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Study of sky condition at Raipur and calibration of the photometer-telescope system

Padmakar, Sudhanshu Barway and S.K. Pandey

School of Studies in Physics, Pt. Ravishankar Shukla University, Raipur 492 010, India

Abstract. To investigate local sky condition for valuable astronomical observation, we obtained values of atmospheric extinction coefficients in BVR filters for over 150 nights during the period of 1994 to 1997. Our observation over nearly three years indicates that although the sky condition at the observing site is not steady, the observing facility can be fully exploited for differential photometric studies on bright variable stars. Several times during each observing season on clear photometric nights we also carried out observation for calibration and checked reliability of our system calibration.

Key words : photoelectric photometry-atmospheric extinction-calibration.

1. Introduction

The photometric monitoring of the variable stars using small telescopes is economic and relatively easy. In 1994, we started a systematic observing programme on RS CVn binaries using University observing facility. Raipur is one of the rapidly growing places in central India suffering from heavy dust and light pollution and representing urban atmosphere of Indian cities. After emergence of the Inter University Centre for Astronomy and Astrophysics (IUCAA), gradually university observatories having small but sophisticated instruments are coming up. For the first time we have performed systematic observations for atmospheric extinction and system calibration and we hope that these results would be useful for those who have similar facilities.

2. Observations

Observations for extinction measurements and calibration were carried out during November 1994 to February 1997 using the 0.35m reflector telescope equipped with SSP-5A PMT photometer and Johnson broad band BVR filters at the University Observatory, Raipur. The detector used in SSP-5A PMT photoelectric photometer is a R4457 9 stage side-on photomultiplier tube (PMT) manufactured Hamamatsu, Japan. From the normalized filter-detector response curve it is clear that response function for B and V bandpass closely resembles the standard Johnson system. However the filter-detector response for R bandpass is closer to the

Cousins system rather than to the Johnson system. To obtain principal extinction coefficients, two or three standard stars of different spectral types were used on each night and observations were restricted on airmass below two. BVR standard stars published in Astronomical Almanac (1995) were chosen as standard stars for deriving transformation coefficients for the telescope-detector-filter system.

3. Atmospheric extinction

For precise photometric observation, extinction measurements must be made with great precaution and each data point should be corrected for extinction. After rejecting uncertain extinction determination and days with $k_v \geq 1.0$ mag. 150 data points are left. In order to investigate long term behaviour of the extinction coefficients, we have plotted the observed data in Fig.1a-c. Our study reveals that visual extinction at Raipur is quite variable and there is no indication of seasonal variations. A very weak periodic trend seems to be present in the monthly extinction variation (Fig.1d). The histogram for the distribution of the visual extinction (Fig.1e) indicates that all observation with $k_v \geq 0.80$ mag. represents very bad observing condition are not statistically significant. One can also obtain a good idea and likely values of extinction at typical urban observing site. The mean values in k_v, k_{bv} and k_{ur} are 0.434±0.142, 0.214±0.067 and 0.100±0.068 respectively. These mean values are comparable with extinction values obtained at urban observatories located relatively at lower altitude in other countries (Reimann *et al.* 1992; Jeong 1991). However, mean values of the observed extinctions are considerably larger than theoretically evaluated values : 0.243, 0.143 and 0.073 using the empirical formula given by Bessel (1990).

In order to determine instantaneous values of the first order extinction coefficients, we used technique introduced by Poretti & Zerbi (1993). Our observations also reveal that even on clear nights and in good weather conditions, extinctions within a night are found to be variable (Fig.1f). The most probable cause of nightly extinction variation could be settling of dust particles, shrinking or swelling of the aerosols due to water vapour content variations and/or the exchange of different airmass over the observing sites (Reimann *et al.* 1992, Forbes *et al.* 1996)

4. Photometric transformations

For universal use of astronomical data, each instrumental magnitude and colour requires to be transformed to a standard system. In order to obtain transformation relation for our telescope-photometer system, we observed a number of BVR standard stars during each observing season, having wide range in B-V and V-R colors. For the photometric calibration observations, only those nights were chosen which were found to be relatively state and the atmospheric transparency was judged to be quite good. Transformations coefficients obtained during different observing season are listed in Table 1.

Our results indicate small variation in the slopes (ε, μ) and a slightly higher variation in zero points. Relatively large variation in zero points may be due to : (i) observed night not being photometric, (ii) inaccurate measurements of the extinction coefficients, (iii) very high dust deposition rate on Schmidt corrector plate and (iv) deterioration of the photometric system

