Stray Light Analysis for the AIMS Telescope Post-print

Authors: Biyuan Gao, Dongguang Wang, Yingzi Sun, Yuliang Shen, Xiao Yang, Junfeng Hou, Yingzi Sun

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Abstract

Stray light has a significant effect on the overall performance of telescopes, particularly for infrared solar telescopes, in which internal thermal radiation causes additional stray light sources. We establish a 3-dimensional model using stray light theory and the real opto-mechanical structure of the Accurate Infrared Magnetic field measurements of the Sun (AIMS) telescope. We use the stray light ratio (i.e., the ratio of stray light energy reaching the detector to the light energy used for observations) to evaluate the imaging performance of the telescope. We analyze both thermal and non-thermal sources of stray light to comprehensively study the visible, 8-10 m, and Fourier transform infrared systems of the telescope, finding stray light ratios of 9.31$×10−6*inthevisiblesystem*, 2.83×10−4*inthe*8–10*μmsystem*, *and*1.54×$10-4 in the Fourier transform infrared system. This verifies that the opto-mechanical system design of the telescope can effectively suppress stray light, benefiting both imaging and magnetic field observations.

Full Text

Preamble

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Stray light analysis for the AIMS Telescope

Biyuan Gao[1],[2], Dongguang Wang[1],[2], Yingzi Sun[1],[2]*, Yuliang Shen[1], Xiao Yang[1],[2], Junfeng Hou[1],[2]

[1] State Key Laboratory of Solar Activity and Space Weather, National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100101, China

[2] School of Astronomy and Space Science, University of Chinese Academy of Sciences, Beijing 100049, China

*Correspondence: syz@bao.ac.cn

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Abstract

Stray light has a significant effect on the overall performance of telescopes, particularly for infrared solar telescopes, in which internal thermal radiation causes additional stray light sources. We establish a 3-dimensional model using stray light theory and the real opto-mechanical structure of the Accurate Infrared Magnetic field measurements of the Sun (AIMS) telescope. We use the stray light ratio (i.e., the ratio of stray light energy reaching the detector to the light energy used for observations) to evaluate the imaging performance of the telescope. We analyze both thermal and non-thermal sources of stray light to comprehensively study the visible, 8-10 m, and Fourier transform infrared systems of the telescope, finding stray light ratios that verify the opto-mechanical system design can effectively suppress stray light, benefiting both imaging and magnetic field observations.

Keywords: Stray light analysis; Non-thermal radiation; Thermal radiation; Stray light ratio

1. Introduction

Stray light is unintended light propagation within an optical system that deviates from the nominal imaging path. These aberrant rays reach the detector through mechanisms such as scattering and reflection, generating parasitic background noise independent of target signals [**?**]. In astronomical observations, stray light significantly degrades image contrast and the signal-to-noise ratio of observational data. As the most luminous celestial body in the solar system, radiation from the Sun has an intensity orders of magnitude greater than other stars. For ground-based telescopes, the complexity of stray light becomes even more pronounced, directly impacting observational reliability and impairing the achievement of scientific objectives \cite{2-6}.

Stray light sources are classified into two categories: exogenous and endogenous. Exogenous sources primarily include atmospheric scattering and terrestrial environmental reflections. During daytime observations, atmospheric scattering of sunlight produces intense background radiation from the sky. Endogenous sources originate from non-ideal characteristics of the optical system in a telescope, including surface micro-roughness of optical elements, thermal emission from structural components, and ghost reflections caused by baffles and optical supports \cite{7-9}. In solar telescopes, high-energy-density solar irradiance accelerates the thermal deformation of optical elements and the degradation of coatings, thereby exacerbating stray light effects.

The AIMS telescope is installed at Lenghu in Qinghai Province of China, at an altitude of 4,000 m above sea level [**?**]. This solar telescope carries out solar spectral-polarization observations at a wavelength of 12.32 m, and imaging observations within the 8-10 m band. Because of the overall stray light challenges, the AIMS telescope adopts an off-axis design to effectively mitigate the influence of the intrinsic infrared radiation from the telescope on solar magnetic field measurements [**?**, **?**].

