Design and implementation of an automatic instrument to diagnose air plasmas produced by earth mesosphere transient luminous events

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We plan to measure simultaneously the spectra and polarization of light emitted from transient luminous events (TLE). To do so, we have designed an instrument consisting of a spectrograph and a polarimeter, both installed on a telescope mount. By consulting a real-time lightning database, the telescope aims automatically to the region of the sky where a TLE is predicted to appear. The instrument will be located outside the 2.2 m dome of the German-Spanish Astronomical Center at Calar Alto, Sierra de Los Filabres, north of Almeria (Andalucía, Southern Spain), at 2168 meters above mean sea level. From this location we can observe the west Mediterranean Sea zone (37º-45ºN; 2ºW-6ºE) with an elevation of 10º-35º above the horizon, a region where the most TLE activity in Europe takes place.

1. Introduction

Transient Luminous Events (TLE) are a kind of electrical phenomena that emit in the visible range and are related to large thunderstorms. These events were observed accidentally for the first time in 1989 [1] and since then, several spectroscopic measurements have been performed [2]-[4] to understand the influence of these TLE over the Earth mesosphere. However, so far, the best spectral resolution used is $R = \lambda/\Delta\lambda = 215$ ($\Delta\lambda = 3$ nm) [4].

Our group intends to analyze the TLE optical emissions with a high spectral resolution and to characterize their polarization, if any. We also aim to combine theoretical models predictions [5]-[8] with the data collected by our spectroscopic and polarimetric diagnosis instrument designed and developed to study the kinetics and electrodynamics of the air plasmas generated by TLEs. This instrument is called GRASSP (Granada Sprite Spectrograph and Polarimeter) and it has been developed by the TRAPPA Group at IAA – CSIC, Spain.

2. GRASSP

2.1. Hardware

GRASSP consists of the remotely controlled subsystems represented in figure 1.

The spectrograph uses a 1440 lines/mm grating and presents a variable free spectral range of 110 nm, with a spectral resolution of $R = \lambda/\Delta\lambda = 1500$; $\Delta\lambda = 0.45$ nm. It uses an intensified CCD of 1360 × 1024 pixels with a FOV of 0.01 mm/px.

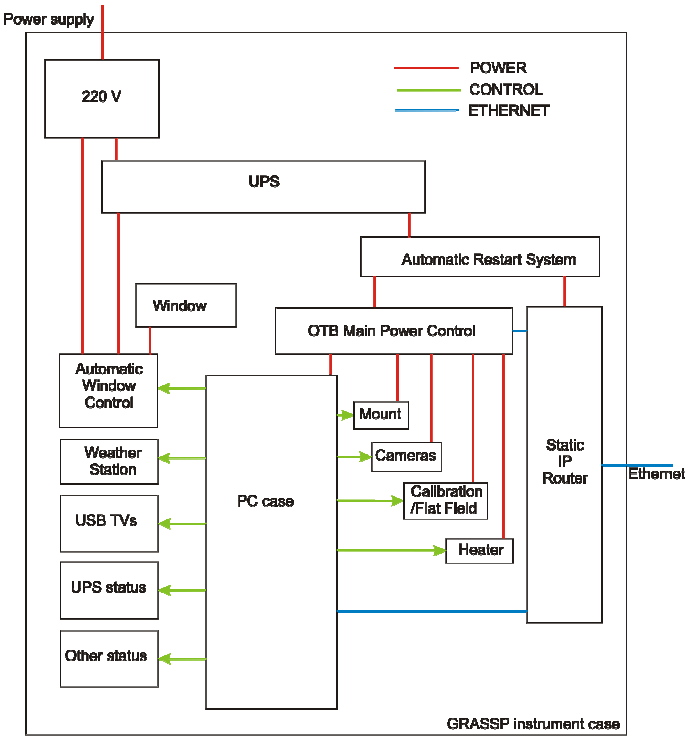

Figure 1. GRASSP hardware basic design

The 6 channel imaging polarimeter covers a spectral range from 500 – 750 nm, with a polarized/unpolarized sensitivity less than 1 %. It presents a circular field of view of 5º and a CCD of 2000 × 2000 pixels with a FOV of 15 µm/px.

2.2. Software

We have developed a software tool to control the GRASSP system remotely. An acquisition software has also been implemented to capture TLE images automatically by consulting lightning databases and pointing to the region where TLE are most likely to appear. Once these data have been acquired, a further image processing software will extract the useful information which will be compared with the results obtained with our group kinetic and electrodynamic simulations in order to quantitatively study some important plasma parameters like, for instance, the rotational temperature and others with the objective to characterize the emitting air plasma and its possible influence on the chemical and electrical properties of the Earth mesosphere.

3. References

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