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High-resolution spectroscopy of the Earthshine

Metal lines detected in Earth reflection spectrum

B. González-Merino (1,2), E.Pallé (1,2), P. Montañes-Rodríguez (1,2)
(1) Instituto de Astrofísica de Canarias
(2) Departamento de Astrofísica, Facultad de Física, Universidad de La Laguna
bgmerino@iac.es

Abstract

The study of the Earth's atmosphere using the Earthshine technique allows us to consider the Earth in an integrated way, as if we were observing it from afar. The spectra we obtain from this technique allow us to characterize the Earth's atmosphere, and identify biosignatures on it. As the Earth is the only habitable planet we know of, the description of such features and its use as a template may be fundamental to identifying the presence of life on other planets.

The observations analyzed were taken in La Palma during the nights 24th and 25th in December, 2010 and the 11th, 12th, 23th and 24th in February, 2011using the TNG telescope and the cross dispersed echelle spectrograph SARG. Between the available grisms, we used the red (4096–1011nm) and blue one (360–514nm) grism. The resolution of the data is 57,000 for the first two nights and 2,9000 for the last four. These data were recorded in cycles: first, a bright side, followed by an Earthshine and finally the sky. The final spectra are obtained from the ratio of the Earthshine and the bright side after subtracting the sky contribution.

To be sure that the method used was reliable, a test considering the Hα solar line was performed. As this line is known not to be present in the Earth atmosphere, it should vanish from the Earth's reflection spectrum. The residual depth of this line was used as a reference of the confidence with which other features in the spectrum can be identified (Figure 1). The most prominent feature identified relates to the sodium doublet (5895.92 and 5889.95 Å) (Figure 2). This was identified during several of the observation nights. The sodium layer in Earth's atmosphere is located at a height of around 90Km, in the mesosphere. It is mainly produced by meteoric showers, and it demonstrate big spatio-temporal variability ([1], [2]). This may explain why the doublet could not be detected in all observation night.

Unlike the observation performance of low-resolution spectrographs, more suited to the identification of absorption bands ([3]), the data from SARG allowed us to detect individual lines in Earth's reflection spectrum. Despite the advantage of the SARG, the integration time needed to reach a good signal-to-noise ratio (SNR) is longer than for low-resolution spectrographs, making it more difficult to detect elements that generate fainter absorption lines.

1. Figures

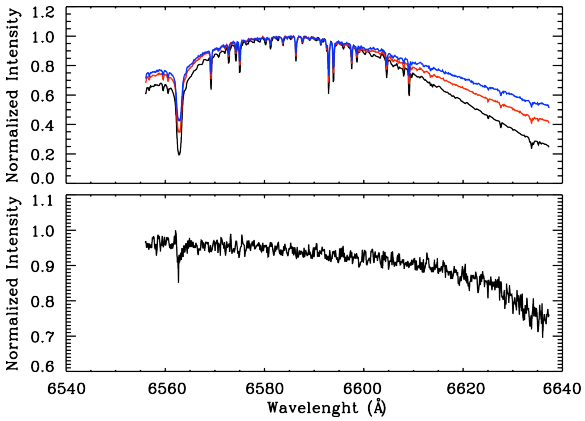

Figure 1: Top panel: spectra for the echelle order corresponding to the Hα line (656.27nm) with a spectral binning of five points. This is one of the most characteristic lines in the solar spectrum, not present in the Earth's spectrum. This line disappears in the Earthshine reflectance spectrum. The spectra are normalized for comparison. Lower panel: Earth's reflection spectrum with a spectral binning of five points.

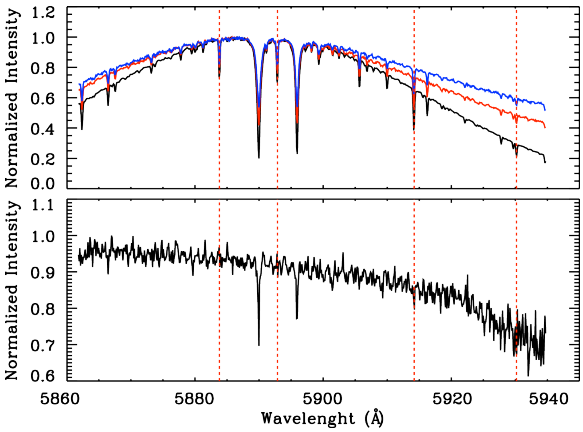

Figure 2: Top panel: Echelle order in which the sodium doublet (588.99nm and 589.59nm) can be found with a spectral binning of five points. The dashed vertical lines point out the position of NiI (589.28nm) and FeI (588.38nm, 591.42nm and 593.01nm) solar lines. These are clearly detected in the spectra of the bright side, Earthshine and sky but disappear completely in the Earth reflection spectrum, unlike the sodium doublet which is still visible. The spectra are normalized for comparison. Lower panel: Earth's reflection spectrum with a binning of five points.

References

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Knowledgements

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