

Payload 1: Measuring light pollution with a spectrometer

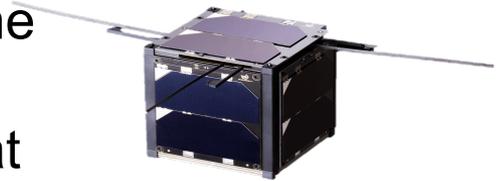
Jakov Tutavac

2.10. 2019.



The objective

- **Acquire** spectrally resolved **night-time images** of the Earth using a CubeSat, analyze the data and **determine** the **fraction** of the overall illumination that originates from solid-state lighting globally and locally in Croatia.



- The first step is to (1) characterize lighting sources, then (2) characterize emission from the Earth/cities, etc., and then (3) from the measured spectra resolve the contribution of each of the source types.

The experiments



Photon Control SPM002-CH
spectrometer with spectral range
between 350 nm to 1000 nm in 3560
pixels.

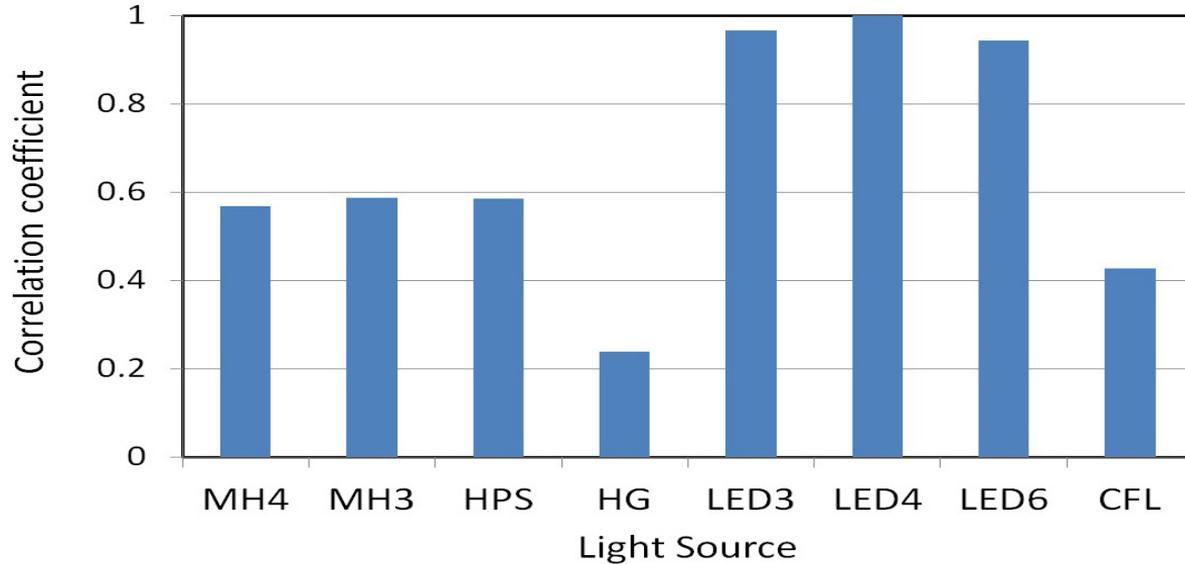
We **measured** the emission
spectra of representative
bulbs for light-sources used
in public illumination.



Characterized lights

Light source	Power	CCT
Metal-halide	150 W	3000 K
Metal-halide	150 W	4000 K
Mercury vapor (HG)	125 W	
Compact fluorescent lamp (CFL)	15 W	2700 K
High-pressure sodium (HPS)	70 W	
LED	9 W	6500 K
LED	9 W	4000 K
LED	9 W	3000 K
LED	11W	2700 K

Spectra correlation



Correlation of **LED 4000 K** spectra with all other measurements.

