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Auroral polarisation : Observations & Modelisation

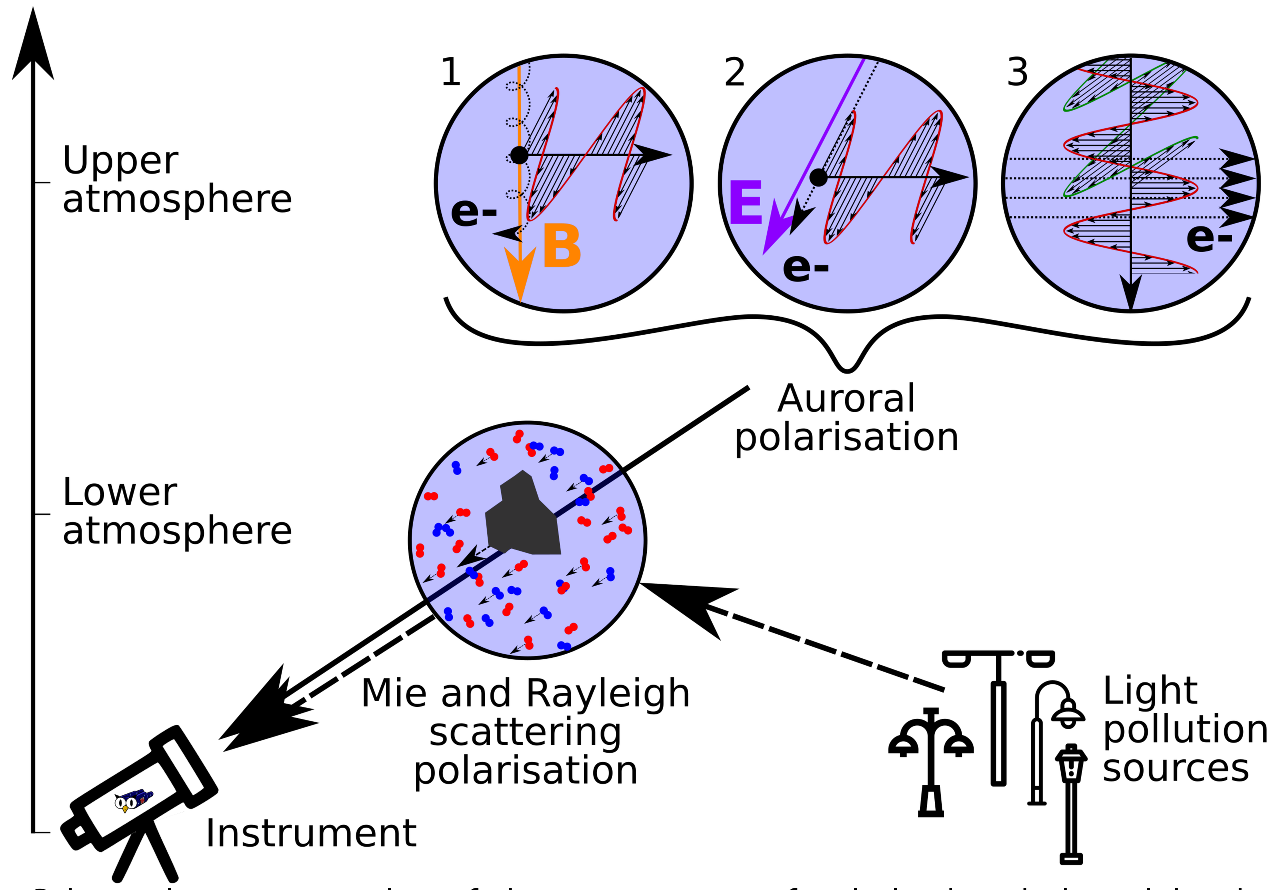
When observing the night sky from the ground, two main sources can produce polarisation of visible light:

