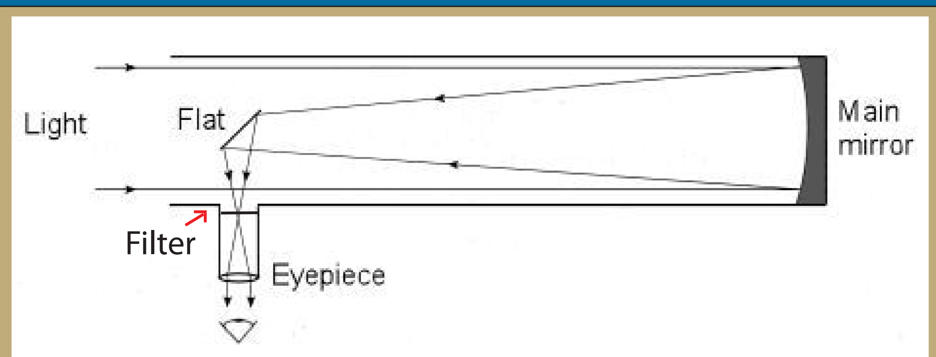
Abstract

We discuss procedures for reducing filtered measurements of asteroids to standard Johnson-Cousins R and V magnitudes. Four asteroids, 1084 Tamariwa, 2167 Erin, 2660 Wasserman, and 17010 1999 CQ72, were observed in 2007 and 2008 using Bessel R and V filters. We used images of Landolt standard fields to find first order extinction coefficients, transform values, and nightly zero points. These values were used to map the instrumental magnitudes of several stars in each asteroid's field onto the standard Johnson-Cousin scales. These comparison stars were then used as secondary standards to establish the V and R magnitudes of the asteroids. For an asteroid of V magnitude 13.9 and R magnitude of 13.5, our procedures yielded typical uncertainties of 0.015 magnitudes in V and 0.020 magnitudes in R. Our measurements also helped to determine the period of 2168 Erin and to confirm the period of 1084 Tamariwa.

Data Collection

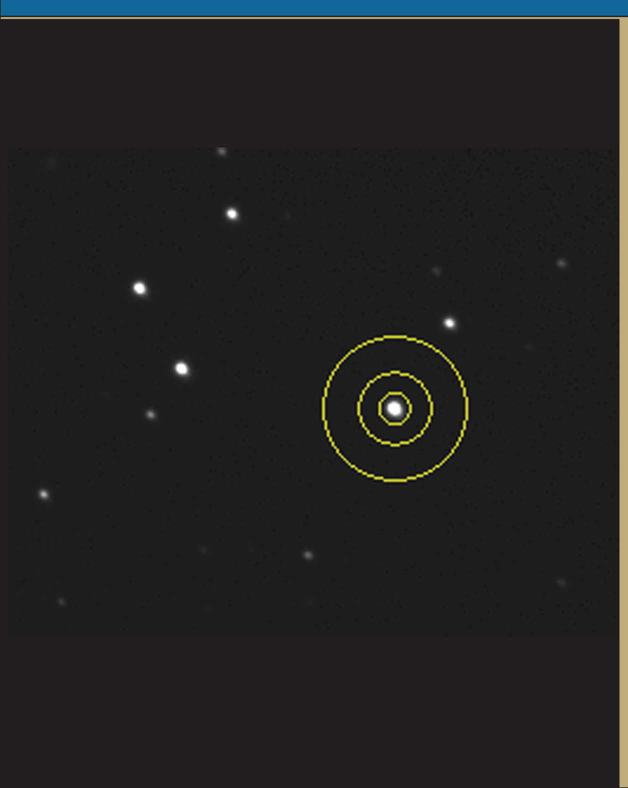
Our data were gathered at Hobbs Observatory in the Beaver Creek Reserve, located outside of Fall Creek, WI.

The Optical Path



The telescope that we use is a 24" Newtonian reflector. The CCD camera is mounted where the eyepiece is shown. Bessel passband filters matched to our camera are placed in the optical path between the camera and the flat mirror. This allows for images in different regions of the light spectrum. In this way we are able to match our images to the Johnson-Cousins system.

