

UV spectrum on the Earth night side – ver. 1

UV spectrum on the Earth night side during moonless nights (i.e. Moon is under horizon) is created by three main sources

- nightglow light
- zodiacal light
- integrated stellar light

For nadir looking detector from low orbit (ISS trajectory) for cloudless situation over oceans nightglow is main source of light. Reflected zodiacal light and integrated stellar light has minor contribution due to low albedo of ocean surface.

Presented UV spectrum is evaluated for moonless and cloudless night conditions as is seen from low orbit in nadir direction over oceans.

Nightglow

Nightglow light measurements in last decades can be divided to two groups. To very precise ground measurements for wavelengths from 310 nm (atmospheric cutoff) and to very few rocket measurements from suborbital flights.

Most precise ground measurement to date is Ultraviolet and Visual Echelle Spectrograph (UVES) from the 8.2-m UT2 telescope at the Very Large Telescope, European Southern Observatory, Cerro Paranal, Chile, consists of 2808 line positions, line widths, and intensities over the 314–1043 nm spectral range (Hanuschik, 2003).

The rocket suborbital measurements are represented by Hennes (Hennes, 1966, JGR) published results.

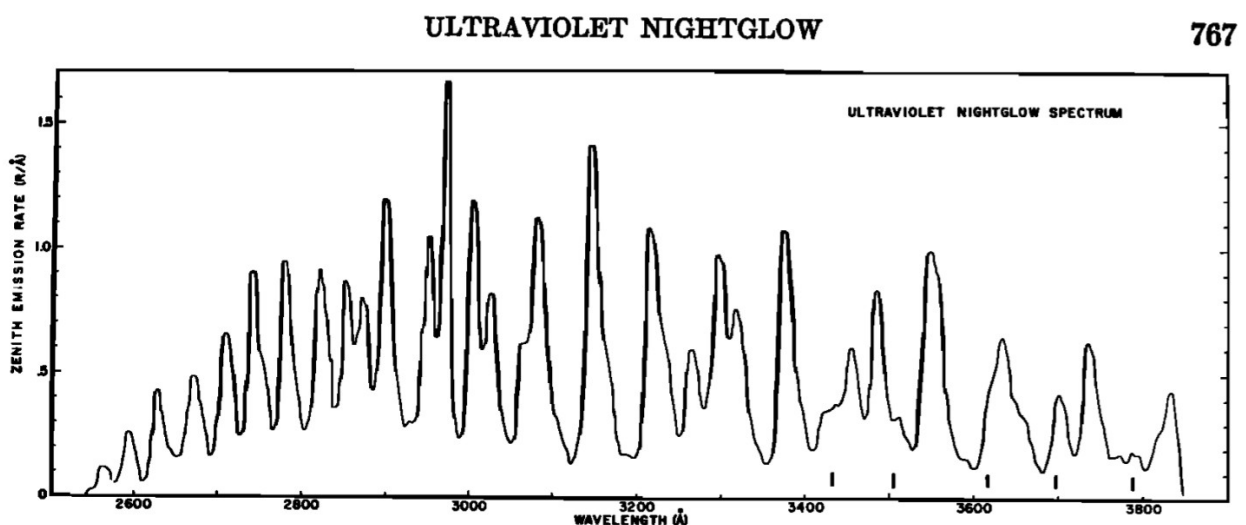


Fig. 5. The ultraviolet nightglow spectrum. The instrument and film response have been removed from Figure 4, and the spectrum has been put on a linear scale. The O I 2972 Å line is mixed with the Herzberg 7,4 band at 2976 Å. The short bars mark features not belonging to the Herzberg system.

Hennes, JGR, 1966

We integrate area of all on ground measured emission lines Gaussian fits to 1 nm and 5 nm bins to evaluate a ground spectrum of UV nightglow. Spectrum is presented on figure 1. upper panel. Comparison with Hennes rocket measurement on figure 1. bottom panel. We can see that both spectra has similar characteristics (peaks on similar positions).

