**PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY**

*Physical and Mathematical Sciences* 2009, № 3, p. 64–66

*Physics*

# ON THE OPERATIVE METHOD MEASURING OF THE ATMOSPHERE'S INFRARED TRANSPARENCY

R. S. ASATRYAN*

*Chair of Optics, YSU*

The results on development of an original method of atmosphere's transparency determination in the infrared region are presented. The method is a half-empirical and based on the direct nephelometric and meteorological measurements of the atmosphere's transparency in the visual region (on $\lambda = 0{,}55\,\mu$) with following recalculation to the other spectrum region in diapason from $1\,\mu$ to $14\,\mu$. The proposed method provides the possibility of the operative valuation "optical weather" in the atmosphere, especially in full-scale tests thermovision equipment and devices of night vision.

***Keywords*:** infrared transparency, meteorological visibility range, aerosol particles.

**Introduction.** The importance of atmospheric transparency in the infrared region is extremely necessary at researches of its optical-physic properties, as well as (in sphere of applied application) for an operative estimation of "optical weather" on services of air navigation and at full-scale tests of a various type apparatus.

As is shown in the monograph [1], a possibility of determination of clouds and fogs spectral transparency in infrared region on the data of their transparency in the visual range is rather tempting, as the theoretical and experimental decision of this task is easier.

**Measurement Method.** The transparency in visual region may be determined from visual measurements of meteorological range of visibility by known relation [2] (if to accept an eye size 0,02 for a threshold of contrast sensitivity):

$$T_a(0{,}55) = \exp(-3{,}91L / S_M), \qquad (1)$$

where $L$ is a distance on line, and $\alpha(0{,}55) = 3{,}91 / S_M$ is the volumetric factor of attenuation in visual region (on $\lambda = 0{,}55\,\mu$).

Let's write down expression for a spectral transparency (taking into account only aerosol easing):

$$T_a(\lambda) = \exp(-\alpha(\lambda)L). \qquad (2)$$

Taking into account the expression for $S_M$, we get:

* E-mail: as_ruben@yahoo.com

$$T_a(\lambda) = \exp[-\beta_a(\lambda)3{,}91 / S_M L], \quad (3)$$

where

$$\beta_a(\lambda) = \alpha(\lambda) / \alpha(0{,}55). \quad (4)$$

The values of the relations $\alpha(\lambda)/\alpha(0{,}55)$ for all possible, realized in liquid droplet clouds and fogs parameters of microstructure and for a range from 0,5 up to 14 $\mu$ are obtained and considered in [1]. On the obtained large experimental material the satisfactory consent of counting values $\beta_a(\lambda)$ experimentally estimated is shown.

Using of these data with the value of meteorological range of visibility $S_M$ (or coefficient $\alpha(0{,}55)$ ), which are measured with the specially developed equipment [3], solves the given task on determination of atmosphere's transparency in IR-range.

**Technique of Account of Atmosphere's Transparency in the Wave Lengths from 8 to 12 $\mu$.** Average factor transparency of atmosphere $\overline{T}$ in the wave lengths of 8–12 $\mu$ is determined by the formula:

$$\overline{T} = \overline{T_M} \cdot \overline{T_a} = \overline{T_M}(L,\gamma)\exp[-\alpha(0{,}55)L\overline{\beta_a}], \quad (5)$$

where $\overline{T_M}$ and $\overline{T_a}$ are also average transparency factors of atmosphere caused molecular (including water vapors) and aerosol easing. The $L$ is the line vising in *km*, parameter $\gamma = e/T^0$ $(mb/dg)$ is determined on the data of measurements of water vapours partial pressure ($e$) and air temperature $T^0(K) = 273 + t^0(C)$. The average values of $\overline{T_M}(L,\gamma)$ for a line $L$ depending on parameter $\gamma$ are submitted in [4].