Apertures and Annulus



- •Inner ring measures light from actual target
- •Center ring called dead zone. No light in this zone is taken into account.
- • Outer ring called "sky annulus." All light here is measured, averaged and subtracted from values of inner ring.
- • Process removes sky background from inner ring.

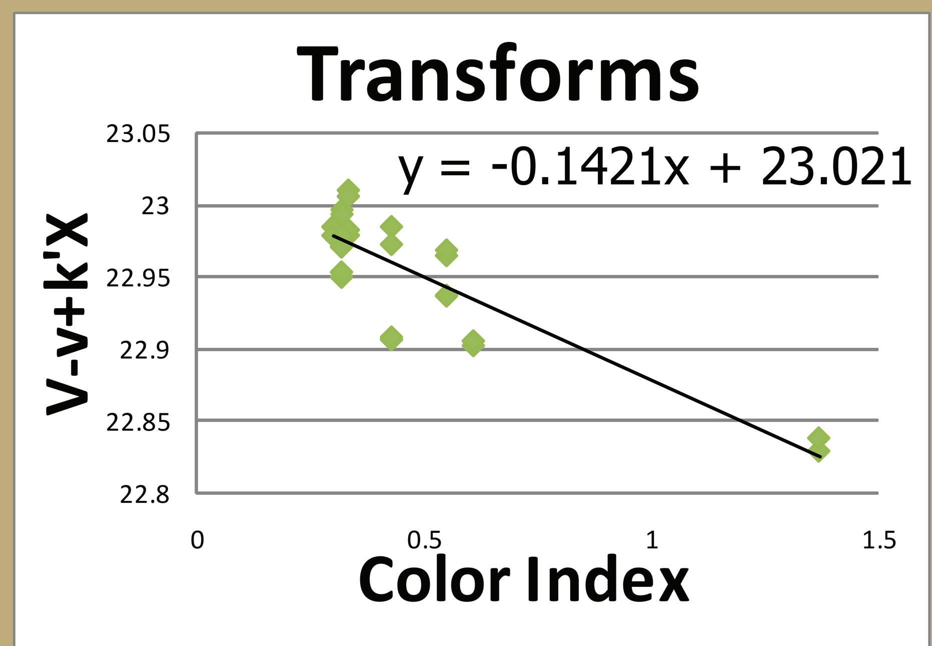
Compensation for Atmosphere and an Imperfect System

Noise

Calibration removes most system noise within the telescope. This noise can include, but is not limited to, amplifier and thermal noise.

