ELECTRONIC CONTROL OF PHOTOELECTRIC MULTIPLIER GAIN WHEN RECORDING LIDAR RETURNS WITH WIDE DYNAMIC RANGE IN PHOTON COUNTING MODE

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Some results of experiments on electronic control of counting photoelectric multiplier (PEM) gain when recording lidar returns of wide dynamic range are presented and discussed.

Lidar returns obtained in laser sounding of the stratosphere and mesosphere at the Siberian Lidar Station (SLS) have wide dynamic range reaching 10^{13}, while the threshold of linearity of modern counting photoelectric multipliers (PEMs) does not exceed 10^5. However, the application of available methods and devices to decrease this range does not allow one to use completely the lidar energy potential and leads to significant distortions in lidar return photorecording and to the decrease of the sounding range. Recent trends in our country[1,2] and abroad[3] are toward the use of electronic techniques for control by the PEM gain (K_g) (its gating) in the current mode of PEM operation.

In this paper, we investigate the techniques for electronic control by K_g of counting PEMs destined for recording in the UV, visible, and near-IR ranges and having different design features. The efficiency of PEM gating of an input chamber, the first dynodes, and the end of the dynode system was investigated, because these three regions were most responsible for the appearance of afterpulses. For PEMs with a modulating electrode (FEU-79, FEU-104, and FEU-106), the most efficient gating is realized for the input chamber of the photodetector by means of applying a controlling voltage pulse to a photocathode rather than to the modulator. For the photodetectors without modulating photoelectrode (FEU-130) with high voltage between the photocathode and the first dynode, the best results were reached for the interval between the first and the second dynodes. The efficiency of the photodetector gating of the last dynodes was insufficient under conditions of intense illumination of photocathode.

Based on the results of investigations, the blocks of electronic control of K_g of FEU-106 were developed and manufactured for a lidar for measuring the temperature in the stratosphere and mesosphere, and of the FEU-130 for a lidar for measuring the stratospheric ozone and aerosol.

Three subsequent lidar returns obtained with 30-min accumulation time at a wavelength of 532 nm on March 20, 1996 are shown in Fig. 1 for illustration. The lidar return *1* was obtained without limitation of the light flux, and the lidar returns *2* and *3* were obtained with the use of the block of electronic control of K_g of PEM and mechanical obturator, respectively, in order to decrease dynamic range. It is seen that the signal *1* undergoes distortions of three types. The first is the regime of photodetector saturation resulting in loss of information up to an altitude of 20 km. The second is the dip after termination of the saturation regime, and the third is the appearance of afterpulses at the end of the sounding path manifested through additional noise pulses, being 5–6 times greater than the sky background and the intrinsic noise of the photodetector. Application of the obturator results in wide transitive zone due to insufficiently high frequency of the engine shaft rotation.

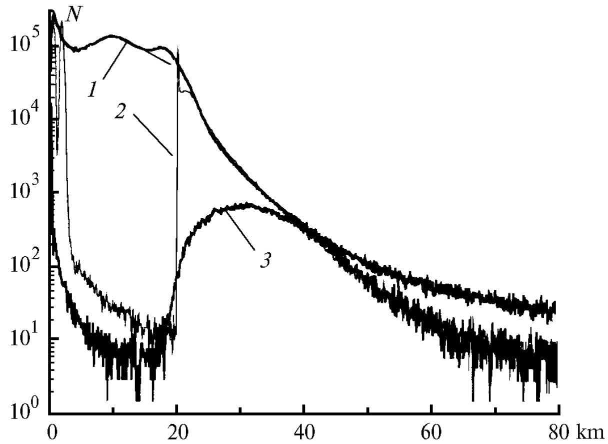

FIG. 1. Lidar returns.

Figure 2 shows the vertical profiles of the temperature reconstructed from these signals. As seen, the best coincidence with the model temperature behavior has the profile obtained using the electronic technique for controlling the K_g of PEM (profile *2*). The temperature profile *3* obtained with the use of the mechanical obturator is reconstructed only starting from an altitude of 45 km, and the profile *1* obtained without limitation of the light flux can be rejected.

The block of electronic control of K_g of PEM has the following specifications: switching time is 10 μsec,

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range of the delay variation is 10 μs – 1 ms, energy supply voltage is 100 V. The delay time of opening PEM is controlled by the controller manufactured in the IBM PC standard.

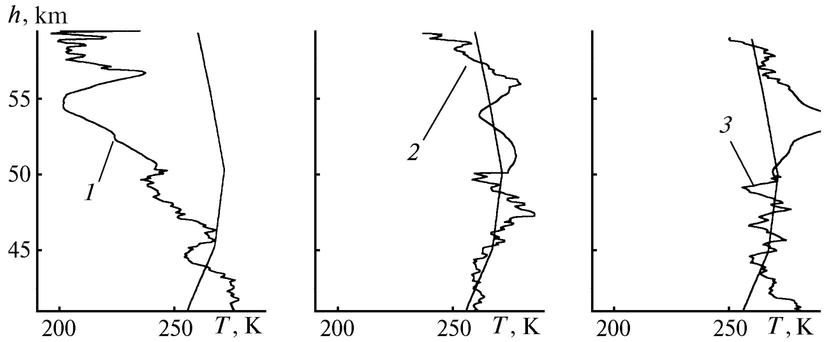

FIG. 2. Profiles of the temperature.

Our laboratory and field dynamic measurements of the response of photocathode and dynode system to intense illumination pulses indicate the efficiency of the method of electronic gating when recording lidar returns of wide dynamic range. The measurements were performed at the Siberian Lidar Station.

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