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Using of subnanometer spectral filters for monitoring of gas objects in atmosphere

Introduction

In the area of Earth and atmosphere monitoring using space-based sensors the problem of detection of gas objects is very relevant. It can be detection of exhaust streams of planes and rockets, bursts of dangerous gases, conflagrations, explosion etc.

During solving this task objects of interest have to be observed against bright Earth surface and clouds. A method of solving the problem with using of subnanometer spectral filters is proposed. It allows increasing signal-noise ratio up to 20 times comparing to traditional approaches.

Method description

For detection of gaseous objects in atmosphere infrared sensors are widely used [1]. In most cases observation is performed in the band of atmosphere absorption due to low level of Earth surface radiance. Spectral bandwidth is usually about units of micrometers.

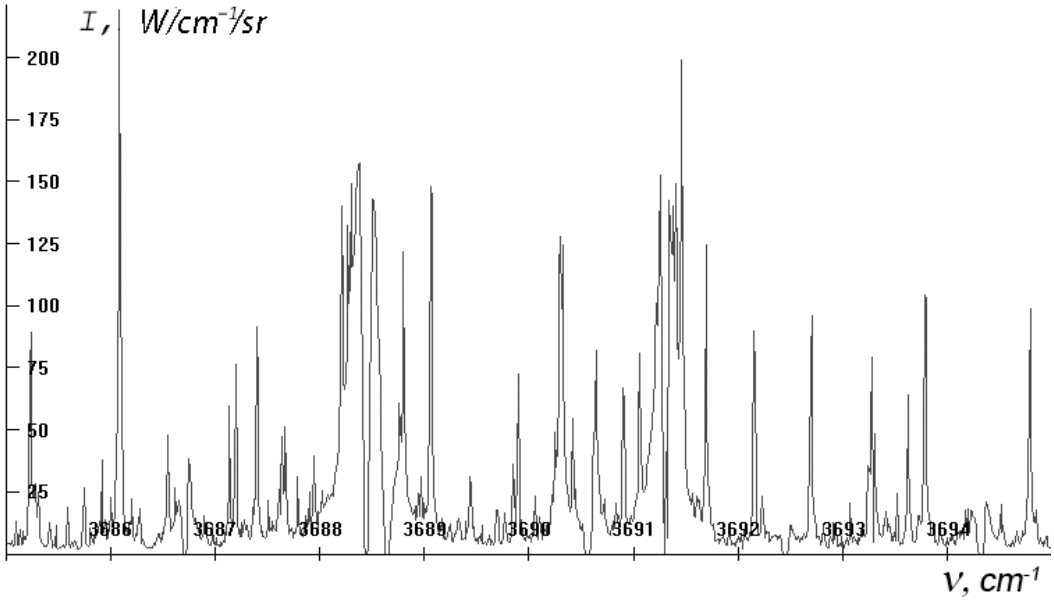

Fig. 1. Typical specter of radiation of exhaust products of gas – dynamic systems in high atmosphere.

Such approach can be significantly improved using information about fine structure of specters of gaseous objects and background. Specter of gas-dynamic systems is a superposition of narrow lines while specter of atmosphere absorption has distinct minimums. Width of such lines is about fractions of cm^{-1}. Maximums of radiation of gaseous objects often coincide with maximums of atmosphere absorption, i.e. with minimums of background radiation. Particularly, according to the model of

gas-dynamic systems specters with resolution ~0.01 cm^{-1} were obtained [2]. Specters of Earth surface and clouds were obtained in model [3]. Both imitators based on elaborates physical models which take into account all basic processes and effects, influencing on radiation forming. Examples of such calculations are shown in fig. 1 and fig. 2. It was shown that most of strong lines of gaseous objects radiation coincide with background radiation minimums.