The values of atmosphere's transparency, caused by aerosol easing $\overline{T_a} = \exp[-\alpha(0{,}55)L\overline{\beta_a}]$, is defined for the same line $L$ depending on values $\alpha(0{,}55)$ and $\overline{\beta_a}$. The current values of $\alpha(0{,}55)$ are measured with a complex from [3], and the typical $\overline{\beta_a}$ values undertake from [4].

At insignificant change of "optical weather" in time the values $\overline{T_M}$ and $\overline{\beta_a}$ also may be taken constant. Then average value of a transparency for a line $L$ at the moment of time $t_i$ will be:

$$\overline{T}(L,t_i) = \overline{T_M}(L)\exp[-\alpha(t_i)L\overline{\beta_a}]. \quad (6)$$

To conduct the accounts by formulas (5)–(6) we developed the special program (on a basis MatLab), intended for accounts of attenuation parameters of visible radiation in atmosphere, meteorological range of visibility and factors of transparency in IR-region at various lengths of a line vising.

**Conclusion.** The above described method of determination of IR-atmosphere's transparency, developed by us, as a matter of fact grows out of continuous registration (with a measuring complex [3]) transparency of an atmosphere in a range from 0,35 to 1,03 $\mu$ and recalculation it on other sites of a spectrum in diapason from 1 to 14 $\mu$. The offered method provides determination of a transparency of an atmosphere with relative error no more than ±20% at $S_M = 3$ *km* and ±6% at $S_M = 25$ *km*.

The essential advantage of the offered technique of determination of an atmosphere transparency in IR-region on the data of its transparency in visual region of the spectrum is that in this technique the necessity of application of the concentration data (difficultly determined on experience) of the different sizes aerosol particles is excluded.

*Received 13.06.2009*

REFERENCES

1. **Zuev V.E.** The Transparency of Atmosphere for Visual and Infrared Beams. M.: Sov. Radio, 1966, p. 318 (in Russian).
2. **Sharonov V.V.** Measurement and Account of the Visibility of Objects. M.: Gostechizdat, 1947, p. 276 (in Russian).
3. **Asatryan R.S., Asatryan S.R.** et. al. Instruments and Experimental Techniques, 2003, v. 46, № 4, p. 125–126.
4. **Asatryan R.S.** The Optoelectronic Methods of Radiation Fields Researches. Ph.D. Thesis, YSU, 2000, 18 p.

*Proc. of the Yerevan State Univ. Phys. and Mathem. Sci., 2009, № 3, p. 64–66.*

## Մթնոլորտի ինֆրակարմիր թափանցիկության չափման մի օպերատիվ մեթոդի մասին

Բերված են ինֆրակարմիր տիրույթում մթնոլորտի թափանցիկության որոշման նոր մեթոդի մշակման արդյունքները: Մեթոդիկան կիսաէմպիրիկ է և հիմնված է տեսանելի տիրույթում ($\lambda = 0,55$ *մկմ*) մթնոլորտի թափանցիկության նեֆելոմետրական և մետեորոլոգիական անմիջական չափումների վրա՝ հետագայում սպեկտրի 1–14 *մկմ* տիրույթի այլ տեղամասերի համար վերահաշվարկով: Առաջարկվող մեթոդը հնարավորություն է ընձեռում մթնոլորտում "օպտիկական եղանակի" օպերատիվ գնահատման համար՝ հատկապես ջերմատեսանելիության և գիշերային տեսանելիության սարքերի դաշտային փորձարկումների ժամանակ:

## Об одном оперативном методе измерения инфракрасной прозрачности атмосферы

Приводятся результаты разработки оригинального метода определения прозрачности атмосферы в инфракрасном диапазоне. Методика является полуэмпирической и основана на прямых нефелометрических и метеорологических измерениях прозрачности атмосферы в видимом диапазоне ($\lambda = 0,55$ *мкм*) с последующим пересчетом на другие участки спектра в области от 1 до 14 *мкм*. Предлагаемый метод обеспечит возможность оперативной оценки "оптической погоды" в атмосфере, особенно при натурных испытаниях тепловизионной аппаратуры и приборов ночного видения.