- **Auroral emissions**
- **Light pollution scattering**

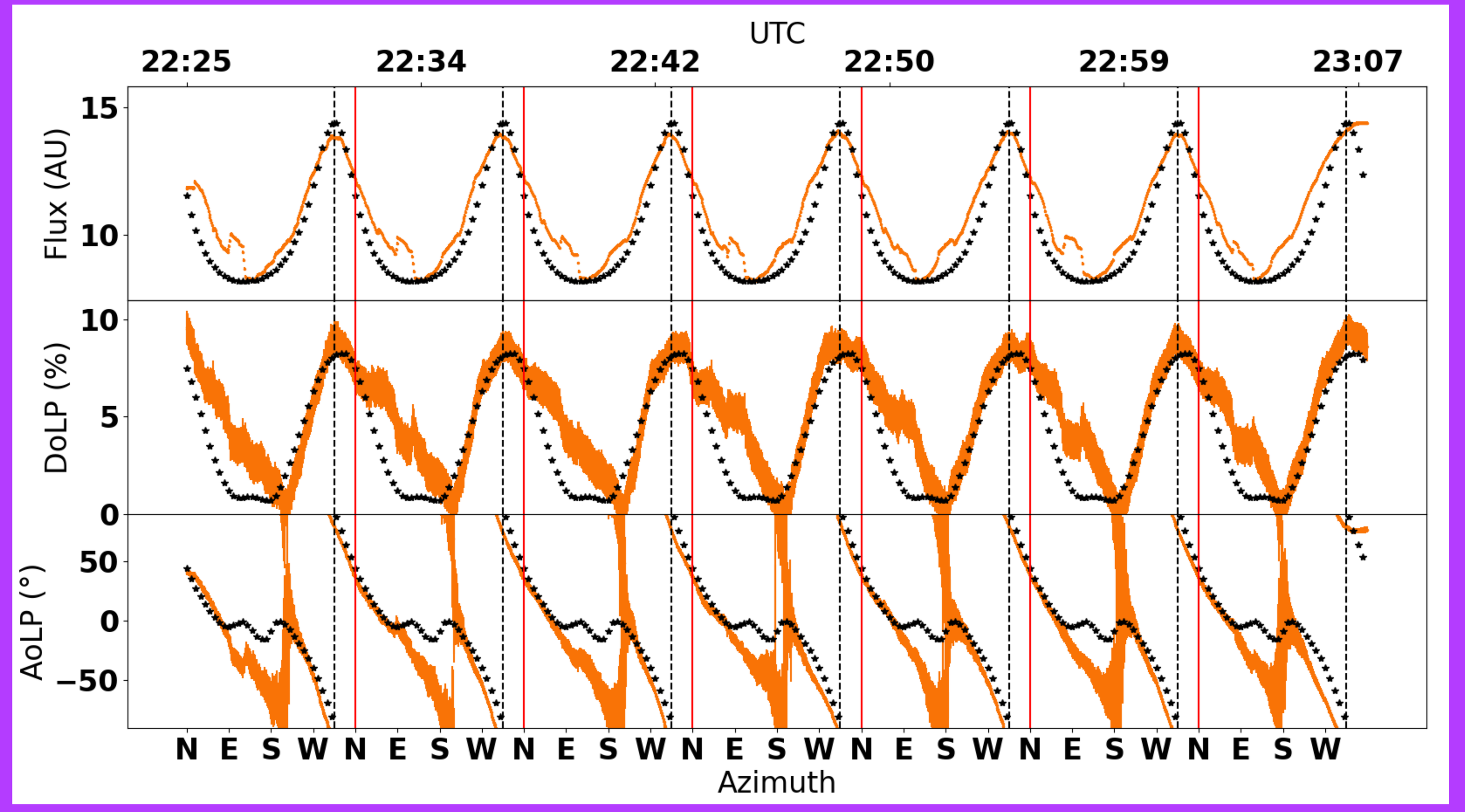
How to determine which source is at the origin of the observed polarisation?

At mid latitudes in populated areas, there is no doubt that light pollution scattering will play the dominant role. But what about remote places in the auroral region?

This poster summarizes the latest studies on auroral light polarisation.



