Measurements of the *UV* Nocturnal Atmospheric Background in the 300-400 nm Wavelength Band with the Experiment BaBy During a Transmediterranean Balloon Flight

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Abstract

We present new results of *UV* nocturnal atmospheric background measured with the balloon borne experiment BaBy that performed a trans-Mediterranean flight on July 11 2002. The experiment looked downwards from about 40 km of altitude the dark nocturnal atmosphere over the sea in a moonless night. It is composed of 8 filtered and collimated fast PMTs detecting the *UV* light in the 300-400 nm wavelength band and in the 3 narrow bands centered at the emission lines of the atmospheric Nitrogen molecules. Both single photon counting and charge integration methods are used in pairs of PMTs with the same filter. The background measured over the sea is about 300 photons m^{-2} sr^{-1} ns^{-1} in the 300-400 nm wavelength band.

Introduction

The Backround Bypass, BaBy, experiment is a scientific support activity to the evaluation of the sensitivity of EUSO [3], devoted to the observation of the Extreme Energy Cosmic Rays from space by detecting *UV* fluorescence light. One of the fundamental information in EUSO design is the *UV* nocturnal atmospheric background level whose main sources are: light pollution from cities, planes and ships, naturally occurring bioluminescence, lightning flashes, reflected moonlight and starlight, auroral flashes, low energy cosmic ray air showers and atmospheric chemical reactions.

Since 1998, nocturnal atmospheric *UV* background measurements, in the wavelength interval (300-400 nm) relevant for EUSO, have been performed by

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BaBy. It flew from the Milo-Trapani base of the Italian Space Agency (ASI) several times. On July 30 1998, a first version of BaBy looked down, from an altitude of about 26 km, over the territory of the west Sicily and the Mediterranean Sea for about 5 hours in a clear moonless night. The instrument was a single box with two photomultipliers (PMTs) filtered by a BG1. A UV background value of 450 photons m^{-2} sr^{-1} ns^{-1} was measured over the sea [2]; this value didn't take into account the absorption of the ozone layer because of the not very high altitude reached by the balloon. On July 24 2001 the current version of BaBy flew from an altitude of 15 km up to 30 km over the land of the west Sicily, for only 3 hours due to a failure on the balloon. Only a few good quality data were collected and the UV background value measured in the 300-400 nm wavelength band over the dark land was about 800 photons m^{-2} sr^{-1} ns^{-1}

Instrument description

The basic BaBy instrument carried out measures by means of a couple of collimated fast PMTs, one working in photon counting mode and the other in charge integration mode. The entire apparatus is composed by four couples of PMTs filtered differently. One of the couple is filtered with a BG1 covering the wavelength band 300-500 nm. The others use narrow bandwidth interferential filters (10 nm) centered on the main lines of emission of the atmospheric Nitrogen molecules (337, 357 and 391 nm). To reduce the amount of light level seen by the PMTs (i.e. the photoelectrons rate) and in order to allow the PMT to work in a linear region and in safety conditions, each PMT is collimated. This reduces the field of view to about 10^{-2} sr. The characteristics of the PMTs used in our experiment are: fast response (< 5 ns), high quantum efficiency (> 20 %) and high gain (10^6). A dedicated electronics allows to store in a local memory buffer 15 bit counts and 12 bit integration together with the relative time at 1 μs step with an integration window of maximum 16 ms. Temperature and pressure sensors are positioned inside the instrument to allow a constant monitoring of its health. To reduce the use of telemetry, limited only to the transmission of the housekeeping data and the count rates sampled every one second, all scientific data collected are stored in a hard disk of a dedicated on board PC. The BaBy assembly includes the detector unit, the electronic unit, the onboard computer and the battery supply unit.

We tested Baby on ground before launch at the monochromator facility at the Osservatorio Astrofisico di Catania. Moreover, observations of the candle source Vega, allowed to check the absolute calibration of the detector.

