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APPLICATION OF PASSIVE OPTICAL ATHERMALIZATION METHOD FOR THERMAL STABILIZATION OF IR OPTICAL SYSTEMS CHARACTERISTICS

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The use of infrared (IR) equipment is extensive in various fields such as measurement, military engineering, and scientific research. IR devices are commonly utilized in challenging environments. Nowadays the methods of digital image processing and artificial intelligence technologies are widely used to automate the IR technics [1, 2], but result of the system will depend primarily on image quality.

Several research studies focus on the development of lenses that are not affected by temperature changes. The article [3] examines techniques for achieving opto-mechanical passive athermalization of optical systems, but there has been insufficient focus on the algorithm for passive optical athermalization. Upon reviewing such literature, it becomes clear that opto-mechanical athermalization methods receive the most attention. However, passive optical athermalization has become more prevalent due to its simplicity of construction, high precision and reliability, and ability to reduce the size and weight of optical systems. Currently, there are only general recommendations for designing athermalized lenses in scientific literature, and the question of mathematical algorithms for passive optical athermalization is still unanswered.

At lenses design process for IR equipment, developers widely use three-component optical systems. At the same time, the task of maintaining image quality over a wide temperature range in most of these compositions remains unresolved. This paper material is devoted to development of mathematical apparatus that allows to design athermalized and achromatic IR triplets with possibility of minimization of necessary image aberrations for the case of uniform temperature distribution in optical system [4].

Equipment for infrared imaging must operate within a temperature range of ±50 ºC to ensure image quality is not adversely affected by changes in the temperature field [5]. Thermal defocusing can occur in the optical system when the back focal length changes and image thermal aberrations can reduce resolution and impair lens characteristics. Therefore, it is important to stabilize the image quality of lenses when faced with changing environmental temperatures, and this is a problem that needs to be addressed during the IR device design stage.

There are active, semi-active, and passive methods to achieve this thermal stabilization. Passive optical athermalization is attractive due to its high reliability, lack of moving parts or manual adjustments required, and simplified design. Additionally, this approach minimizes weight and size properties. The use of new optical materials suitable for IR spectral range further enhances the potential of this approach.

The synthesis of an athermalized dioptric objective relies on combining optical materials with different thermo-optical constants to minimize image aberrations and optimize the supporting structure material for lenses during thermal stabilization. Using only two different optical materials, athermalized IR objectives can be synthesized using two or three lenses [6].

It is important to consider athermalization of the optical system during the design of high-precision and sensitive devices as temperature fluctuations can significantly affect image quality and informativeness. Athermalization and achromatization of IR triplets can be achieved by selecting optical materials compositions, while minimizing the main aberrations of IR dioptric lenses image.

Synthesized in accordance with developed technique IR triplet with 50 mm focal length, 1:1 relative aperture, field of view angle 12º is characterized in the temperature range from -20ºC to +60ºC by 4 μm changing of back focal length, that is 1-2 orders less than for non-athermalized lenses with similar operational parameters [7].

To maintain image quality in IR technology, it is crucial to consider the working temperature range. Fluctuations in temperature can lead to thermal defocusing in the optical system, thereby reducing resolution and overall lens performance. For sensitive IR devices, it is expedient to carry out athermalization and achromatization of IR triplets through selection of optical material compositions, ultimately resulting in improved overall performance.

Continued development in this area ought to focus on enhancing the design methodologies for achromatic and athermalized IR optical systems with the objective of creating an algorithm capable of providing a comprehensive set of parameters for the optical system, eliminating the need for extra optimization; reducing optical system aberrations; devising optical systems comprising over three components.

Keywords: *passive optical athermalization, image quality thermostabilization, dioptric objective, optical system*.

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