Schematic representation of the two sources of polarisation during night sky observations. In the upper atmosphere, we make the assumption that the impacting electrons motion drives the polarisation. In the lower atmosphere, Rayleigh and Mie scattering produce polarisation from light pollution sources.



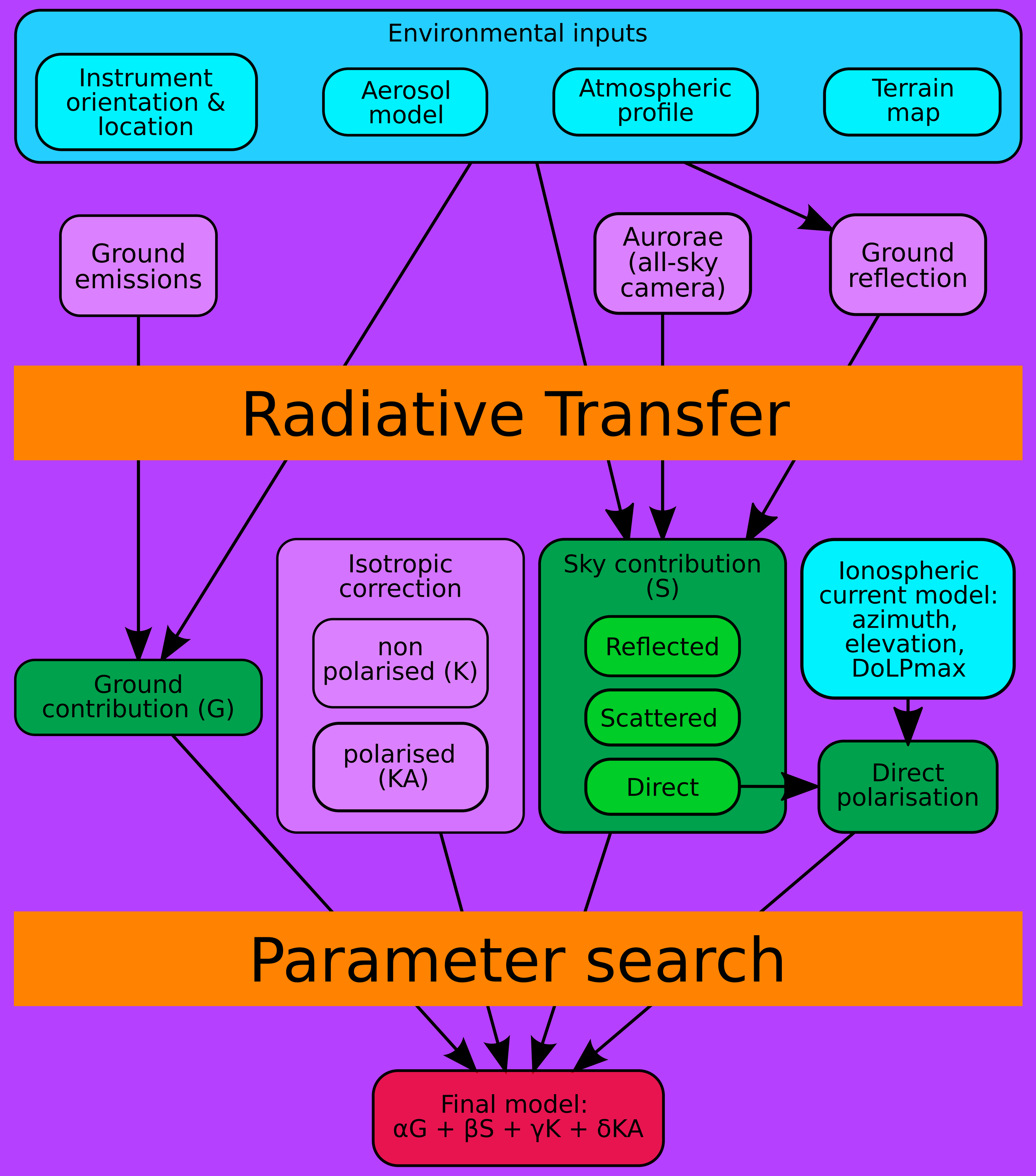
In orange, an observation at 620 nm, outside of the auroral emissions at elevation 45° near Skibotn. We use this band as a tracer of the light pollution. In black, the best fit of the POMEROL model.