Table 1. Flux (photons m^{-2} sr^{-1} ns^{-1})

Wavelenght band	Flux	Observed surface	Obseration date
300–400 nm	310	sea	2002
300–400 nm	800	land	2001
BG1 (300–500 nm)	450	sea	1998
337 nm	50	sea	2002
357 nm	45	sea	2002
391 nm	65	sea	2002

Results

On July 11 2002 BaBy performed a trans-Mediterranean balloon flight successfully. It flew in a clear night and moonless condition from an altitude of 39 km providing valuable good quality data both in the integrate wavelength band of 300-400 nm and in the three narrow bands at 337, 357 and 391 nm.

The UV background fluxes have been evaluated from the detected count rates using the following expression:

$$B = \frac{R}{A\,\Omega_{eff} < \epsilon >} \tag{1}$$

where R is the measured count rate, A the collecting photons area, Ω_{eff} the effective solid angle subtended by the PMT and $< \epsilon >$ is the overall collecting efficiency of the PMT averaged in the wavelength band of the filters. As the spectral shape of the UV background is approximately flat between 300-450 nm [1], $< \epsilon >$ can been evaluated by:

$$< \epsilon >= \frac{\int_{\lambda_1}^{\lambda_2} \epsilon_{pmt}(\lambda) T(\lambda) d\lambda}{\Delta\lambda} \tag{2}$$

where $\epsilon_{pmt}(\lambda)$ and $T(\lambda)$ are respectively the collecting efficiency of the PMT and the filter transmittance as function of the wavelength and $\Delta\lambda$ is the wavelength bandwidth.

The profiles in the 4 wavelength bands of the UV fluxes are reported in Fig.1. The average UV background fluxes measured over the sea are 310 photons m^{-2} sr^{-1} ns^{-1} in the 300-400 nm wavelength band and about 50, 45 and 65 photons m^{-2} sr^{-1} ns^{-1} at 337, 357 and 391 nm respectively as summarized in Table 1.

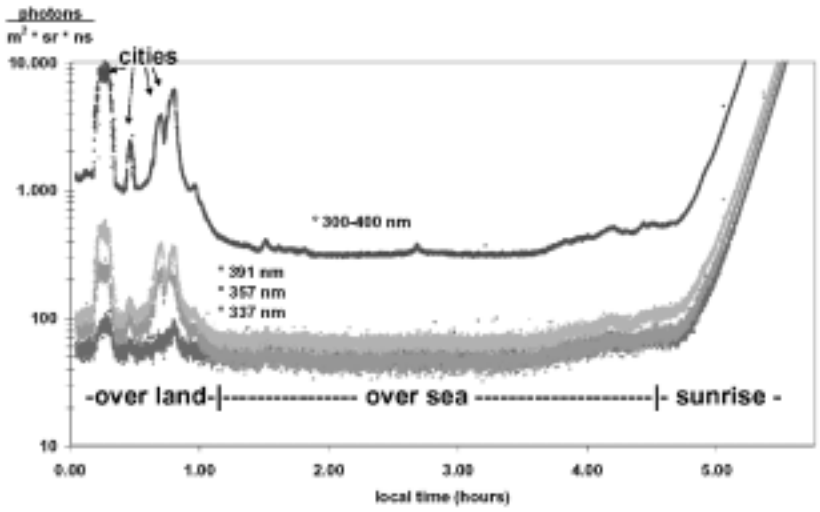

Fig. 1. BaBy 2002 flight Nocturnal Background Photon flux profiles

Conclusion

We reported the measured fluxes in the 300-400 nm wavelength band and in the three narrow bands centered at 337, 357 and 391 nm of the nocturnal atmosphere UV background measured over the sea looking downward from about 40 km of altitude in a clear night and moonless condition during a balloon trans-Mediterranean flight. These values are comparable with the previous observations of BaBy, coherent with the on ground measurements made by BaBy [6] and more important are in agreement with earlier rocket observations [4,5]. Other BaBy flights are foreseen in the future from different latitudes and under different environmental conditions to complete the program of systematic and exhaustive observations of the UV nocturnal atmospheric background.

References

1. Benn C.R., Ellison S.L. astro-ph/9909153
2. Catalano O. et al. 2002, NIM A 480, 547
3. Catalano O. et al. 2003, this proceedings
4. Greer R.G.H. et al. 1986, Planet and Space Sci. 34, 771
5. Lebedinsky A.I. et al. 1966, Space Research Nauka, Moscow, 77
6. Mineo T. et al. 2003, this proceedings