SATELLITE METHOD FOR RESEARCH OF THE OZONE CONTENT BY MEANS OF ABSORPTION OZONEMETER

Garo Mardirossian, Stiliyan Stoyanov, Angel Manev

Space Research Institute – Bulgarian Academy of Sciences

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Abstract: *The possibility for research of the total ozone content is studied by means of the satellite spectral limb method.*

The methodological diagram of the satellite limb experiment, as well as the geometry of the experiment is researched.

A block diagram of the absorption ozonemeter and its characteristics are presented and the experiments are to be carried out in the near ultraviolet part of the ozone specter, in the absorption bands of the ozone of Hartley-Huggins and the specter of the aerosole diffraction in the atmosphere is taken into consideration.

The scientific program of the Second Bulgarian-Soviet Space flight includes large scientific tasks and experiments in the area of space physics [1…5]

The aim of this research is to offer a method and apparatus for investigation the atmospheric transparency and aerosol content by a satellite spectral limb method.

A method for determination of the gas components of the atmosphere by the method of star occultation is determined. A methodological scheme of the satellite limb experiment is presented on fig. 1.

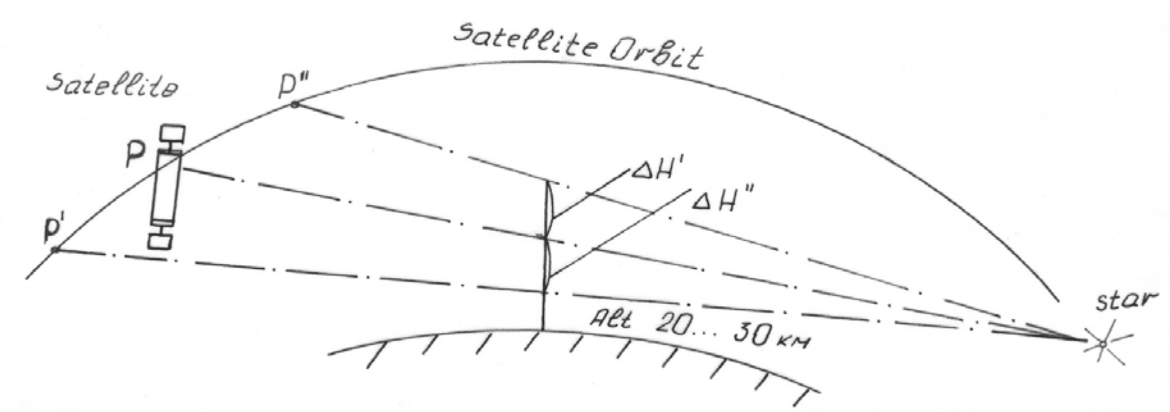

Fig. 1. Star occultation measurement geometry

Fig. 1 shows the viewing geometry for measuring in the limb viewing mode. Simulated measurements in four channels (λ=3914 Å, 4278 Å, 5200 Å and 5577 Å) were used to retrieve vertical profiles of the following quantities:

- aerosol size distribution;
- aerosol density, particles;
- real part of aerosol reflective index;
- molecular density;
- ozone density.

Theoretical calculations of the twilight aureole brightness showed that they are governed by the atmosphere's dust content at different heights. It is, therefore, possible to determine the spatial distribution of dust from aureole spectra data recorder at different points of the Earth.

An occultation experiment is a promising method for retrieving aerosol vertical profile in the stratosphere. In this case, radiation attenuated by the long atmospheric paths is registered from space at starset.

An equation for radiation transfer for occultation geometry is rather simple:

(1)
$$I_{\lambda}(h) = I^{*}_{\lambda}(h)$$

Here $I_{\lambda}(h)$ is the radiation registered along the viewing line with its pedigree altitude, h; I^{*}_{λ} is the intensity of the extra atmospheric solar radiation. The atmospheric optical thickness $\tau_{\lambda}(h)$ along the viewing line is calculated by the formula:

(2)
$$\tau_{\lambda}(h) = \exp\left\{-2\int_{h}^{\infty}(\beta_{\lambda}(h')dx(h,h'))\right\},$$

where $(\beta_{\lambda}(h)$ is an unknown distribution of the attenuation coefficient with an altitude h; x(h,h') in the variable of the geometrical part along the viewing line between the points at altitudes h and h'.

It is seen form the above two equations that the solution of the inverse problem is reduced to solution for $\beta(h')$ in the Volterra's equation of the first kind:

(3)
$$g_{\lambda}(h) = \ln\{1/\tau_{\lambda}(h)\} = 2\int_{h}^{\infty}\beta(h')dx(h,h'),$$

The star occultation geometry (fig. 1) is typically used to measure the stratosphere because of clouds in the troposphere. The extinction by clouds is so high that the attenuation of the radiation by aerosols would be undetectable.