Two methods have been used to identify the origin of the observed polarisation:

Multi-instrumental comparisons with independant ionospheric measures.

Modelisation of the light pollution

We present here the two approaches and their main results and applications.



Complete workflow of the POMEROL model. Blue boxes: environmental inputs. Pink boxes: input emissions (satellite ground picture at night and all-sky cameras). Green boxes: Ground (G) and sky (S) models. Orange bands: main steps of the process. Red box: Final output in the same format as the measurements.

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The POMEROL model is able to reproduce night sky observations outside of the auroral emission spectrum. Yet, it fails when observing the ionospheric emission lines. Then, scattering from street lamps, from auroras and snow reflection are not enough to reproduce the measurements. An other polarisation source must be added to the model.

We introduce this new source using the idea that polarisation will follow the electron motion at the emission. We add 4 parameters: 2 for the orientation of the electronic motion, 1 for the DoLP created (which depends on the angle between the electrons motion and the line of sight of the instrument) and 1 for the AoLP, which is either parallel or perpendicular to the electron motion. POMEROL applies this polarisation to the all-sky camera images used as inputs. It allows the model to reproduce the observations.

This model is critical to understand and interpret our findings. Once the light pollution is subtracted from the measurements, one might be able to observe the ionospheric polarisation and deduce the state of the ionosphere (electron motion, energy, concentration...) at the emission.

POMEROL might also have applications for light pollution and aerosol studies. For exemple, some insects orient themselves using the night sky polarisation. The effects of light pollution polarisation on their behavior are not well known. Also, choosing the right aerosol model is critical for POMEROL to reproduce the observations. The measures and the model could be used to constrain aerosol profiles and optical properties without using the Sun and Moon.