The impact of stray light on the AIMS telescope manifests in three dimensions: Spatially, it blurs fine solar features such as granulation boundaries and sunspot penumbral fibrils, resulting in resolution degradation; spectrally, it contaminates specific emission lines, obscuring weak emission signals and distorting spectral line profiles [**?**, **?**]; and in magnetic field measurements, stray light-induced polarization signal contamination substantially reduces the accuracy of vector magnetograms.

In this study, we perform a stray light analysis on the AIMS telescope. This paper is structured as follows: In Section 2, we introduce stray light theory and define the evaluation function of the system. Building on this, we construct a stray light model for the overall opto-mechanical system of the AIMS telescope in Section 3, and in Section 4, we carry out an analysis of the impacts of thermal and non-thermal radiation on the AIMS telescope. Finally, our conclusions are presented in Section 5.

2. Stray Light Theory

2.2. Radiation Theory

For the stray light analysis, we implement the Monte Carlo method using the Advanced Systems Analysis Program (ASAP) software [**?**]. Light rays are emitted from a source and pass through a three-dimensional model of the optical and structural components of the telescope. Every time a light ray intersects an object, additional scattered light rays are generated. The intensity of these scattered light rays is determined by weighting them proportionally to the intensity of the incident light rays and the Bidirectional Scattering Distribution Function (BSDF) of the surface. The scattered light rays are then collected by the detector to calculate the irradiance distribution.

2.1. Surface Properties

The system has an open-structure design, with negligible stray light generated by secondary scattering surfaces, so this study focuses exclusively on the contributions of primary scattering. To ensure accurate simulation results, it is essential to precisely set the optical property parameters of the system components before conducting software simulations. When the root-mean-square (RMS) roughness of a mirror surface is much smaller than the wavelength of the incident light, the mirror scattering can be described by the modified third-order Harvey scattering model, as

$$\mathrm{BRDF} = \frac{\beta}{\beta_0} = \frac{A}{B + (|\beta - \beta_0|)^g}$$

where β is the angle of incidence (the angle between the incident light ray and the normal of the mirror surface); β_0 is the scattering angle between the scattered light ray and the normal of the mirror surface; A is the normalization coefficient (related to the surface roughness and the wavelength); B is the characteristic length parameter, giving the spatial frequency characteristics of the surface roughness; and g is the attenuation exponent, controlling the broadening degree of the scattering distribution (directly proportional to the concentration of scattering in the specular direction) [**?**].

The Harvey model is configured for optical surfaces and high-reflectivity mechanical surfaces, in accordance with characteristics such as the surface reflectivity and material properties of the mirror. Remaining surfaces are set as “black paint surfaces” to maximize the absorption of stray light. We employ a Bidirectional Reflectance Distribution Function (BRDF) model, and its scattering model can be expressed as

$$\mathrm{BSDF}(\theta;\theta_0) = \frac{b_0}{6}\left[1 + \left(\frac{\sin\theta - \sin\theta_0}{L}\right)^2\right]^{S=2}$$

where θ and θ_0 are the outgoing directions of surface scattering and surface specular reflection, respectively, while b_0, L, and s are fitting parameters [**?**].

2.3. Evaluation Function

To describe the stray light from thermal and non-thermal radiation and thereby evaluate the imaging performance of the system, we define the metric of Stray

Light Ratio (SLR) as the ratio of stray light energy reaching the detector (E_{stray}) to the light energy reaching the detector required for observation (E_{actual}), as

$$\text{SLR} = \frac{E_{\text{stray}}}{E_{\text{actual}}}$$

For thermal radiation, the focus is on the distribution of radiant energy from the source and the radiance reaching the detector. The radiance of a light source, L, is given by

$$L = \frac{d^2\Phi}{dA\cos\theta\, d\Omega}$$

where $d^2\Phi$ represents the differential power emitted by the differential projected area of the light source dA into the differential solid angle $d\Omega$. The units are ph s^{-1} m^{-2} sr^{-1}, or in photometric units as cd m^{-2}. The Planck blackbody equation can be used to calculate the spectral radiance of an extended source as

$$L(\lambda; T) = \frac{C_1}{\lambda^5\left[\exp\left(\frac{C_2}{\lambda T}\right) - 1\right]}$$

where $C_1 = 5.99584 \times 10^{22}$ ph m^5 s^{-1} m^{-2} sr^{-1}, $C_2 = 14387.9$ m K, and T is the temperature of the source in Kelvins [**?**]. After the extended source passes through the system, the irradiance at the position of the detector is given by

$$E_{\text{SL}} = \sum_{i=1}^{n} L_i \epsilon_i \Omega_i \tau_i$$

where L_i and ϵ_i are the in-band blackbody radiance and emissivity of the i-th surface, respectively; Ω_i is the solid angle corresponding to the i-th surface; and τ_i is the corresponding transmittance.

