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Atmospheric extinction

Abstract

We used observations obtained at the Rapid Eye Mount (REM) at the La Silla Observatory between 2016 June 7 UT to determine the extinction coefficients of the REM filters currently in use. The observations were obtain on 6 nights, spanning 2016 June UT through 2016 July 4 UT, over a wide range of airmass values, to determine the mean atmospheric extinction coefficients at the La Silla Observatory site. Coefficients in the REM filter sets—Sloan *g*', *r*', *i*', *z*', and *J*, *H* and *K* were determined, where the REM infrared filters closely match those of the *J*, *H*, and *Ks* filters of the 2MASS All-Sky Survey.

1. Introduction

In order to obtain precise photometric data, it is necessary to compare observed brightnesses of a science target of interest with those of calibrated standard stars. While this is most easily done if the science target and calibration star are obtained at the same airmass, this condition is occasionally not met in practice. If there are photometrically measured stars in the field of view with reliable data from various sources (the Sloan Digital Sky Survey or 2MASS survey, for example), differential photometry is possible. If not, and if the science targets and calibration stars are observed at different values of the airmass, it is necessary to correct for the differences in the atmospheric extinction between the two, using some sort of extinction coefficients for that telescope. For each object the extinction-corrected magnitude is:

$$m_{\lambda,0} = m_{\lambda} - k_{\lambda}X$$

where m_λ is the observed magnitude at a given airmass X, $m_{\lambda,0}$ is the magnitude outside the atmosphere, and k_λ is the extinction coefficient at wavelength λ. Here we do not include color corrections for the color of the star nor for color terms within the photometric system itself.

Many photometric systems exist today, such as the Geneva photometric system (Golay 1972) and Strömgren photometric system (Strömgren 1956; Crawford 1958), used for deriving the observed properties of stellar photospheres. Considerable effort has been expended in determining the atmospheric extinction coefficients at La Silla in these systems (Rufener 1986; Cramer 1989; Sterkin & Manfroid 1992; Burki et al. 1995). Tüg (1977) determined the extinction at 3000–9000 Å in 50 Å steps, and made these available for the general user in the ESO Users Manual 1977 December, binned to 200 Å intervals. [3]

With the Sloan Digital Survey and 2MASS date sets being so popular today, a similar set of extinction coefficients at those bandpasses would be useful, particularly for transient phenomena and stellar variability where the net flux, and not spectroscopic parameters are of interest. The Rapid Eye Mount (REM) (Chincarini et al. 2003; Tagliaferri et al. 2004) located at the La Silla Observatory site of the European Southern Observatory (ESO). REM was designed to be a rapid-slewing robotic telescope used for (primarily) transient objects (γ-ray bursts, and the like). Starting with an IR camera (REMIR), it contained J, H, and K filters for imaging and a Z-band slitless spectrograph (ROSS) for spectroscopy. Eventually V, R, and I filters were added, later replaced with Sloan g', r', i', and z' filters in its current configuration (ROS2 [4]).

2. Observations and Data Reduction

As part of a program to observe the Herbig Fe star SAO 206462 (HD 135344B, Stolker et al. 2017), we observed both this star and the nearby binary companion, SAO 206463 (HD 135344A,A0V) with the REM telescope. Because these two stars are only 20 s of arc from one another, and SAO 206463 seems to be photometrically stable (standard deviation

in the *B* band of 0.0369 mag) (Sitko et al. 2012), [5] SAO 206463 was an ideal calibration star for the target of interest, SAO 2056462. Both can be included in the visible and infrared detectors fields of view of REM, so simple differential photometry was possible.

However, other interesting targets were observed in the same observing season (2016 June 7 UT through 2016 July 4 UT), at a wide range of airmass values. In general, however, the "standard" calibration stars normally observed by the REM facility are sometimes not observed at an airmass greater than 1.5, while some of our targets were observed at much larger values of the airmass.

correct for the differing extinction, we collected 6 nights of photometric observations of SAO 206463, obtained at airmasses between 1.0 and 2.9. In Figure 1 we show the observed magnitude (which includes a zero-point constant for the given photometric system), using the Sloan *g*', *r*', *i*', and *z*' filters of the ROS2 "visible" photometric channel, and *J*, *H*, and *K* filters of the REMIR infrared channel. The the raw counts for SAO 206463 were then extracted using the ATP aperture photometry routine atp.pro [6] running under IDL.

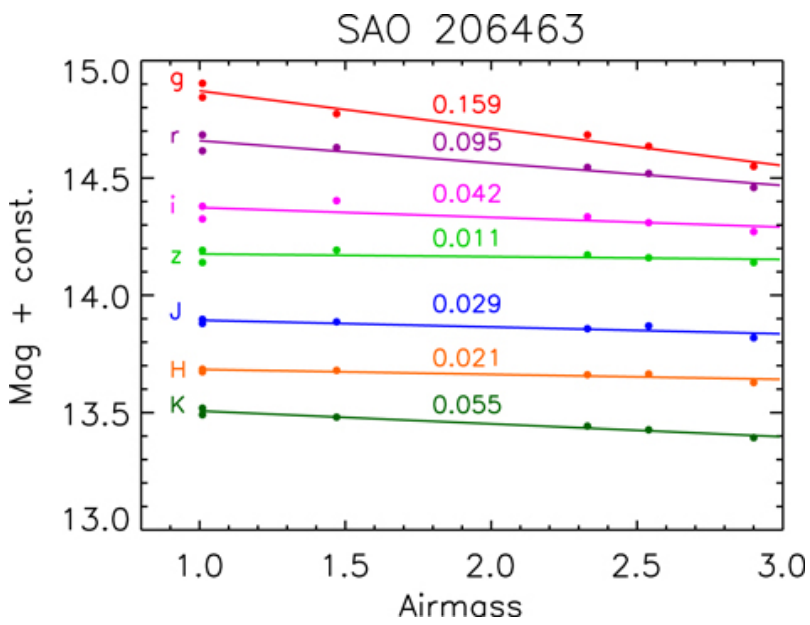

Figure 1. The instrumental magnitude for the observations in the *g*', *r*', *i*', *z*', *J*, *H*, and *K* filters of the Rapid Eye Mount of the European Southern Observatory site at La Silla, Chile. The labels in the figure are the extinction coefficients, determined from a least-squares linear fit to the data for each filter.

3. Wavelength-dependent Extinction at La Silla

Figure 1 shows the instrumental magnitude in each filter versus airmass for the 6 nights of REM observations of SAO 206463. As can be seen in the figure, the extinction coefficient decreases with increasing wavelength in the *g*', *r*', *i*', and *z*' bands, as expected for extinction dominated by atmospheric scattering. The *J*, *H*, and *K* band, however, include molecular absorption features, and the extent that this contributes to the extinction in these band depends on the precise bandpass of the filter used (see, for example, Simons & Tokunaga 2002). The REM filters are a close match to the ones used in the 2MASS All-Sky Survey. [7]

As there are many users of REM, we believed that this information should be available to them, and for other La Silla facilities, should they have similar filters in use.

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Facility: REM—the Rapid Eye Mount - .

Software: ATP.pro, https://aperturephotometry.org.

Footnotes

3 See https://www.eso.org/sci/observing/tools/Extinction.html.

4 http://www.rem.inaf.it

5 *G* band magnitude in the GaiaDR3 was constant to within 0.01—https://gea.esac.esa.int/archive/.

6 https://aperturephotometry.org

7 https://irsa.ipac.caltech.edu/data/2MASS/docs/allsky/docs/releases/allsky/doc/figures/secvi4bf1.gif