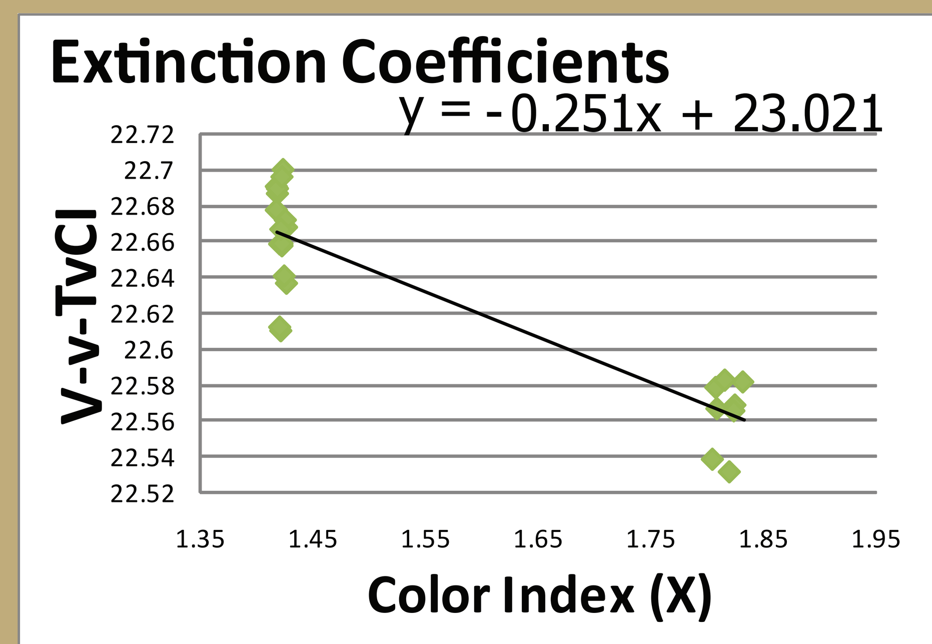
Star Field of 2167 Erin: Uncalibrated

Star Field of 2167 Erin: Calibrated



Variations in Color

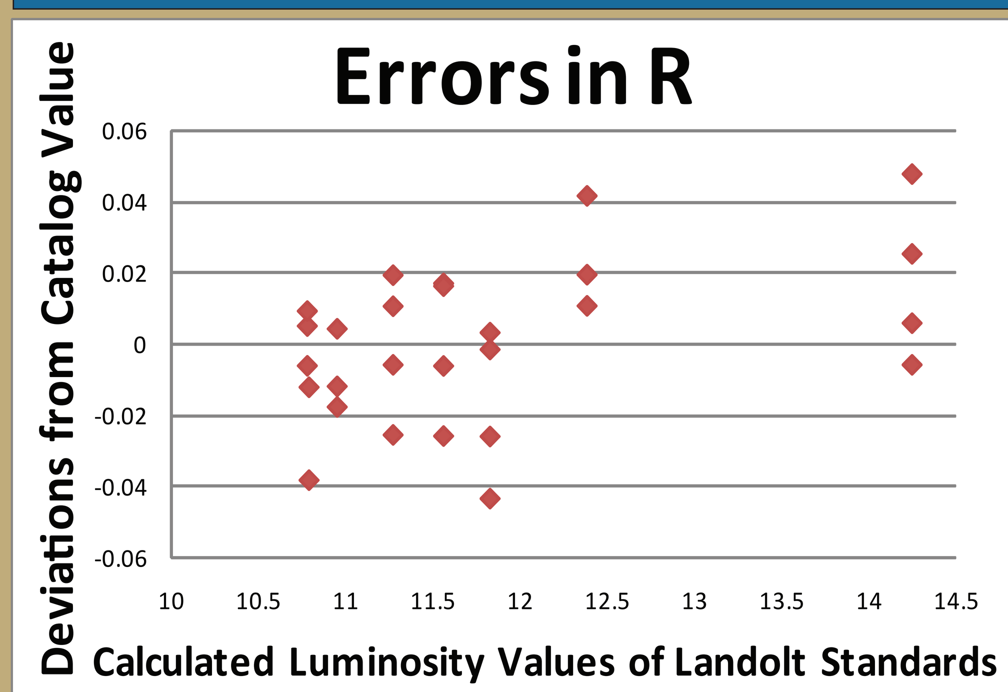
A standard scale of color magnitude exists for all astronomical data. No instrument is perfectly matched to the standard system. Use of standard transform values found from standard Landolt star fields allows our system to match the standard.