Linear mixture model

- For m measurements with p samples of the acquisition variable (wavelength), and n assumed source signals:

$$Y^{m \times p} = X^{m \times n} \cdot S^{n \times p}$$

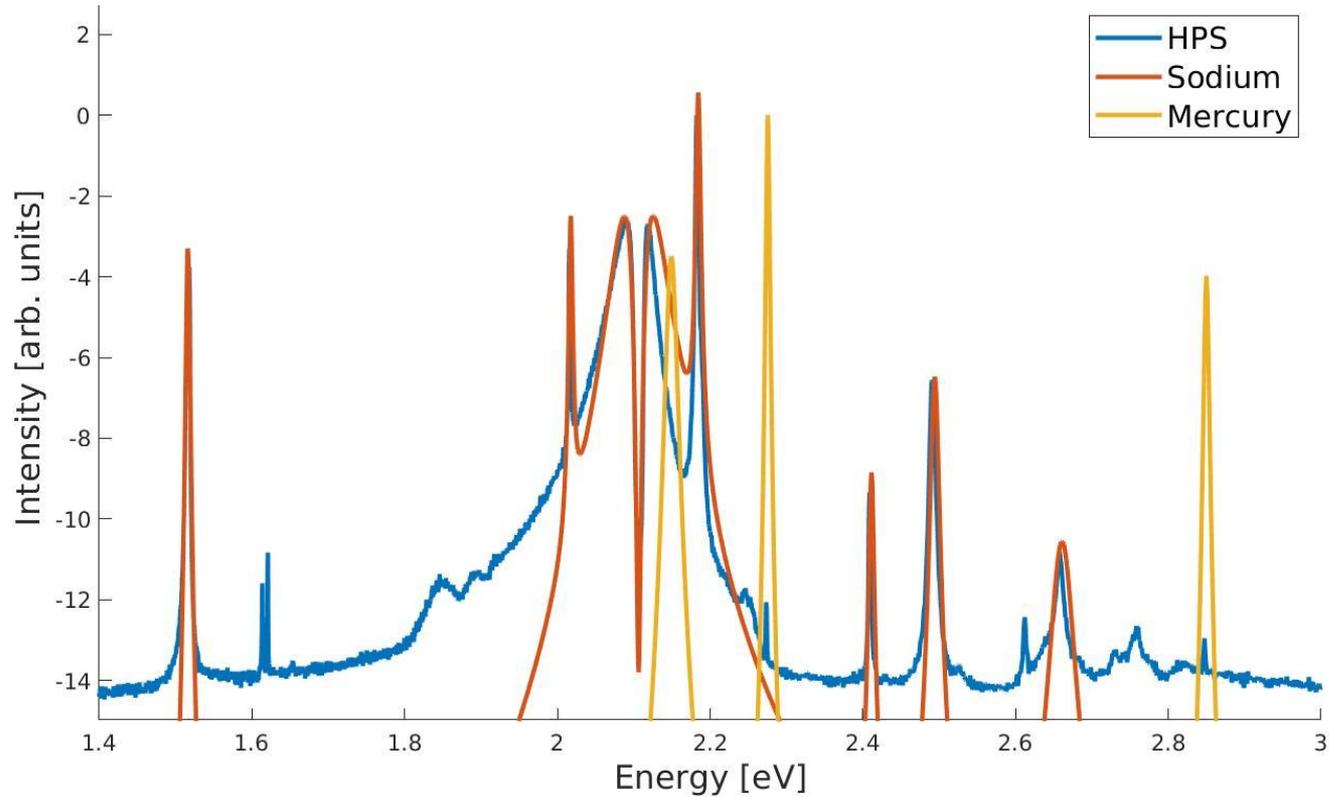
$$X = (S^T S)^{-1} S^T Y$$

Dimension reduction

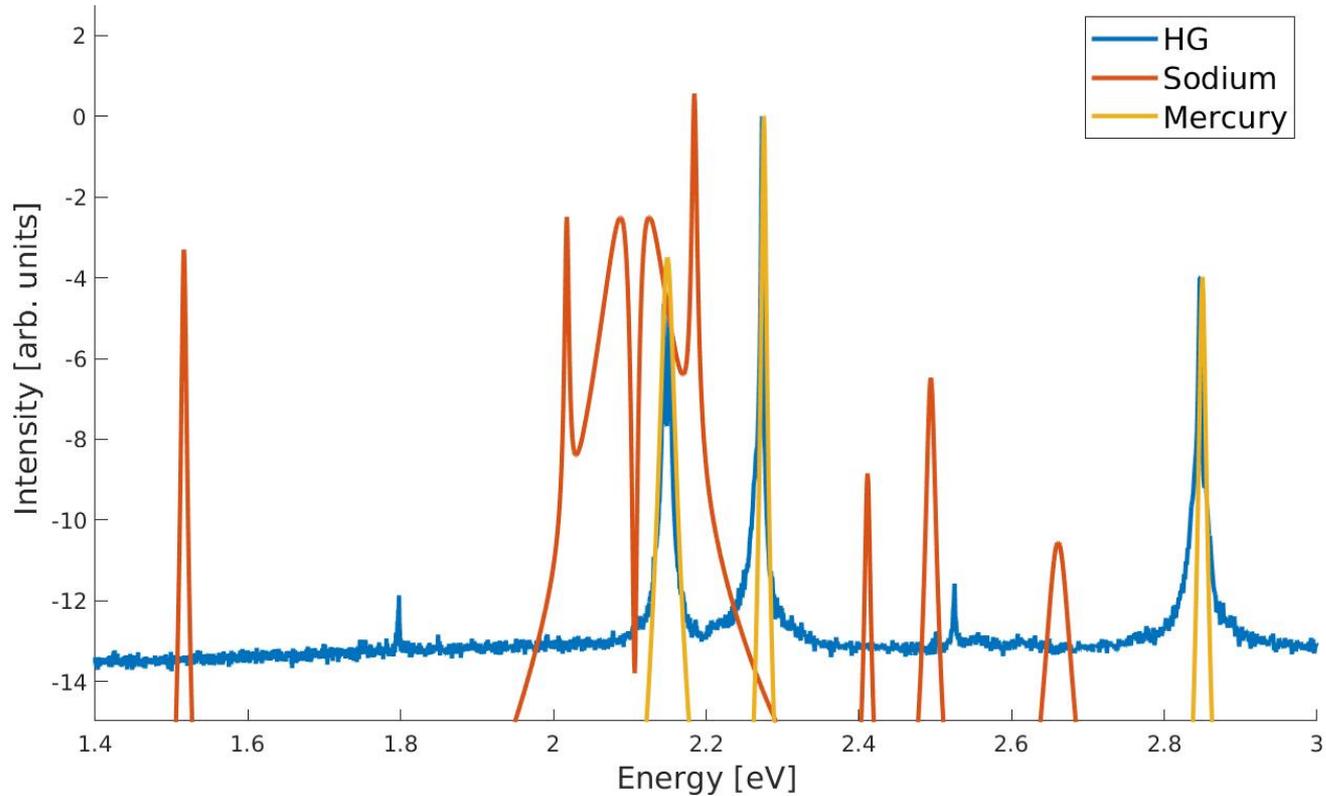
- Based on analytical models, light sources may provide partially orthogonal sources.
- For each partially orthogonal source, there is at least one value for which this source represents a non-null response, to the exclusion of all other sources.
- The analytical models are derived from the emission lines of elements used in a particular light source combined with the double sided exponential (Laurentz) distribution.



HPS spectra



HG lamp spectra



Summary

- We proposed a novel CubeSat payload mission: determine the fraction of solid-state lighting in global illumination, and to evaluate the contribution of different light sources to global light pollution.
- To this end, we **measured** emission spectra of conventional and solid-state light sources and **computed** their mutual correlations.
- High correlation has been found between the spectra, therefore, resolving the Earth-emission spectra into **orthogonal** spectral vectors will not be possible.
- Algorithms for spectral resolving are in development.

