LIGHTNING AND SPRITES OBSERVATIONS 
ON BOARD OF THE INTERNATIONAL SPACE STATION

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Abstract: The experiment LSO (Lightning and Sprite Observations) is dedicated to the study of the light emissions, called sprites, occurring in the upper atmosphere above the thunderstorms. Observations of sprites were performed on board of the International Space Station (ISS) by the experiment LSO (Lightning and Sprites Observations) for the mission Andromede during the flight of the French Astronaut Claudette Haigneré. The objectives are to study this new phenomena and to validate a new measurement concept for future measurements at the nadir by the micro-satellite Tararis. This paper describes the first observation of a sprite from space at the nadir using an adapted filter.

-1- Scientific objectives

The measurements of the luminous effects of the sprites from space are difficult because the emissions of sprites are superimposed on the intense light emissions of the intra cloud lightning. They are possible in specific narrow spectral bands.
The objectives of LSO are
- The definition of a method for the observations of lightning and sprites from space at the nadir
- The determination of the relative intensities of lightning and sprites in specific narrow spectral bands
- The determination of the apparition frequency and characteristics of sprites in different regions of the earth

-2- Measurement concept

A theoretical spectrum of the sprites is presented in Figure 2 (Milikh et al., 1998). The N2P 3-1 band (762 nm) corresponds to the most intense emission. This emission doesn’t appear on the spectra measured at the ground (Figure 2), because it is close to the absorption band of the dioxygen, characterized by an important density at low altitude. At the contrary, it will be observed from space because the sprites are produced in the altitude range 30-100 km where the dioxygen concentration is low. The other light emissions from ground and lightning produced in the lower atmosphere will also be absorbed. Measurements of lightning above thunderstorms (Christian et al., 1989) do not detect any emission in this spectral band (Figure 3). The signal to noise ratio of sprite measurements in this band is then expected to be high.

-3- Technical characteristics

Two micro cameras are used for horizon or nadir observations. One camera is equipped with a filter (756-766 nm), the second measures in the visible.

Temporal resolution: 1 frame/3s, integration time: 1s
Spatial resolution: 512x512 pixels, 0.5 km nadir, 2.7 km limbs
Amplitude measurements: 10 bits/pixel, 1 LSB=1.78 10^-4 pJ/pixel (with filter)

-4- First sprite observed from space at the nadir

A bright emission was observed above Japan by both LSO cameras over a thunderstorm (Figures 5 and 6). Because this emission was observed simultaneously by both cameras and because the cameras were calibrated (by CEA/DAM), a sprite has been identified.

Hypothesis 1:
- One lightning was observed with Mc2 in the visible : 452 ± 149 LSB and in Mc1 with the filter.
- Knowing the camera responses and the lightning spectrum, the Mc2 emission would produce, on Mc1 with the filter, 8 to 17 LSB. The measured value is much higher 48 ± 4 LSB. Hypothesis 1 is then false and there is an additional emission from above 30 km produced by a sprite.
- The contour line in both pictures (Mc1 and Mc2) underlines the sprite feature.

Hypothesis 2:
- One sprite was observed with Mc1 with the filter: average value 48 ± 4 LSB and with Mc2 in the visible.
- Knowing the camera responses and the sprite spectrum, the Mc1 emission would produce on Mc2 in the visible 309 LSB. There is an additional emission in Mc2 (in blue in the picture) outside the contour line of 149 ± 39 LSB. This emission is produced by the lightning associated with the sprite. At the total the emission is 455 LSB in agreement with the observation.

Conclusion:
In Figure 5, the bright emissions in both pictures underlined by a contour line are produced by a sprite.
The additional blue emission at the bottom picture with a lower intensity is produced by the lightning associated with the sprite.
The sprite brightness is 125 kR. The lightning brightness, observed only with the camera in the visible, is 30 to 60 kR.

-5- Toward the microsatellite Tararis* (Tool for the Analysis of RDiations from lightNIng and Sprites)...

* Gallic god of lightning and thunder

Sprites are a manifestation of a transitory coupling between the atmosphere, the ionosphere and the magnetosphere during the thunderstorms. They could be produced by runaway relativistic electrons triggered by cosmic radiation. Observations of X emissions from the Earth atmosphere by chance or by satellites dedicated to gamma astronomy studies (Fishman et al., 1994) suggest considerable energies.
Tararis is a project of microsatellite dedicated to the study of the sprites and associated emissions.

References:

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