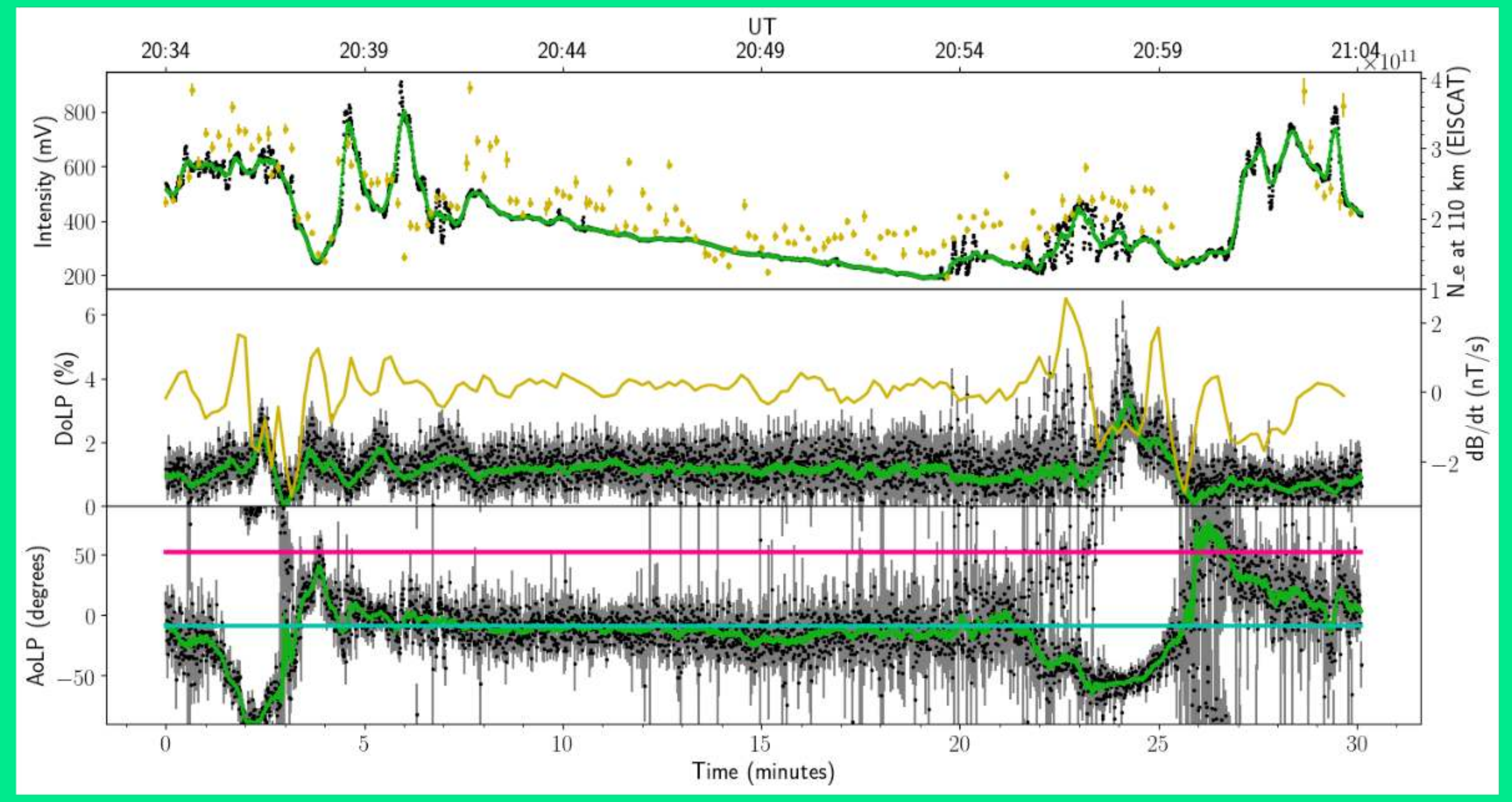
Conclusion:

The night sky is polarised in the visible range. In populated areas, this polarisation arrises from light scattering in the lower atmosphere.