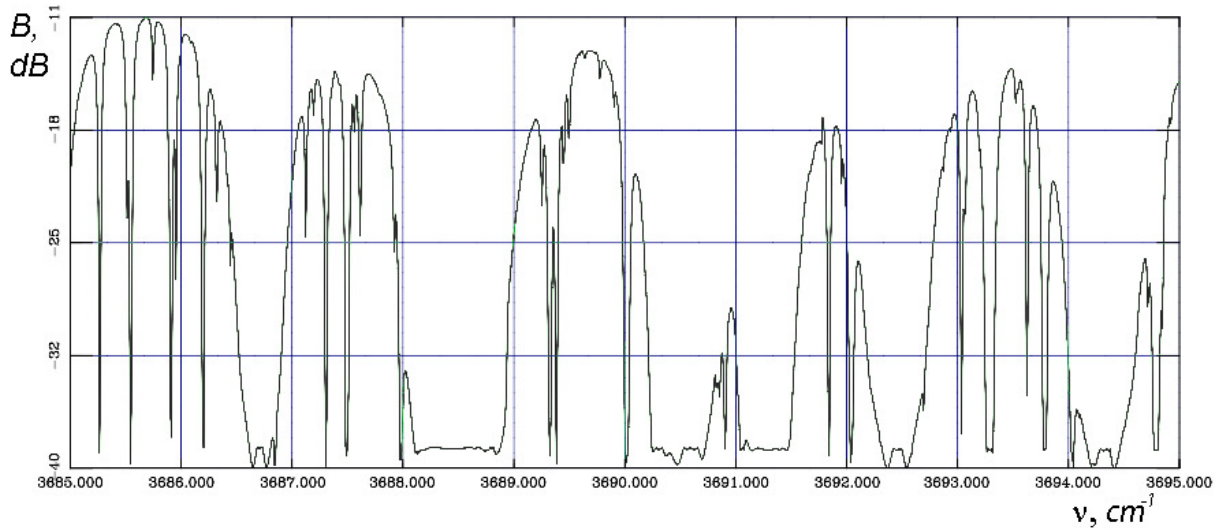

Fig. 2. Specter of radiation of clouds with top height of 10km.

This fact can be used for designing of detectors based on reconfigurable interference filters. In order to solve the task they must have wavelength resolution about 10^{-10} m. Along with high resolution these filters must have the following merits. They must be reconfigurable in order to change observation wavelength, i.e. gas of observation. Interferometers must have rather wide field of view which allows to use it for observation of large objects. Moreover, radiation, filtered with narrowband filter, can be streamed onto another photodetector.

In fig. 3 fundamental scheme of proposed device is shown. It consists of telescope, wideband and several narrowband filters, two photodetector matrices and computational facility [4].

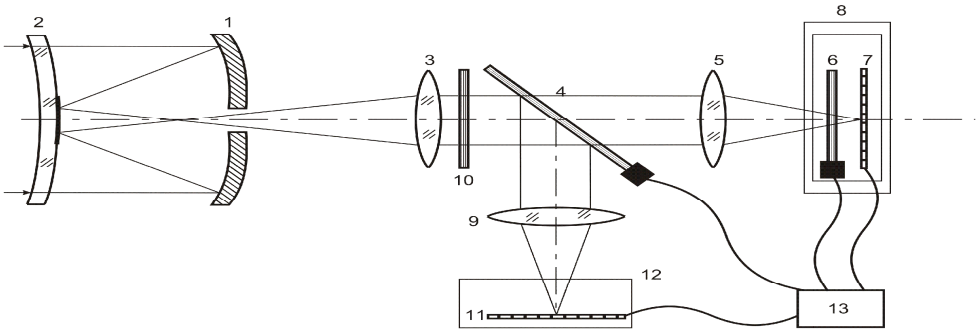

Fig. 3. Scheme of monitoring device. 1, 2 – telescope; 3 – collimator; 10 – input cooled interference optical filter; 4, 6 – narrowband interference optical filters; 5, 9 – lenses; 7, 11 – cooled photodetector matrices with coolers 8, 12; 13 – computational facility.

Conclusion

Using of filters with subnanometer resolution allows increasing of signal-noise ratio up to 20 times in the task of monitoring of gas-dynamic systems. Dynamic adjustment of filter parameters allows using such system for detection and identification of gas objects of various gas compositions.

References

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