Measurements of Diffuse Night Sky Background

T. Mineo,[1] O. Catalano,[1] G. Agnetta,[1] B. Biondo,[1] G. Cusumano,[1] S. Giarrusso,[1] G. Gugliotta,[1] A. Mangano,[1] and F. Russo[1]
(1) IASF-CNR Sezione di Palermo, via U. La Malfa 153, 90146 Palermo, Italy

Abstract

This paper presents results of measurements of night sky background in the range 300-650 nm and several sub-intervals. Measurements were performed at Piano Battaglia (Sicily) pointing both to the zenithal direction and towards a mountain about 1 km far. These results are very useful for studying the sensitivity of fluorescence and Čerenkov on-ground telescopes, and for fluorescence on-space detectors looking down to the Earth to observe cosmic-rays and neutrinos.

1. Introduction

The experiments that observe Čerenkov or fluorescence light produced by high energy particles interacting in the atmosphere needs appropriate measurements of the diffuse background. In fact, the extensively studies on the night sky brightness [6] are not straight-forward usable for these instruments because of their relatively large imaging pixels that integrate over several faint stars. Moreover, a new class of experiments, among which EUSO [3] that propose to observe cosmic rays and neutrinos looking towards the Earth and NUTEL [5] that is planning to look skimming Earth and mountain, require an ad-hoc evaluation of the background.

We started an observing campaign to measure the diffuse night background pointing to the sky and a mountain surface. In this paper, results relative to sky brightness and background pointing toward a mountain in moon-less nights are presented. Measurements from the background looking at the sea are presented in [4].

2. Description of the Instrument and measurement set-up

The instrument consists of 4 cylindrical aluminum cases each housing two separate PMTs. In each pair, one PMT works in single count mode and the second in charge integration mode. The particular configuration of the design is motivated by the demand to have a cross-check of the measurements. Two equal aluminum collimators on top of the PMT windows reduce the field of view. In

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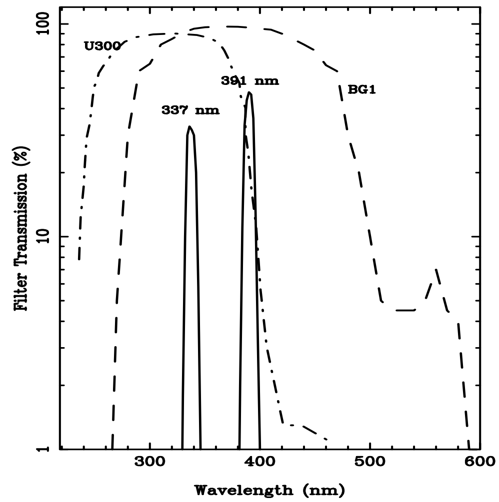

Fig. 1. Transmittance of the filters used in the measurements presented in the paper.

this configuration the instrument has been used to perform balloon flight mission for a survey of the nightglow from the sea [2].

The 8 PMTs R3878 Hamamatsu are sensitive in the band 300-650 nm with quantum efficiency of $\sim$ 16 % at 400 nm, sensitive area 38 mm^2 and double pulse resolution of $\sim$20 ns. Absolute calibration of the experimental set-up was performed in laboratory and checked with the flux of the candle Vega, that was also used to evaluate the effective solid angle of the collimator whose value resulted 1.71×10^{-2} sr equivalent to 4.23 effective diameter of the field of view. Signals from each PMT are cabled to two different electronic channels. The charge integration channel consists of a precision charge integrator module and a digital counter. Signals are integrated in a period of τ=10 ms. The capacitor is discharged with a constant current. The counting channel consist of a fast discriminator with threshold voltage sensitivity better than 1.5 mV. In both configuration the dark current gives a negligible contribution to the signal.

Measurements in narrower bands are also performed with a set of filters positioned o top of the collimators. In particular, we used the two wide band filters BG1 (280-500 nm) and U300 (250-400 nm) with $\sim$ 80% of transmittance, and the narrow band filters 337 nm (30% transmittance) and 391 nm (40% transmittance). In both filters, the transmission is well described by a gaussian of width $\sim$4 nm. Figure 1 shows the characteristic trasmittance of these filters.

The measurements were performed at an observing level of 1500 m a.s.l., in a site, Piano Battaglia (Sicily), far from artificial light pollution, pointing the detector at the zenithal direction and towards a mountain located at a distance of $\sim$ 1 km.

Table 1. Fluxes (ph m^{-2} s^{-1} sr^{-1}) measured in different bands pointing at the sky and at the mountain, and their relative ratio.

Filter	Sky	Mountain	Mountain/Sky
No Filter (300–650 nm)	$(1.9\pm0.4)\times10^{12}$	$(1.3\pm0.2)\times10^{12}$	0.68 ± 0.18
BG1 (300–500 nm)	$(6.4\pm1.1)\times10^{11}$	$(2.7\pm0.5)\times10^{11}$	0.42 ± 0.13
U300 (300–400 nm)	$(3.2\pm0.6)\times10^{11}$	$(7.1\pm1.4)\times10^{10}$	0.48 ± 0.13
337 nm	$(5.8\pm0.6)\times10^{10}$	$(1.6\pm0.2)\times10^{10}$	0.27 ± 0.07
391 nm	$(3.9\pm0.8)\times10^{10}$	$(1.4\pm0.3)\times10^{10}$	0.36 ± 0.11

3. Results

Detected count were converted to photon flux by applying the following expression

$$\Phi = \frac{R}{A\,\Omega_{eff} \int_{\lambda_1}^{\lambda_2} S(\lambda)\,T(\lambda)\,\epsilon_{PMT}(\lambda)} \tag{1}$$

whith:

$$S(\lambda) \begin{cases} = 1 & \text{for the narrow band filter} \\ \int_{\lambda_1}^{\lambda_2} S(\lambda)\,d\lambda = 1 & \text{for the wide band filter} \end{cases} \tag{2}$$

where R is the measured counting rate, A the photocatode entrance area, Ω_{eff} the effective solid angle of the baffled tube. $T(\lambda)$ and $\epsilon_{PMT}(\lambda)$ are the filter transmission and the photomultiplier efficiency as function of the wavelength, respectively. $S(\lambda)$ is the spectral shape assumed for the night sky background used to compute the average efficiency of the wide band filters. It is approximately flat between 300 and 450 nm, and rises toward longer wavelengths with number of narrow lines superimposed [1]. $S(\lambda)$ is set to 1 for the narrow-band filters assuming that the spectral distribution of the light is constant over their small response width. Table 1 shows the values of measured fluxes for the whole set of filters and without filter.

4. Conclusion

The measured flux in the 300-650 nm band of night sky background at Piano Battaglia (Sicily) is in agreement, within 2 standard deviations, with the results previous published [7]. Moreover, the light intensity towards the mountain is lower than the background towards the sky and their ratio, shown in the last column of Table 1, is function of the wavelength. In particular, from these data an indication of increase of the ratio with wavelength can be inferred.

As further work, more measurements are planned in order to investigate variations with weather condition or moon phase.

5. References

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