

THE IMPACT OF LIGHT POLLUTION ON ASTRONOMICAL OBSERVATIONS AT THE ORM (Roque de los Muchachos Observatory)

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Low Resolution Sky Spectra were taken during year 2003 with Do.Lo.Res at the Telescopio Nazionale Galileo with a wavelength range ~ 3800 - 8000 angstroms.

They include the most important Sodium and Mercury light pollution lines and span a wide interval of azimuth and observing conditions, essential to disentangle environmental and seasonal effects. Light pollution from Na₅₈₉₂₋₈ emitted by the LPS lamps increased by a factor of 1.5-2 with respect to the average values of 1998. At the same time, light pollution from Hg lines decreased by $\sim 40\%$ and reaches the 1998 levels only when observing toward the towns.

The contribution of Na₅₈₉₂₋₈ to sky background is 0.05-0.10 mag at V-band and 0.07 -0.12mag at R-band. The effects of the application of the Canary Sky Law are directly visible in our spectra as a 50% dimming of the Hg light-polluting lines in the spectra taken after local midnight.

Observational DATA

- Low-Res spectra taken at the 3.6m TNG during year 2003 with 3800-8000 Ang range include most of the important NaI and Hg polluting lines, some of them never detected before at ORM (NaI_{5683_8} NaI₆₁₅₄₋₆₁).
- The Spectra were grouped into 6 templates spanning a wide range of azimuth values, epoch of the year and observing conditions, giving a representative view of the observing conditions at the observatory.
- To avoid strong night-to-night variations of the polluting lines flux (due to the typical sea-of-clouds often present below the ORM), we decided to include in the same group only those spectra whose NaD₅₈₉₂₋₆ lines flux differed by no more than 30%. In particular the spectra with the highest NaI lines fluxes (less cloud cover) were considered.

Natural and Artificial contributions to the NaD 5892 line

- The inventory of the street lamps at La Palma is known (F.J. Diaz Castro) as well as the relative intensity of the NaI lines of the LPS and HPS lamps (Philips catalog). By analyzing two of the above templates taken at the same azimuth, one before and one after 24:00 p.m. and assuming that the flux of the Na₅₆₈₃₋₈₈ line is due to the HPS+LPS and LPS lamps respectively, we could disentangle for the first time the artificial contribution of the NaD₅₈₉₂₋₆ flux emitted by the LPS lamps from the natural NaD sky background.

- When observing within ± 4 hrs of R.A. from the meridian, the average contribution to Light Pollution from the NaD line is $\sim 150R$ before midnight.
Benn & Ellison (1998) reported an average value of $\sim 70R$ (~ 70 Ang equivalent width)

Table 1. Light Pollution at the ORM – The numbers

Line	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
HgI_4046	3.4	5.2	9.5	6.1	10.2	6.3
HgI_4358	5.6	7.9	22.0	17.6	14.2	4.5
HgI_5461	4.4	5.5	25.7	10.9	8.6	4.7
OI_5577	310	256	303	303	447	504
NaI_5683-8	3.5	6.3	30.6	9.5	11.4	3.6
Hg_5679	n.d.	n.d.	7.2	n.d.	1.9	1.4
Hg_5790	n.d.	n.d.	4.7	n.d.	1.7	0.7
NaD_5892-6	189(156)	148(89)	658(431)	284(134)	251(162)	270(161)
NaI_6154_61	n.a.	n.d.	9.5	n.a.	9.6	n.a.

Group1: ± 4 hrs R.A. from meridian Before Midnight
 Group2: NW Before Midnight
 Group3: S-SW Before Midnight (thin cirrus)
 Group4: SE Before Midnight
 Group5: S Before Midnight
 Group6: S After Midnight (same night as Group5)



Conclusions

- For the first time at the ORM, the natural and artificial contributions to the NaD line flux have been disentangled and quantified without the need of a general black-out (like in 1991)
- The NaD_5892-6 line flux due to street-lighting has increased by a factor 1.5-2.0 in the period 1998-2003 (before midnight: quite alarming indeed). Its contribution to the sky-background is now 0.05-0.10 mag at V-band and 0.07-0.12 mag at R-band
- The IAU recommendation that the NaD emission should not exceed the natural background is definitely no longer met at La Palma. Light pollution from Mercury lamps was ~50% lower in 2003 than in 1998 (Benn&Ellison) except when observing toward the towns: in this case we found very similar levels
- In some cases (e.g. Group 3 and 4) emission lines identified as ScI (Scandium) have been detected for the first time at the ORM. These lines were already known at Kitt Peak (AZ) or Mount Hamilton (CA)
- In general Light Pollution is increasing quite rapidly in a so small island as a consequence of its economic and tourism development
- The LPS lamps are OK but the sky background at V and R-bands begins to be affected by the NaD emission; the situation is quite alarming especially before midnight (in winter there are ~5hrs of dark observing time before that time)