In the case of the "occultation-mode" the radiative transfer is completely described by the law of extinction (4), which is the analytical solution of the appropriate special case of the equation of radiative transfer and which is simple compared to the "scattering-mode":

(4)
$$E_{\lambda} = E_{\Theta\lambda}\exp-(\delta_{R\lambda} + \delta_{G\lambda} + \delta_{D\lambda}),$$

Where:

E	–	spectral solar flux density at the spectrometer;
$E_{\Theta\lambda}$	–	spectral solar flux density before entering the atmosphere;
$\delta_{R\lambda}$	–	optical depth of the atmosphere integrated over the optical path, due to air molecules (Rayleigh optical depth);
$\delta_{G\lambda}$	–	same, due to absorption by gases;
$\delta_{D\lambda}$	–	same, due to aerosol particles.

As can be seen from (4) the desired quantity, the aerosol optic depth can be gained reasonably by simply "inverting" the measured quantity E_{λ}. In fact the Rayleigh optical depth is the only perturbing quantity. The gaseous absorption on optical depth can be chosen to be zero by an appropriate choice of the peak wavelengths and the bandwidths of the spectrometer channels.

The developed method is provided by an absorption ozonemeter. The absorption ozonemeter consists of the following constructive blocks: hinge block with a position lock pin, lather light-protective blind, vizir, photometric channel and connection cable to the apparatus.

The general view of pulse photometer is presented on fig. 2.

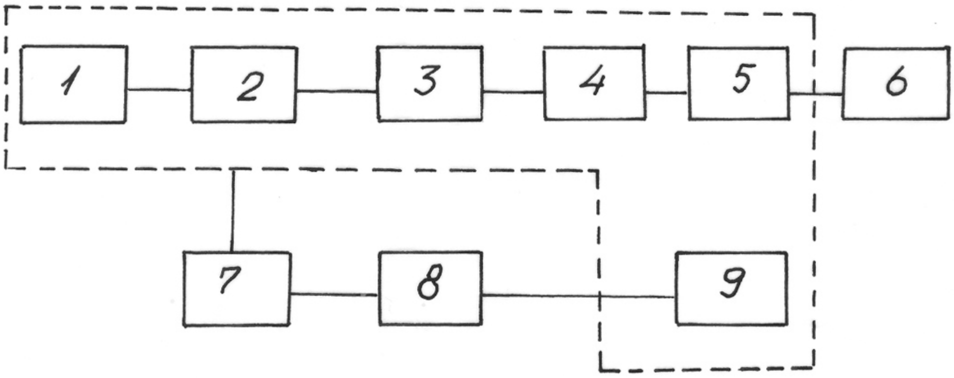

Fig. 2. Block-scheme of absorption ozonemeter: 1-sight-protective device; 2-objectives; 3- filter block; 4-sensor; 5-photon counter; 6-microprocessing unit; 7-guiding device; 8-operator; 9-control desk.

The hinge block serves for the absorption ozonemeter mounting to the space station illuminator. A lock pin for positioning is assembled in it, which provides fixing of the pulse photometer in the desired direction. The blind serves for photometer objective and vizir protection from side lightings. The vizir serves for apparatus guiding to the researched object.

The photometric channel consists of the following blocks, changeable filters block, input optical system, photometric multiplier, analogue unit, digital unit, control panel. The input optical system means an afocal objective. It serves for receiving of the optical signal, as at its output a concentrated parallel beam which descends on the corresponding interference filter is formed.

A diaphragm is located in the focal plane.

The design permits the diaphragm shift depending on the required in the experiment visual field. The photo electronic multiplier is provided for the information flow conversion into electronic signal. The used photoelectronic multiplier is of 9893 B/100 type, made by “Torn EMI”. A secondary supplying source for stabilizedvoltages (±15 V, 5 V, +1,5 V, …2,3 kV, 27 V) is provided. The analogue unit serves for signal amplification and forming into convenient shape for digital conversion at the input of the photoelectronic multiplier. The digital unit is provided for solving of following tasks: counting of pulses from analogue unit, signal transmission for recording in apparatus, run mode of absorption ozonemeter selection, providing of control panel indication.

The changeable filters block provides the subsequent transition of the photon flux trough the various interference filters to the photoelectronic multiplier. The control panel serves for: switching on the power supply of absorption ozonemeter, selection of automatic or manual mode of filter change, selection of high time resolution mode “100 μs” or low time resolution mode “1 ms” and “100 ms”, manual selection of the desired filters, switching on the mode of the information recording into the apparatus.

Run mode of absorption ozonemeter.

The light flux from the researched object is registered by the following sequence: transmitting trough the optical system and filter block, it hits the photocathode of the photoelectronic multiplier anode the signals pass in the form of electrical pulses to the analogue unit where they are amplified into digital form.

Depending on the selector position “100 μs – 1 ms – 100 ms” on the control panel, the digital unit counts this pulses with high (100 μs) or low (1 ms or 100 ms) time resolution.

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