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3. Stray Light Models of the AIMS Telescope

To establish the stray light model of the AIMS telescope, it is necessary to first determine its optical and mechanical structures, define surface scattering characteristics, and clarify the characteristics of internal and external light sources. For this, we use a Monte Carlo ray-tracing algorithm to construct a 3D model with the ASAP software, to simulate the propagation of light, and subsequently analyze it.

3.1. The AIMS Telescope

The AIMS telescope is a 1-m off-axis solar telescope. The optical system of the AIMS telescope, shown in Fig. 1A, consists of five distinct subsystems: the telescope system, the folding axis system, the de-rotator system, the collimation system, and the focal plane system. The focal plane system is further subdivided into five components.

In our stray light analysis, as presented in Fig. 1B [Figure 1: see original paper], only the 550 nm visible system, the 8–10 m infrared system, and the imaging optical path parts of the Fourier transform infrared (FTIR) spectrometer are taken into account. These selected components play crucial roles in understanding and managing the stray light issues within the AIMS telescope, the system parameters of which are shown in Table 1 .

Fig. 1. (A) Optical system diagram of the AIMS telescope and (B) the focal plane system.

Table 1. Optical system parameters

Systems	Field of view	Wavelength	Detector size/pixel
The visible system	23.4 × 3.4	550 nm	2048 × 2048 (8 m)
The 8–10 m system	4256 × 256	8–10 m	3.2 × 3.2
The FTIR system	64 × 2 (8 m)	12–12.5 m	3.2 × 3.2

As shown in Fig. 2A [Figure 2: see original paper], the AIMS telescope adopts an open truss structure with an alt-azimuth mount. A heat stop with a field of 6.4 is integrated at the focal plane of the primary mirror. This configuration serves the twin functions of mitigating the thermal impact of out-of-field solar radiation on downstream optical paths, and reducing the aperture requirements for subsequent optical components. The heat stop redirects extraneous sunlight outside the effective field of view, away from the main optical axis, while incorporating active cooling to suppress thermal noise. The detailed mechanical design of the heat stop is shown in Fig. 2B.

To mitigate the impact of thermal radiation, the two infrared systems are cooled separately. The 8–10 m system is cooled with an operating temperature of 100 K. The FTIR system is locally cooled, maintaining the imaging mirror at 80 K, the aperture stop at 62 K, and the field stop at 80 K.

3.2. AIMS 3D Model

The 3D model of the AIMS telescope includes the dome and the opto-mechanical system, the latter of which is extremely complex. Many elements within it, such as minuscule components and intricate geometries, are not only time-consuming but also unnecessary to model for an effective analysis. Consequently, a simplified ASAP model is shown in Fig. 3 [Figure 3: see original paper] composed of the dome, the optical system, the mechanical structure (including the aperture, truss, pier, and mirror mount), and the detector. Due to the highly complex structure of the FTIR spectrometer, during the analysis, only the guiding optics and imaging sections within its optical system are taken into account.

Fig. 2. (A) Structural diagram of the AIMS telescope. The position pointed by the arrow is the specific location of the heat stop. The detailed structure is shown in (B), that is, the detailed diagram showing the structure of the heat stop.

Fig. 3. 3D model of AIMS Telescope.

The stray light sources affecting the AIMS telescope include sunlight, sky background, and internal thermal radiation. We focus on thermal and non-thermal radiation.