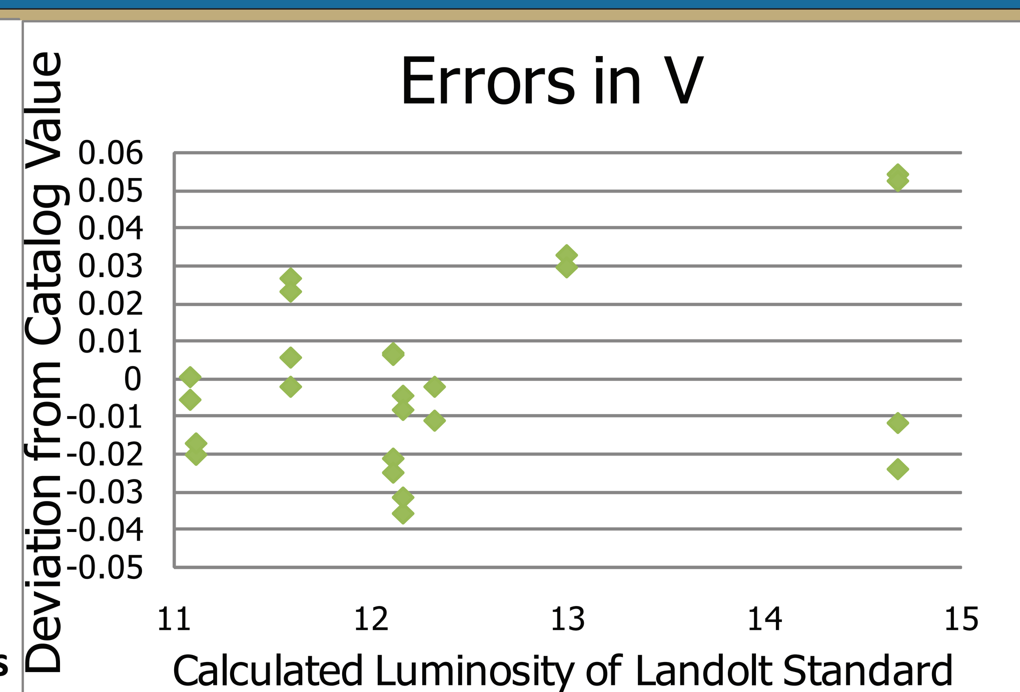


First Order Extinction

When looking near the zenith, we are looking through less atmosphere (less air mass) then when we are looking near the horizon. The first order extinction coefficient addresses for this varying amount of atmosphere

