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COMPOSITION AND TEMPERATURE MEASUREMENTS WITH A SPECTRAL CAMERA IN THE MIDDLE ATMOSPHERE AND THERMOSPHERE

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ABSTRACT.

A spectral camera flown on a polar platform could be used in a variety of modes in order to monitor spatial and temporal in the stratosphere, mesosphere and thermosphere. This camera, which can be oriented towards the limb or pointed to a star, is composed of a 25 cm telescope, two spectrographs (UV : 110 - 350 nm ; Visible : 300 - 1100 nm) and photon-counting intensified CCD detectors. In the occultation mode, the absorption of the sun, stars and moon light by the atmosphere is measured ; in the emission mode, the atmosphere emission (aiglow, Rayleigh scattering, aerosols scattering) is monitored at each latitude as a function of altitude in a single measurement, with the entrance slit projected perpendicular to the limb.

SCIENTIFIC CONTEXT

The study of the middle atmosphere has been the object of an extensive programme MAP which will culminate with the launch of UARS. However, it has become increasingly clear that there will be after UARS an absolute need of continuous monitoring of the middle atmosphere, mainly because of the potential hazard in the ozone layer depletion threatened by human activity. This monitoring of the middle atmosphere will be an essential part of the GLOBAL CHANGE scientific programme now approved by ICSU.

On the other hand, the relationship between solar activity and climatology is a long-standing puzzle. It is likely that the upper atmosphere, including the lower thermosphere could be implied because this is the place where deposited solar UV radiation is most variable with solar activity. This approach is a part of the whole STP programme.

TECHNIQUES OF OBSERVATIONS

In the occultation mode, a light source (sun, stars moon) is monitored and its spectrum continuously measured at all wavelengths from 110 to 1000 nm. From the shape of the absorption spectrum a number of vertical distribution of constituents can be retrieved (O_2, O_3, NO_2, NO_3, aerosols, H_2O, ClO, etc..). It can be remarked that an absoluted value is derived from relative measurements.

The same is true for temperature measurements, obtained from the derivative of a main atmospheric constituent (O_2 from $\simeq$ 20 to 200 km of altitude). An estimate indicates that there are about 10 stars which can provide a temperature estimate with an accuracy of 2 K and a vertical resolution of 2 km of altitude in a single occultation, which can be repeated 16 times per 24 hours for a better statistics.

INSTRUMENTATION

It consists of a 25 diameter telescope (could be scaled slightly larger if weight is available) with a focal length f = 100 cm. In the focal plane, different slits (12 mm high) can be used according to a compromise of spectral resolution versus sensitivity. Behind the slit system is placed a beam splitter to feed two spectrographs :

- UV : 105 → 350 nm
- visible : 250 → 1000 nm

The spectrograph uses off axis parabolic mirrors for collimating on a plane grating. The image of the entrance slit is formed on the front end of a 2D detector. The field of view is about 1°.

The rotating grating is fixed in a certain position during an observation and each point of the slit is dispersed between λ_1 and λ_2 on a line of the detector. λ_1 is selectable by ground command or on automatic operation.

The detectors are of similar design for the two spectrographs, but with different cathodes. Each one of them combines an image intensifier with micro-channel plates ; and are proximity focused. A phosphor is excited, with fiber optics connection to a 512 x 512 CCD. The gain of the tube is such that one level of digitization corresponds to the impaxt of one photo-electron espacing from the cathode, or less. Therefore, the sensitivity of this pseudo-counting mode is maximum, with still the guarantee to accomodate for large levels of illumination.