3.3. Ray Tracing

With the AIMS telescope model established, we use ray tracing to determine the critical surfaces and illuminated surfaces. First-order stray light paths originate from surfaces that are both illuminated and critical [**?**, **?**]. Identifying such surfaces is important. The critical surface, defined as the surface detectable by the detector, is obtained through reverse ray tracing. In the 3D model of the AIMS telescope, an extended light source is positioned at the detector location. The reverse ray tracing parameters are approximately one hundred thousand rays with a light threshold of 10^{-18}. The surfaces receiving the light flux are identified as the critical surfaces. The illuminated surface is obtained using forward ray tracing. A light source is placed at the front of the telescope, and approximately ten thousand rays are traced with a light threshold of 10^{-18}. Multiple ray tracings are carried out, with each tracing corresponding to a different angle of the light source. The surface that receives the light flux is identified as the illuminated surface. Fig. 4 [Figure 4: see original paper] demonstrates the processes of forward and reverse ray tracing, and Table 2 lists the illuminated surfaces and critical surfaces obtained.

Fig. 4. Ray tracing diagrams.

Table 2. Overview of illuminated surfaces and critical surfaces obtained from forward and reverse ray tracing

Illuminated surfaces	Critical surfaces
8-10 imaging lens barrel structure	8-10 imaging lens L4
8-10 dewar structure	8-10 lens barrel
Cold stop	Cold stop
FTIR Spectrometer mounting structure	FTIR L4 EDGE

Illuminated surfaces	Critical surfaces
Heat stop	FTIR sleeve and support bracket
M7, 8, 9 and other multiple frame and support structures	M1 etc.
Near mounting structure	M1 frame
Multiple optical surfaces	M2 mounting structure and support
Beam splitter frame and support structure	M7, 8, 9, 10, 11 and other multiple frame and support structures
Platform and support structure	Platform
Upper truss and dome of the platform	Detector sleeve
Decentering lens barrel structure, end face of intermediate focus sleeve	End face of intermediate focus sleeve

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4. Stray Light Analysis

Here, we analyze thermal and non-thermal radiation, where the thermal radiation consists of both external and internal thermal sources. External thermal radiation primarily comes from the Sun outside the field of view of the optical system, and internal thermal radiation comes from the telescope itself. It is worth noting that for the visible system, we only analyze non-thermal radiation, while for the 8–10 m and FTIR systems, both thermal and non-thermal radiation are taken into account.

4.1. Non-thermal Radiation

According to the system model and parameter settings established in Section 3, following the ray tracing, the results of non-thermal radiation analyses for the visible system, 8–10 m system, and FTIR system are presented in Fig. 5 [Figure 5: see original paper]. Here, the analysis was extended up to 16 ; the curve gradually levels off, so only data up to 6 is shown. Table 3 presents the mean values of SLR both within and outside the fields of view of the three systems.

The SLR of the infrared system in our experiment is one order of magnitude higher than that of the visible system, which may be attributed to the coatings of the infrared optical components. When reflectivity and transmittance of the coatings in the infrared band are consistent with that in the visible light band, as shown by the dotted line in Fig. 5. After modifying the parameters of the coatings, the SLR decreased by 80% compared to the original value.

Fig. 5. The SLR curves of each system varying with incident angle, showing incident angles of up to 6 only. The horizontal axis shows the incident angle, and the vertical axis is the SLR of the system. Here, the black, green, and

red lines show the variations of SLR with the incident angle of the light source for the 8-10 m system, the FTIR spectrometer system, and the visible system, respectively. The black dotted line shows the situation after the parameters of the 8-10 m system have been modified.

Table 3. SLR of the three systems

System	In field of view	Out of field of view
The 8-10 m system	7×10^{-5}	3×10^{-4}
The FTIR system	1.94×10^{-5}	5.53×10^{-4}
The Visible system	9.31×10^{-6}	1.54×10^{-4}

4.2. External Thermal Radiation

The external thermal radiation mainly originates from the Sun outside the field of view of the optical system. In our model, the temperature of the Sun is set at 5,778 K. A telescope with a 1-m aperture receives 0.95 W of solar radiation in the 8-10 m wavelength band and 0.00677 W in the 12-12.5 m wavelength band. Fig. 6 [Figure 6: see original paper] shows the SLR of external thermal radiation varying with the incidence angle. The external thermal radiation remains effectively constant. The SLR of the 8-10 m system is approximately 2.68×10^{-4}, and that of the FTIR spectrometer system is approximately 4.1×10^{-4}.