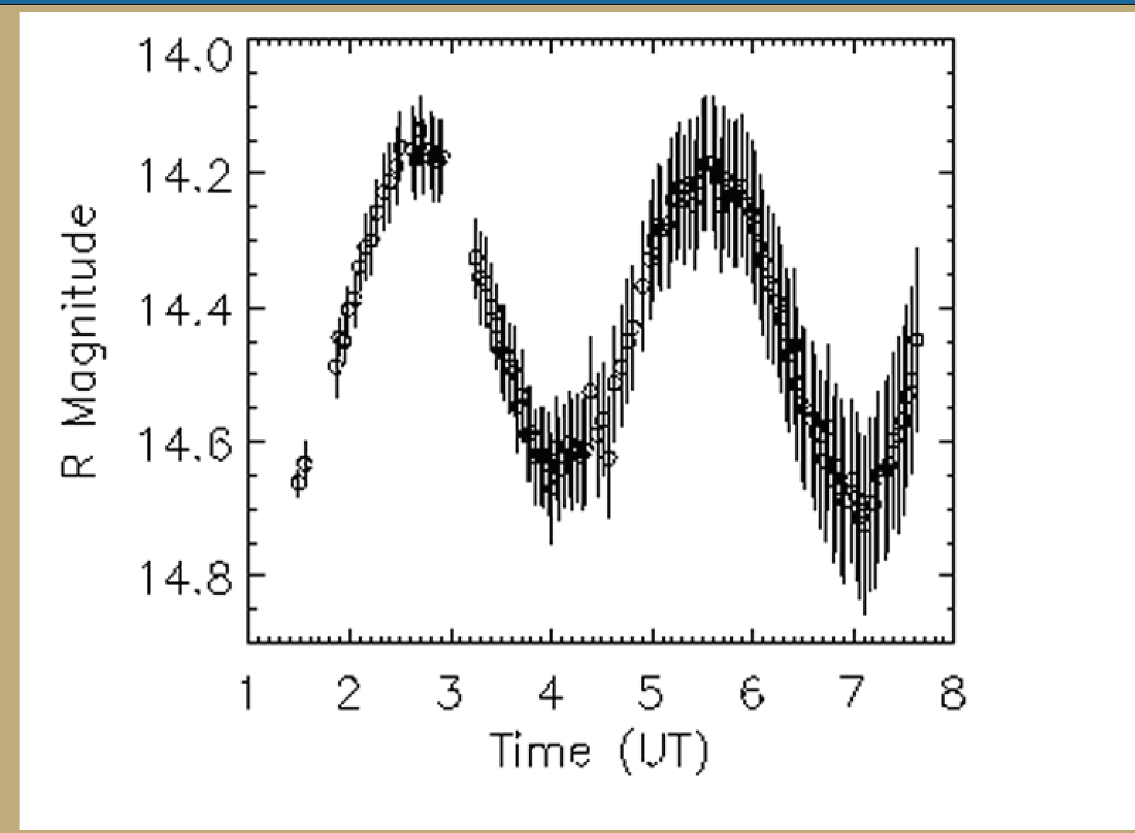
Minimizing Errors



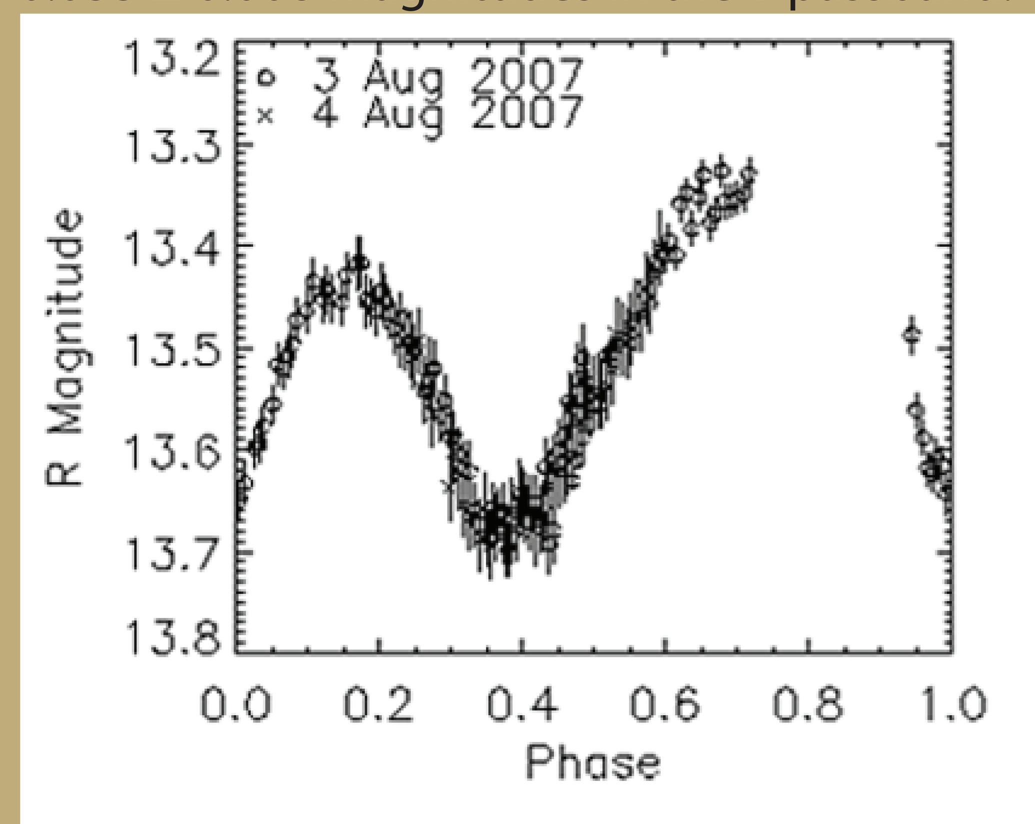


Using the values of transforms and extinction coefficients, we can see how close our found values of brightness are to the true values of brightness. In this example, a standard deviation from catalog zero was ±0.021 magnitudes in the R passband and ± 0.025 magnitudes in the V passband.

Results



2167 Erin: Average error of 0.089 ± 0.028 magnitudes in the R passband. Average error of 0.033 ± 0.008 magnitudes in the V passband.



1084 Tamariwa: Average error of 0.025 ± 0.008 magnitudes in the R passband. Average error of 0.014 ± 0.003 magnitudes in the V passband.

17010 1999 CQ72 and 2660 Wasserman were both measured using this method. 17010 1999 CQ72 was found to have errors of 0.092±0.039 magnitudes in the R pass band and 0.052±0.014 magnitudes in the V passband. 2660 Wasserman was found to have errors of 0.086±0.021 magnitudes in the R passband and 0.046±0.017 magnitudes in the V passband.

References and Acknowledgements

Warner, B. D. (2006). A Practical Guide to Lightcurve Photometry and Analysis. Springer, New York, NY.

Warner, B.D. (2007). MPO Software, Canopus version 9.3.1.0, Bdw Publishing, http://minorplanetobserver.com.

We thank the United States Department of Education (Ronald E. McNair Postbaccalaureate Achievement Program) and the University of Wisconsin-Eau Claire Blugold Fellows program for funding this research. We also thank the Theodore Dunham Fund for Astrophysics, the National Science Foundation (award number 0519006), and the University of Wisconsin-Eau Claire Office of Research and Sponsored Programs.