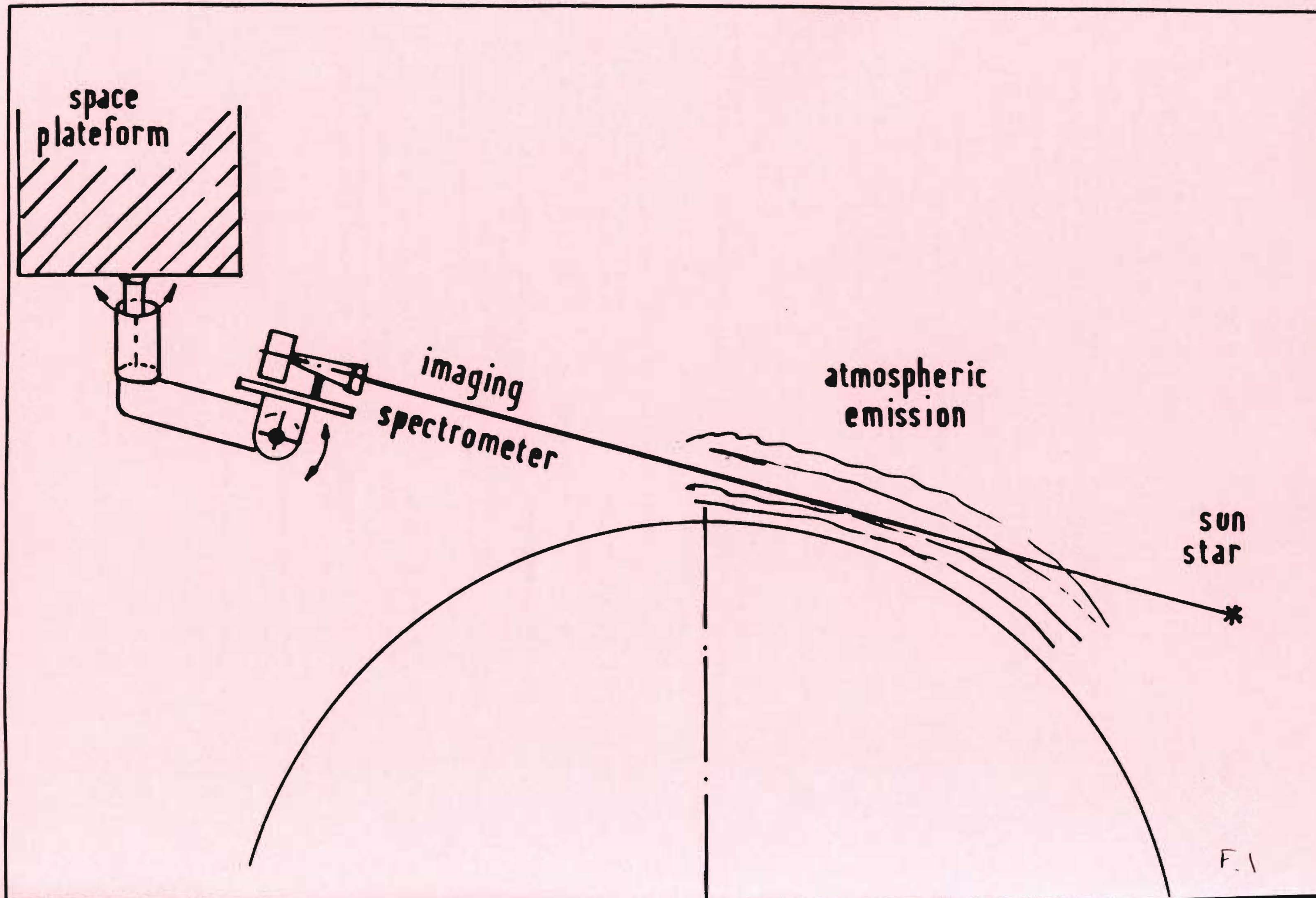
The instrument, with a estimated weight of 40 kg, should be mounted on its own scanning device in order to look at the limb and various occulting targets.

MEASUREMENTS

A non-exhaustive list of measurements is attached, with some indication of the altitude range.

Species	Scientific values	Altitude Range (km) UV-Vis-NIR Emission	Occultation
O	Chemistry, dynamics temperature	90 - 300	
O_2	Energetics, dynamics		15 - 200
O_3	Chemistry, energetics	20 - 60	20 - 80
N	Energetics, chemistry	150 - 300	
N_2		> 150	
NO	Dynamic, chemistry energetics	80 - 150	
NO_2	Chemistry, dynamics	20 - 40	20 - 40
NO_3	Chemistry		25 - 40
H	Chemistry	>120;90-120	
HO	Chemistry, energetics	50 - 85	30 - 85
H_2O	Dynamics, chemistry		20 - 35
ClO	Chemistry		25 - 40
SO_2	Volcanoes Chemistry		15 - 30
Aerosols	Volcanoes Dynamics	20 - 50	20 - 30
Polar stratospheric/mesospheric clouds		70 - 80	15 - 80

Note : During the Colombus Worshop at RAL on 14 and 15 october, it has been envisionned to add a third channel covering the infrared from 1 to 2,5 μm, which could fulfill the scientific objectives of the proposal by Grossmann, Offermann and Ulwick : the MOPTE experiment.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