Fig. 6. The SLR of external thermal radiation varies with incidence angle.

4.3. Internal Thermal Radiation

Internal thermal radiation is the thermal radiation emitted by the telescope itself, including its optical and mechanical components. The impacts of ambient temperature and material emissivity variations are also considered. In our telescope model (as described in Section 3), we place an extended light source at the detector, and obtain the luminous flux on each critical surface by reverse tracing the light rays from this source. Using the formulae defined in Section 2.2, we calculate the irradiance at the detector position, with each critical surface serving as an extended light source. Table 4 presents the critical surfaces of the 8-10 m and FTIR spectrometer systems, and the irradiance of the stray light produced on these surfaces.

In the internal thermal radiation model, the critical surfaces are defined as heat sources. We calculate their energy as blackbody radiation and incorporate these values into the model, to determine the total energy reaching the detector. The total thermal radiation amounts detected by the 8-10 m and FTIR systems under both cooled and uncooled conditions are shown in Table 5 , together with the SLR values of these two systems.

For the 8-10 m system, cooling the system to a temperature of 100 K causes the internal thermal radiation to reduce by 2.3 orders of magnitude. For the FTIR spectrometer system, when the imaging mirror was cooled to 80 K, the aperture stop was cooled to 62 K, and the field stop was cooled to 80 K, causing its internal thermal radiation to also reduce by 2.5 orders of magnitude.

Fig. 7 [Figure 7: see original paper] shows the SLR curves of the two infrared systems at different ambient temperatures and different material emissivities, at 300 K. The SLRs decrease with the material emissivity, which can in turn be decreased by polishing or changing the coating, reducing the impact of internal thermal radiation. However, non-thermal radiation also needs to be considered comprehensively. Ambient temperature has a negligible effect on the SLR, which is consistent with a real-world scenario, in which the telescope is subject to varying environmental conditions. The systems after the derotator are all located in the Coudé room, with relatively constant temperature, and the 8-10 m and FTIR systems are both refrigerated. Consequently, the impact of ambient temperature is extremely small.

In summary, considering the non-thermal radiation, the external thermal radiation and the internal thermal radiation yields an SLR of 9.31×10^{-6} in the visible system, 2.83×10^{-4} in the 8-10 m system, and 1.54×10^{-4} in the FTIR system.

Table 4. Critical surfaces in the 8-10 m and FTIR systems and their generated irradiance

Critical surfaces	Temperature (K)	Emissivity	Radiance (W cm^{-2} sr^{-1})	Projected solid angle × τ (sr)	Detector irradiance (W cm^{-2})
8-10 m system					
M2 bottom plate	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
M1 frame	300	0.9	3.16×10^{-5}	6.17×10^{-6}	3.14×10^{-6}
M2 mirror base	300	0.9	5.49×10^{-5}	1.94×10^{-5}	1.03×10^{-5}
M2 mirror frame	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
Intermediate focus sleeve end face 1	300	0.9	1.33×10^{-4}	1.94×10^{-5}	2.34×10^{-5}

Critical surfaces	Temperature (K)	Emissivity	Radiance (W cm^{-2} sr^{-1})	Projected solid angle × τ (sr)	Detector irradiance (W cm^{-2})
Intermediate focus sleeve end face 2	300	0.9	1.33×10^{-4}	1.94×10^{-5}	2.34×10^{-5}
Intermediate focus sleeve end face 3	300	0.9	1.33×10^{-4}	1.94×10^{-5}	2.34×10^{-5}
Platform 1	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
Platform 2	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
M7 mirror base	300	0.9	5.49×10^{-5}	1.94×10^{-5}	1.03×10^{-5}
M8 mirror frame	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
M9 mirror cylinder	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
M11 mirror frame 1	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
M11 mirror frame 2	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
8-10 cold stop	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
8-10 imaging mirror L4	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
8-10 mirror cylinder end face 1	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}