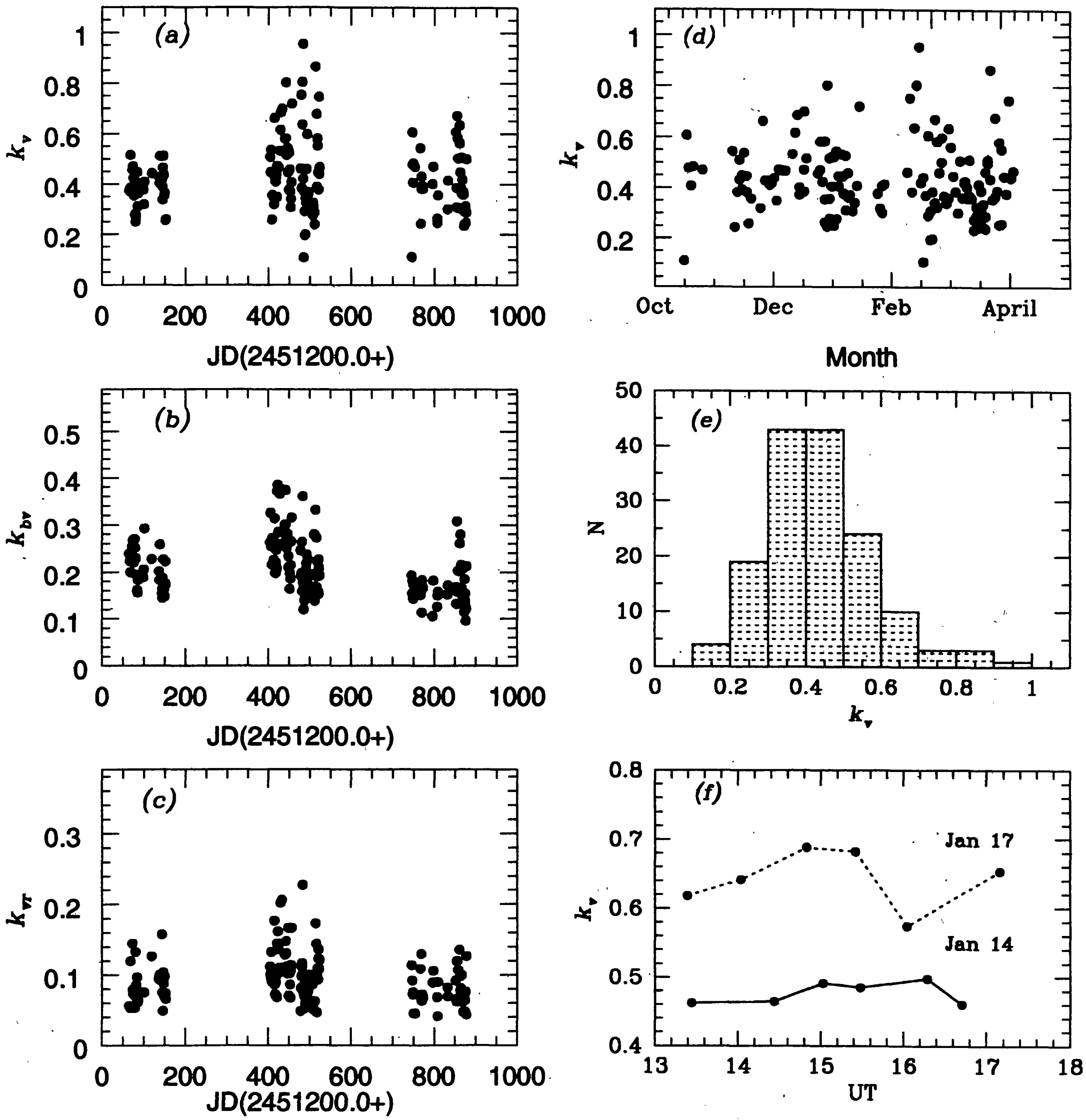

Fig. 1 : Variation of atmospheric extinctions at Raipur during November 1994 to February 1997: (a) k_v, (b) k_{bv}, (c) k_{vr}, (d) monthly variation of extinction in k_v (e) distribution of the nearly three years visual extinction coefficient and (f) variation in k_v within two different nights.

itself (Burki *et al.* 1995; Mayya 1991). Higher and negative values of ε_r (not included in Table 1) indicates that our R bandpass does not match with Johnson R band, it probably corresponds to Cousins system (Mohan *et al* 1991).

Table 1. Transformation coefficients obtained during 1994-97

Night	ε_v	ζ_v	μ_{bv}	ζ_{bv}	μ_{vr}	ζ_{vr}
Nov 30, 1994	-0.044	11.920	1.086	-0.065	1.362	1.282
	±0.029	±0.017	±0.019	±0.012	±0.030	±0.015
Feb 19, 1995	-0.048	11.927	1.114	-0.099	1.379	1.330
	±0.020	±0.004	±0.020	±0.006	±0.004	±0.006
Dec 18, 1995	-0.058	12.067	1.147	-0.335	1.373	1.205
	± 0.029	± 0.016	± 0.012	±0.018	± 0.036	± 0.026
Jan 22, 1996	-0.041	11.987	1.124	-0.298	1.352	1.200
	± 0.039	± 0.022	± 0.0296	±0.020	± 0.014	± 0.016
Feb 12, 1997	-0.036	12.021	1.109	-0.248	1.365	1.272
	± 0.06	± 0.039	± 0.014	± 0.001	± 0.022	± 0.017

Photometric repeatability is considered to be a measure of the goodness of transformation coefficients. And for this, on each photometric night when observations for transformation coefficients were performed, 10 to 15 other standard stars were also observed. Instrumental magnitudes and colors of these stars were transformed into the standard system using the derived transformation coefficients. The mean deviation between the observed and the standard V magnitude and (B-V), (V-R) colors are found to be 0.017, 0.028 and 0.017, respectively. The small values of the mean deviation demonstrate the accuracy of our photometric calibration.

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