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Photometry of all-sky cameras of MOROI network

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Abstract

To bridge the gaps between asteroids, meteoroids and meteorites, numerous fireball networks have been deployed. Long term analysis of all-sky data provide us with essential information for meteor studies, along with evaluations of light pollution or site astroclimatic characterization. We present the photometric analysis of two sets of all-sky images of MOROI (Meteorites Orbits Reconstruction by Optical Imaging) network [8] collected over the period of 1 year. The results entail applications for systemic studies for the larger FRIPON network [3].

1. Introduction

Up until now, over 790,000 asteroids and comets have been discovered, and many thousands are discovered annually. The disintegration of these bodies by collisions, rotational fission or cometary activity, leads to meteoroids [7]. Astrometry and photometry of meteoroids entering the atmosphere provide us with essential data from which, we can project the orbit of the body, and estimate the location of the strewn field, to aid the meteorite recovery team. This has been demonstrated by numerous networks [4]. Furthermore, calibrated photometric measurements of bolides are useful to derive the mass of incoming objects [9, 5] and constrain the measurements on flux of matter entering the atmosphere.

2. The MOROI network

The MOROI project begun in 2016 following the installation of the most eastern FRIPON [2] camera in Bucharest. After an array of three cameras had been deployed on Transylvania for testing and validation on early 2017, the network was extended to 11 cameras as of February 2019. For this study, we used all the calibration frames acquired in Feleac and Berthelot stations, in Romania, over the course of one year. For the image acquisition and meteor detection pipeline, we employed FreeTure open source software [1] on all of MOROI stations. On the meteor detection images (33ms exposure), we hardly see any stars, therefore, along with the meteor acquisition algorithm, we need to collect a long exposure image (5 seconds) for the astrometric and photometric calibrations. This procedure is repeated every 15 minutes. We used the IRAF *daofind* [10] procedure on the calibration images to extract the sources, and match them with their horizontal coordinates by fitting a simple polynomial distortion function for zenith distance (z). Since high accuracy astrometric solution [6] is not crucial for all-sky photometry, a radius of two pixels was used as a threshold for the matching sequence. To measure the atmospheric extinction and calibrate the instrumental zero point, we converted the measured fluxes into a positive magnitude, and added the catalog magnitude of detected stars. This value was plotted for each star as a function of airmass, and, the linear regression of those points is the Bouguer extinction law (fig 1). Cloud coverage was estimated by dividing the sky using a polar grid binning method, and we count the number of stars expected for each sky parcel. A similar method was used to produce extinction maps along different azimuth directions.

3. Results

Our algorithm can identify on a clear sky up to 230 stars (as far as magnitude 6) for Berthelot station, and 130 stars for Feleac on the calibration images. This number is greatly influenced by the lunar phase. During a full moon clear sky, the number of detected stars drops to a maximum of 25 on both sites. For the atmospheric extinction, we obtain an all-sky integral average of 0.35 mag/airmass for Berthelot and 0.40 mag/airmass for Feleac station. Along with the errors produced by the aerosols, lunar brightness or the type of clouds, another source of uncertainty is caused by the strong extinction towards short wavelengths. When we take into account the star B-V color, the Bouguer fit errors drop by >10%. This is done by dividing the stars into four color groups and plotting the fit for each color. The uncertainties are further reduced when we treat events separately, and eliminate the biased data. However, overlapping large amounts of data can increase the confidence level, due to a cancellation of transitory phenomena. This all-sky instantaneous determination of extinction coefficients using a single frame, will be followed by a thorough analysis based on tracking selected standard stars at different zenith distances in the calibration captures.

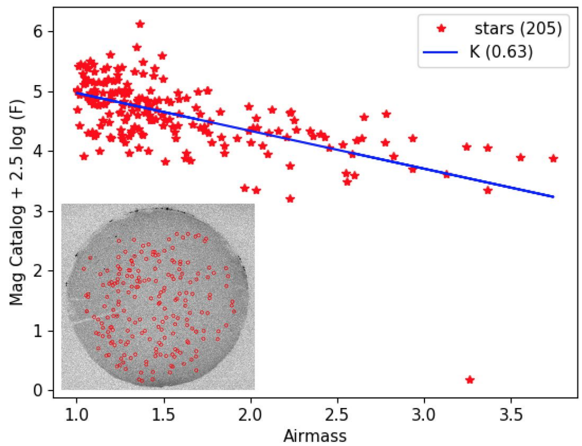

Figure 1 : Example of Bouguer extinction law fit of stars detected in the attached all-sky image (2019/03/05 at 20:27:55UT, Berthelot, Romania). The matched stars (red) are fitted with a linear regression line, and K is the derived magnitude/airmass drop. The median of the residuals is 0.24 mag. The outlier (3.26 airmass) is an example of internal error caused by IRAF *daofind* centroid flux measurement.

4. Summary and Conclusions

We have performed a study on all-sky photometry for two of MOROI stations, Berthelot and Feleac, over the course of one year. This period translates into more than 30000 images analyzed by our routine. During a long-term analysis on all-sky images, along with meteor data, we can find the number of photometric nights, the number of nights suitable for observations and how atmospheric extinction changes around the sky or throughout the year. The advantages mentioned above, come with a list of challenges, that we addressed for both stations. In a scenario where a fireball occurs and clouds impede a proper measurement of atmospheric extinction, long term analysis intervenes to calibrate the instrumental zero point, and with it, to estimate the meteor magnitude. The obtained results entail applications for systemic studies within the FRIPON network.

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