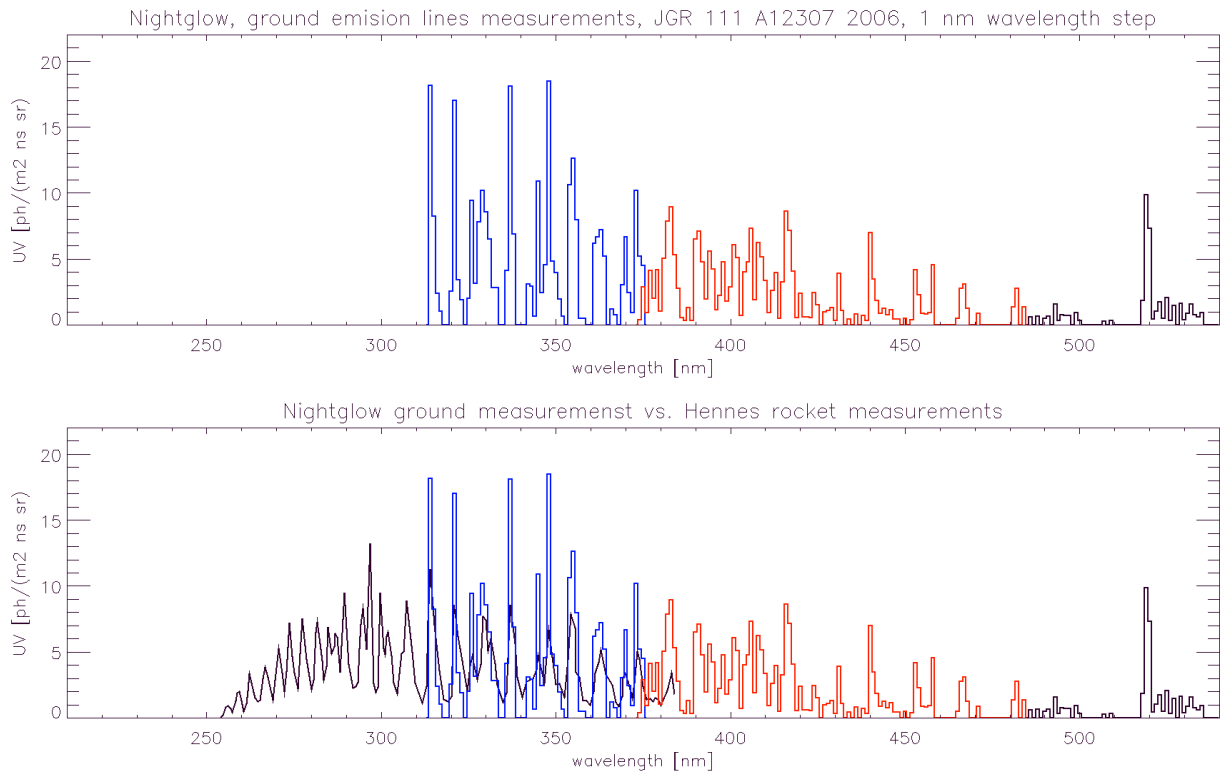


Figure 1. Spectrum evaluated from emission lines list from ground measurements (bottom panel) and comparison with Hennes rocket measurements (1966).

Ratio between intensities in Hennes 250-300 nm band and 300-383 nm is

$$I_{H\ 300-383}/I_{H\ 250-300} = 1,63$$

Ratio between intensities in ground emission lines band 313-400 nm and 400-500 nm band

$$I_{G\ 313-400}/I_{G\ 400-500} = 2,45$$

However peaks of both measurements are on similar positions, ratio of both spectra has following shape presented in Table 1.

Table 1.

wavelength range [nm]	I_{GROUND} / I_{HENNES}
310 - 320	0.8499
320 - 330	1.1284
330 - 340	1.2711
340 - 350	1.2757
350 - 360	1.2317
360 - 370	1.0756
370 - 380	1.9683

We made simple assumption that spectrum of ground measured emission lines is 25% higher than Hennes spectrum. Based on this assumption we connect Hennes and ground spectra and renormalize region 300-400 nm to 500 ph/(m² ns sr). In overlaped region of both spectra we take Hennes data to spectrum from 250 to 500 nm.

Then ratio of nightglow emission in bands/bins

250-300 nm : 300-400 nm : 400 - 500 nm is 1.51 : 2.77 : 1

and total intensity from 250 nm to 500 nm is 953 ph/(m² ns sr). See spectrum with 5 nm bins in Apendix 1.