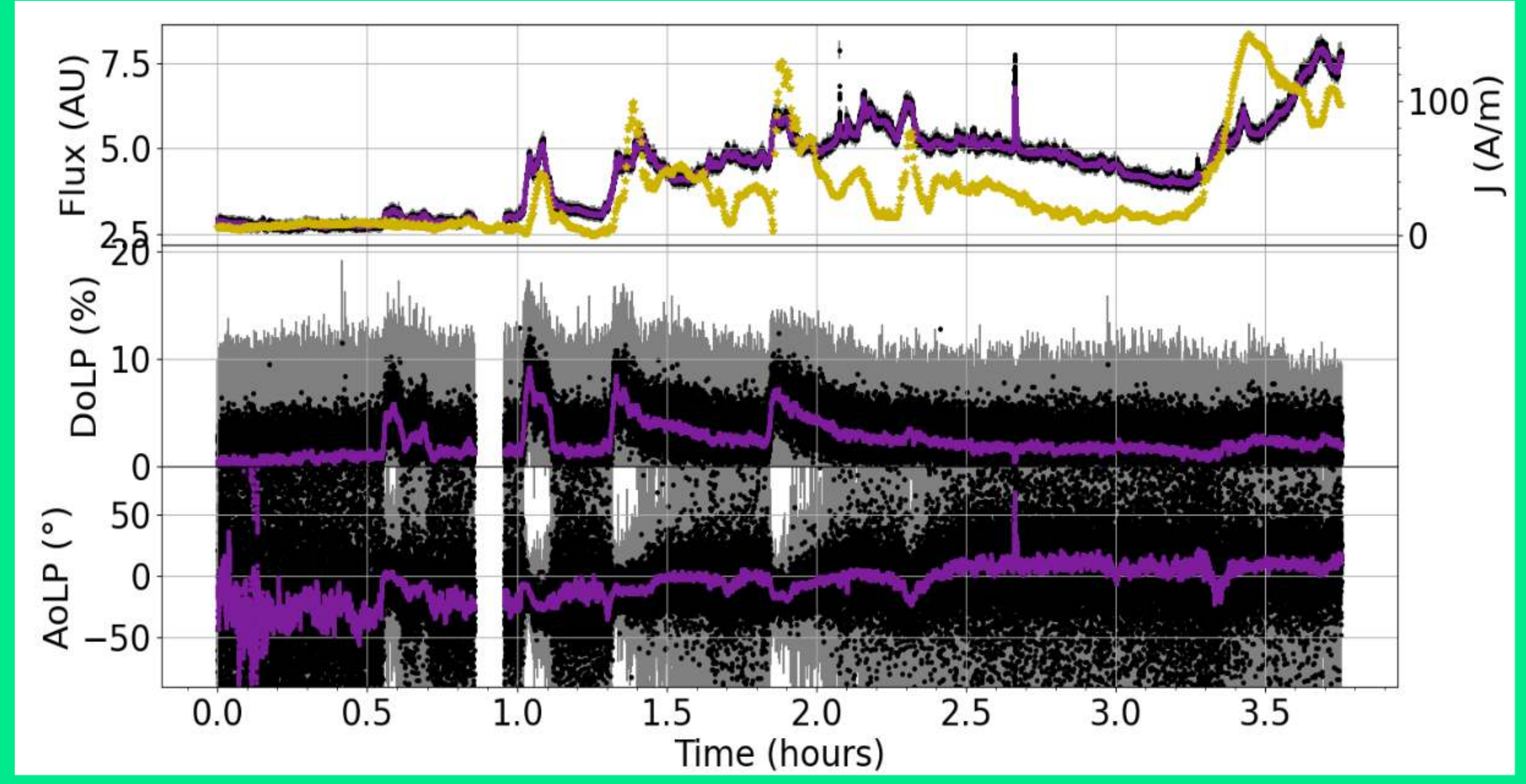
However, this is not sufficient to explain the polarisation observed in auroras (at 630, 557.7, 427.8 and 391.4 nm). In the auroral oval, night sky polarisation is strongly correlated to the ionospheric activity.

We make the assumption that the collimated electron motion drives the polarisation of the emissions.

Related articles links



Green line (557.7 nm) observation near Skibotn, Norway at azimuth 164°, elevation 45°. Top: In yellow, the electronic density at the emission measured by EISCAT. Middle: In yellow, the rate of change of the ground magnetic field measured in Tromsø. Bottom: In blue, the apparent angle of the magnetic field as seen by the instrument. In pink, the expected light pollution polarisation angle.



Purple line observation (391.4 nm) around Kilpisjärvi, Finland at azimuth -42°, elevation 47°. In yellow, the equivalent current magnitude at the emission modeled from ground magnetometer data. We note the strong increase of the DoLP during auroral bursts, correlated with an increase of the equivalent current magnitude.