Critical surfaces	Temperature (K)	Emissivity	Radiance (W cm^{-2} sr^{-1})	Projected solid angle × τ (sr)	Detector irradiance (W cm^{-2})
8-10 mirror cylinder	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
8-10 Mirror Cylinder End Face 2	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
8-10 mirror cylinder end face 3	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
8-10 mirror cylinder	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
Detector sleeve	100	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
FTIR System					
M2 bottom plate	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
M2 mirror base	300	0.9	5.49×10^{-5}	1.94×10^{-5}	1.03×10^{-5}
M2 mirror frame	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
Platform	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
M9 mirror frame	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
M10 mirror frame	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
M11 mirror frame 1	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}
M11 mirror frame 2	300	0.9	1.11×10^{-4}	3.48×10^{-5}	3.48×10^{-5}

Critical surfaces	Temperature (K)	Emissivity	Radiance (W cm^{-2} sr^{-1})	Projected solid angle × τ (sr)	Detector irradiance (W cm^{-2})
FTIR sleeve non-refrigerated part 40	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
FTIR sleeve non-refrigerated part 42	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
FTIR sleeve non-refrigerated part 44	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
FTIR sleeve support bracket	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
FTIR sleeve non-refrigerated part 50	300	0.9	1.08×10^{-4}	8.24×10^{-5}	8.77×10^{-5}
FTIR cold stop	62	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}
FTIR L4 edge	80	0.1	1.94×10^{-5}	5.53×10^{-4}	1.07×10^{-5}

Table 5. Thermal radiation of the 8-10 m and the FTIR systems

System	Internal thermal radiation (W)	Solar radiation (W)	SLR
The 8-10 m system			
Uncooled	5.49×10^{-4}	9.5×10^{-1}	2.83×10^{-4}
Cooled	2.43×10^{-7}	9.5×10^{-1}	2.83×10^{-4}

System	Internal thermal radiation (W)	Solar radiation (W)	SLR
The FTIR system			
Uncooled	6.99×10^{-4}	6.77×10^{-3}	1.54×10^{-4}
Cooled	2.16×10^{-7}	6.77×10^{-3}	1.54×10^{-4}

Fig. 7. SLR curves of both infrared systems under different ambient temperatures and different material emissivities at 300 K.

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5. Conclusion

In this study, we systematically analyze the stray light in the AIMS telescope, focusing on the visible system, 8-10 m infrared system, and FTIR spectrometer system. By establishing a 3D model with the ASAP software, using the Monte Carlo ray-tracing method, we evaluate the SLR considering both thermal and non-thermal radiation.

For the infrared system, with the same coating reflectivity and transmittance as the visible system, the SLR is lower by 80%, meaning that the coating is very important in an infrared system to suppress non-thermal stray light. For the 8-10 m system, the internal thermal radiation is reduced by 2.3 orders of magnitude when the system is cooled to 100 K. For the FTIR system, when the imaging mirror, the aperture stop, and field stop are cooled to 80 K, 62 K, and 80 K, respectively, the internal thermal radiation reduces by 2.5 orders of magnitude.

Additionally, the influence of the ambient temperature on the stray light is limited. The SLR is 9.31×10^{-6} for the visible system, 2.83×10^{-4} for the 8-10 m system, and 1.54×10^{-4} for the FTIR spectrometer system. Our results show that the opto-mechanical system design of the AIMS telescope can effectively suppress stray light, which is beneficial for both imaging and magnetic field observations.

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AI Disclosure Statement

The authors utilized AI tools for both literature research and English writing/revision, as detailed below:

Literature review: The AI tools Kimi and Deepseek were used to assist in retrieving, organizing, and analyzing relevant scientific literature.

English language support: Deepseek was employed for language and grammar checks within the article. The authors carefully reviewed, edited, and revised the Deepseek-generated texts to their own preferences, assuming ultimate responsibility for the content of the publication.

The AI tools functioned as auxiliary resources, and the authors retain full responsibility for all content, data, and conclusions presented in the manuscript.

Author Contributions

Biyuan Gao was responsible for conducting the research and writing the paper. Dongguang Wang and Yingzi Sun provided professional guidance throughout the research process. Junfeng Hou contributed the core ideas for the study. Yuliang Shen offered crucial technical support in the field of optics with his expertise. Xiao Yang provided guidance on paper writing. All authors read and approved the final manuscript.

Declaration of Interests

The authors declare no competing interests.

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Note: Figure translations are in progress. See original paper for figures.