Zodiacal light

Zodiacal light spectrum is comparable to solar spectrum. Very precise measurements of solar spectrum during Columbia Spacelab 1 mission in November-December 1983 show maximum around 300 nm (see Figure 6. p. 211 from Labs 1987 SoPh).

Putting sources together

All three main sources of UV light are roughly equal in magnitude for baloon high altitude measurements from zenith direction (downward radiance, all sources ~220 ph/(m² ns sr)). For orbit nadir looking detector (upward radiance) is directly seen just nightglow light. Zodiacal light and integrated starlight are seen from orbit as reflected light by Earth surface and atmosphere. In case of reflection by ocean (albedo ~7%) is total albedo roughly equal 40%. On ISS orbit then for cloudless situation dominate nightglow (~55%). Because that, we base our first version UV spectrum estimation on nightglow measurement.

References

- Hanuschik R. W., A flux-calibrated high-resolution atlas of optical sky emission from UVES, *Astron. Astrophys.*, 407, 1157 – 1164, 2003
Hennes, J. P., Measurement of the Ultraviolet Nightglow Spectrum, *Journal of Geophysical Research*, 71, No. 3, 763-770, 1966
Labs D., Neckel H., Simon P. C., Thuillier G., Ultraviolet Solar Irradiance Measurement from 200 to 358 nm during Spacelab mission, *Solar Physics*, 107, 203, 1987

Apendix 1.

UV night spectrum during cloudless and moonless night.

Next columns show measured spectrum combined from Hennes and found measurements.

Wavelength from X_1 to X_2 nm, flux in $\text{ph}/(\text{m}^2 \text{ ns sr})$

250	255	0.0948
255	260	1.1336
260	265	1.6646
265	270	3.0971
270	275	4.0504
275	280	4.1600
280	285	5.4705
285	290	6.0473
290	295	4.5947
295	300	6.2921
300	305	4.1503
305	310	5.4326
310	315	4.2270
315	320	2.7810
320	325	5.2450
325	330	4.9413
330	335	3.4825
335	340	4.3443
340	345	3.9383
345	350	3.5467
350	355	4.1521
355	360	2.1322
360	365	3.8778
365	370	1.7502
370	375	3.0614
375	380	1.1524
380	385	1.6075
385	390	0.8455
390	395	4.1581
395	400	2.2634
400	405	2.9981
405	410	4.0665
410	415	1.8054
415	420	3.7787
420	425	1.0548
425	430	0.7757
430	435	0.9260
435	440	0.2912
440	445	2.3088
445	450	0.4490
450	455	1.1742
455	460	1.1464
460	465	0.0000
465	470	1.2154
470	475	0.1366
475	480	0.0000
480	485	0.8769
485	490	0.2008
490	495	0.4814
495	500	0.4927

UV spectrum normalized to 500 ph/(m² ns sr) in band from 300 to 400 nm.

Wavelength from X₁ to X₂ nm, flux in ph/(m² ns sr)

250	255	0.1413
255	260	1.6897
260	265	2.4812
265	270	4.6164
270	275	6.0373
275	280	6.2007
280	285	8.1540
285	290	9.0138
290	295	6.8486
295	300	9.3787
300	305	6.1862
305	310	8.0975
310	315	6.3005
315	320	4.1452
320	325	7.8179
325	330	7.3652
330	335	5.1908
335	340	6.4754
340	345	5.8702
345	350	5.2865
350	355	6.1889
355	360	3.1781
360	365	5.7800
365	370	2.6088
370	375	4.5632
375	380	1.7177
380	385	2.3960
385	390	1.2603
390	395	6.1978
395	400	3.3737
400	405	4.4688
405	410	6.0613
410	415	2.6910
415	420	5.6323
420	425	1.5722
425	430	1.1562
430	435	1.3802
435	440	0.4340
440	445	3.4414
445	450	0.6693
450	455	1.7502
455	460	1.7088
460	465	0.0000
465	470	1.8116
470	475	0.2036
475	480	0.0000
480	485	1.3071
485	490	0.2993
490	495	0.7175
495	500	0.7344