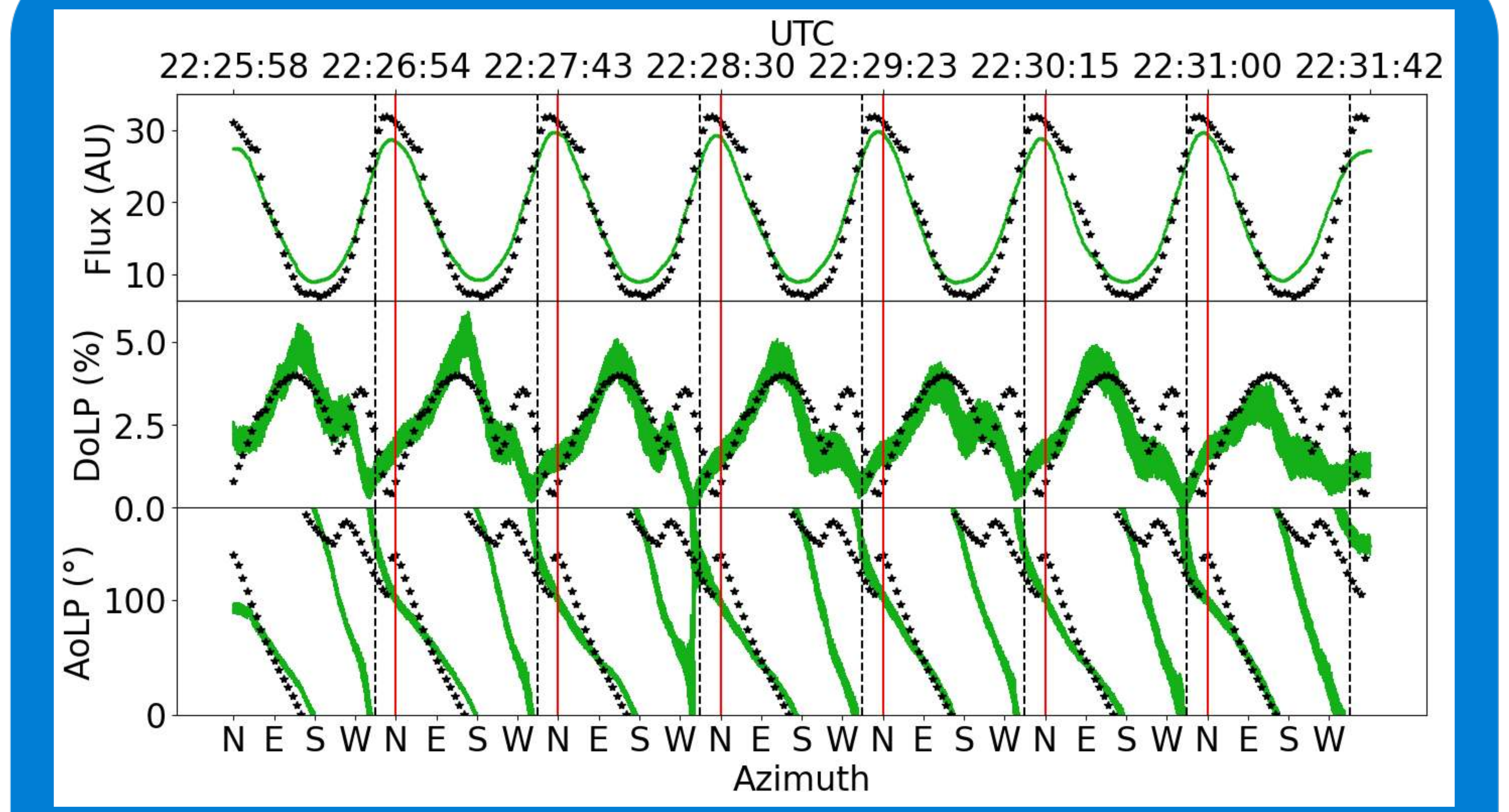
Observation of auroral emissions during auroral events show clear correlation between the polarisation variations and the ionospheric activity. Auroral lights have an impact on the night sky polarisation.

Combined with the POMEROL model, we can exclude the contribution of auroral light scattered in the lower atmosphere, as well as reflections on the snow.

This tends to show that upper atmospheric emissions are polarised enough to be detected.

Yet, the exact phenomena at the origin of this polarisation is still an open question.

To go further on this subject, we need a better understanding of the physic phenomena at play during the auroral emissions in the ionosphere. Especially for the atomic oxygen lines. Today, the main assumption is that the collimated electrons motion drives the polarisation. The DoLP and AoLP depend on the orientation of this motion relative to the emission, as well as on the electronic energy and concentration. Understanding the links between these parameters might enable us to determine the state of the ionosphere from polarisation observations.



In green, an observation at 557.7 nm near Skibotn, at elevation 45° and in all directions. In black, the best fit of the POMEROL model using a polarised auroral emission. This auroral polarisation is perpendicular to a NE motion inclined by 20°, with a DoLP below 5%.%