MEASUREMENTS OF SHORT-PERIOD VARIATIONS IN OZONE ABUNDANCE AND SOLAR RADIATION

L.S. Ivlev, O.V. Maksimenko, and V.S. Sirota

Research Institute of Physics, Leningrad State University
Arctic and Antarctic Research Institute
Leningrad Hydrometeorological Institute
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We analyze a methodology for measuring variations in total ozone abundance (TOA). We describe a thermally stabilized photometric system for making simultaneous high-accuracy measurements of TOA and the intensity of incoming solar radiation (ISR). Our equipment can operate unattended, and is fit ted with a two-axis sun-tracker. It enables the user to carry out coordinated investigations of weak, short-period variations of both TOA and ISR.

Studies of quasiperiodic variations in the total atmospheric ozone abundance and the relationship between these variations and certain heliophysical parameters have recently become quite important. Investigations of solar intensity and total ozone variations necessitate the use of sensitive, fast-response, compact instrumentation capable of synchronous automatic ozone and actinometric measurements. A number about 15) of different instruments are known to be employed in routine total O_3 measurements[1]. While most of the devices rely on quasimonochromatic measurements, including Dobson's[2], Brewen's[3] and Kuznetsov's[4] spectrophotometers, the integrated method is also used. The latter is typified by Guschin's M-124 ozonometer[5]. The total ozone measurement techniques are reviewed in Refs. 6–9. The main disadvantages inherent in the quasimonochromatic ozonometers are as follows:

a) a very small fraction of solar flux is detected, resulted in noise induced by the radiation scattered within the instrument at low sun elevations;

b) the instruments have large dimensions;

c) the instrumentation used and the relevant measurements are very costly.

Some devices of this type also suffer from such shortcomings as a long total count-reading time for all subbands, lack of a solar guiding system, a very complicated calibration procedure, etc. The above handicaps are partially alleviated in the integrated ozonometer design[5], but M-124 is devoid of a solar guiding system, thermal stabilization and automatic operation capability. Hence, the solar radiation and total ozone measurement errors are estimated to be 3%, which makes it difficult to monitor weak short-period variations of these values. To improve the measurement accuracy and provide synchronous solar intensity and total ozone observations we have developed a special photometric setup.

The proposed design overcomes some of the foregoing limitations of the measuring instrumentation. Thermal stabilization provides a temperature of 20°C within the device. The Instrument operates automatically and is equipped with a solar guiding system. In addition, there is an internal reference source for subcalibration purposes. The optical filters and detector are rigidly attached, which eliminates uncertainties due to variable filter positions upon their replacement. The setup also includes a branching light pipe for directing the filtered solar radiation and the calibration source output to a fixed region on a photocathode. Thus the most sensitive part of the photocathode can be found during instrument alignment, and the noise induced and the noise induced by the light scattered within the device eliminated.

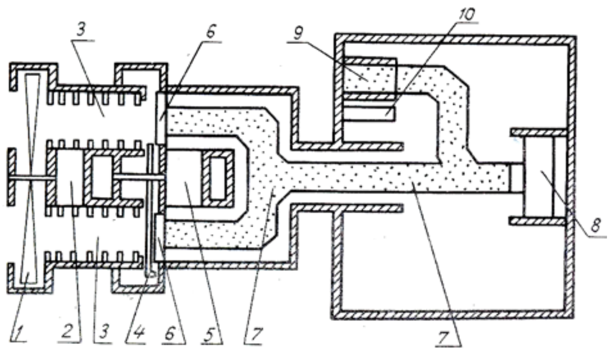

FIG. 1. Block diagram. 1. chopper wheel; 2. electric motor; 3. tube system; 4. shutter; 5. stepping motor; 6. light fielters; 7. branching light guide; 8. detector; 9. calibration source; 10. silica gel cartridge.

A diagram of the system and its components is shown in Figures 1, 2 and 3. The principle of operation is as follows. A set of observations begins with a subcalibration of the measuring channels. To this end, stepping electric motor sets the shutter to position 0, blocking the solar radiation to the detector. Simultaneously, the reference calibration source is repeated; channels 3, ..., *n* follow in turn delivered to the detector by a light pipe. The detector signal is then recorded by a measuring unit. Upon calibration, the shutter is set to 1, allowing solar radiation through a light filter of the first measuring channel onto the detector. After the detector data have been recorded, the shutter is set to 2 and the measurement procedure is repeated; channels 3, ... *n* follow in turn. The chopper wheel is compatible with an a.c. amplifier, which improves system stability. A silica gel cartridge maintains a constant humidity within the instrument, making for stable operation.

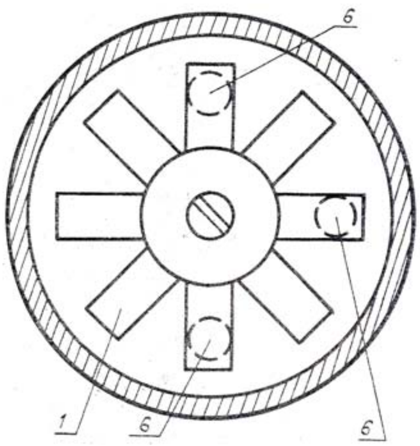

FIG. 2. Chopper wheel (see caption for Fig. 1).

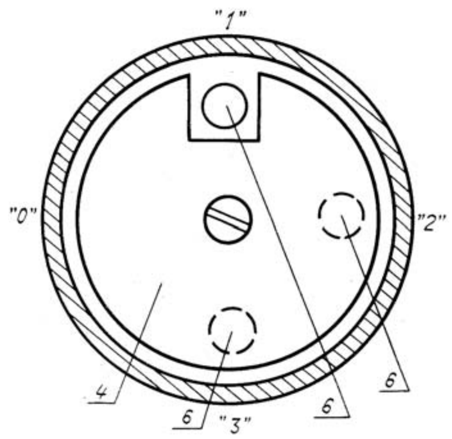

FIG. 3. Shutter (see caption for Fig. 1).

For synchronous ozone and actinometric observations, the first two channels are employed for total ozone measurements by Guschin's technique[8] with light filters similar to those used in M-124. Wide-band filters can be replaced by interference filters. The other channels measure solar radiation. The interference filters cover the entire range of spectral detector sensitivity. The signal from the first two measuring channels are processed automatically. The total ozone content in terms of Dobson units is monitored by a special recorder. A measurement cycle using 10 channels takes ≤ 10 s. The automatic operation allows the sun to be followed by means of a two-coordinate tracking system[10,11].

The proposed setup for solar intensity and total ozone variation measurements provides synchronous observations and long time series. A described scattered intensity within the instrument, a fixed light filter position with respect to the detector when switching measuring channels, and alignment to the most sensitive photocathode region reduce the total measurement error by a factor of approximately 1.5.

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