Available online at www.sciencedirect.com
ScienceDirect
Optik 121 (2010) 1688–1692
Optik Optics
www.elsevier.de/ijleo

Analysis of space off-axis and performance of Cassegrain optical antenna system ☆

Kai Huang[a,*], Huajun Yang[a], Tuohui Li[a], Chenghong Li[a], Quan Xu[b], Kang Xie[b]

[a]*College of Physical Electronics, University of Electronic Science and Technology of China, Chengdu 610054, China*
[b]*College of Optoelectronic Information, University of Electronic Science and Technology of China, Chengdu 610054, China*

Received 1 December 2008; accepted 30 March 2009

Abstract

The research of optical antenna is of greatest importance in the field of modern optical communication. For optical antenna, alignment of optical system is a significant factor, which influences the transmission quality of optical antenna system. Antenna off-axis is one of the important factors influencing the transmission quality of optical antenna system. In this paper, we analyze and numerically simulate how power attenuation ratio and gain of Cassegrain antenna vary with the antenna deflection angle and the distance that the central axis of receiving antenna deviates from z-axis, when space off-axis happens to the system. Finally, the coupling efficiency of Cassegrain antenna is tested experimentally, and the results show that the coupling efficiency of the Cassegrain antenna dramatically reduces in the case of off-axis. These studies provide a theoretical basis for optical antenna system to achieve accurate alignment in optical communication.

Keywords: Cassegrain optical antenna; Off-axis; Deflection angle; Power attenuation ratio

1. Introduction

With the constant development of optical communication technology and optical devices, Fiber optics and satellite communications develop faster and faster, which play an important role in the rapid transmission of information [1,2]. Then the design of accurate optical antenna system is more stringently required, however, these systems are designed where the axes are all in alignment. If any subsystem axis of optical platform system, including collimation subsystem axis, transmission optics subsystem axis, and optical antenna subsystem axis, misaligns with the rest, power and gain attenuation will happen [3,4]. Based on the power attenuation ratio of antenna system varying with antenna deflection angle, this paper analyzes the antenna space off-axis performance of Cassegrain optical antenna system, and the corresponding coupling efficiency data of antenna system are adopted by specific experimental tests. These studies will have broad application prospects in the field of optical communication [5,6].

2. Modeling on antenna space off-axis theory of optical antenna system

Off-axis of optical antenna means that the optical axes of transmitting antenna and receiving antenna are

☆Project supported by NSFC: 60588502.
*Corresponding author.
E-mail address: huangkai@uestc.edu.cn (K. Huang).

0030-4026/$ - see front matter © 2009 Elsevier GmbH. All rights reserved.
doi:10.1016/j.ijleo.2009.03.017

out of alignment. Off-axis of optical antenna is the main cause of declining in the power of antenna system. Aiming at this instance, this paper discusses how the power attenuation ratio of antenna system varies with space off-axis angle. For the convenience of discussion, two Cassegrain antennas are out of alignment and the optical axes of the rest subsystems are in alignment is supposed. As shown in Fig. 1, the antenna total deflection angle on x-axis and y-axis is γ, and the distance that the central axis of receiving antennas deviates from z-axis is h.

As shown in Fig. 1, the primary mirror aperture of transmitting antenna and receiving antenna is $2a$, and the secondary mirror aperture is $2b$. The distance from entrance to primary mirror of receiving antenna is l, and the aperture of reference plane is R. According to the light straight-line propagation rule through homogeneous medium, the ratio of receiving antenna power p_r to transmitting antenna power p (power attenuation

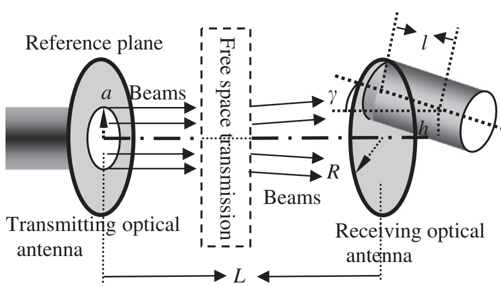

Fig. 1. Schematic diagram of off-axis optical antenna system.

ratio p_r/p) should be the ratio of receiving spot area to transmitting spot area. When the distance L between transmitting antenna and receiving antenna is quite short, the barrier hole which is shaded by transmitting antenna and receiving antenna will appear [3]. Supposing laser distribution on cross-section is uniform, according to different deflection angles, each case can be analyzed as follows.

(1) When $\gamma \geqslant \arcsin[(a+a\cos\gamma - h)/l]$, the transmission power of antenna system is zero.
(2) When $\arcsin[(a+b\cos\gamma - h)/l] \leqslant \gamma$, and $\gamma < \arcsin[(a+a\cos\gamma - h)/l]$, according to the area integral theorem, the receiving spot area of receiving antenna is

$$A_1 = a^2 \arcsin\left(\frac{x_1}{a}\right) - y_1 x_1 + \frac{\pi}{2} h_1 a + h_1 a\left[p_1\sqrt{h_1^2 - p_1^2}/h_1^2 + \arcsin(p_1/h_1)\right] \quad (1)$$

As shown in Fig. 2(a), the power attenuation ratio of antenna system is

$$p_r/p = \frac{A_1}{\pi(a^2 - b^2)}, \quad (2)$$

where $y_1 = m/(\cos\gamma + 1)$, $m = l\sin\gamma + h$, $x_1 = \sqrt{a^2 - y_1^2}$, $p_1 = y_1 - m$, $h_1 = a\cos\gamma$.

According to the theory above, the receiving spots and power attenuation ratio should be obtained by the same token in the following cases.

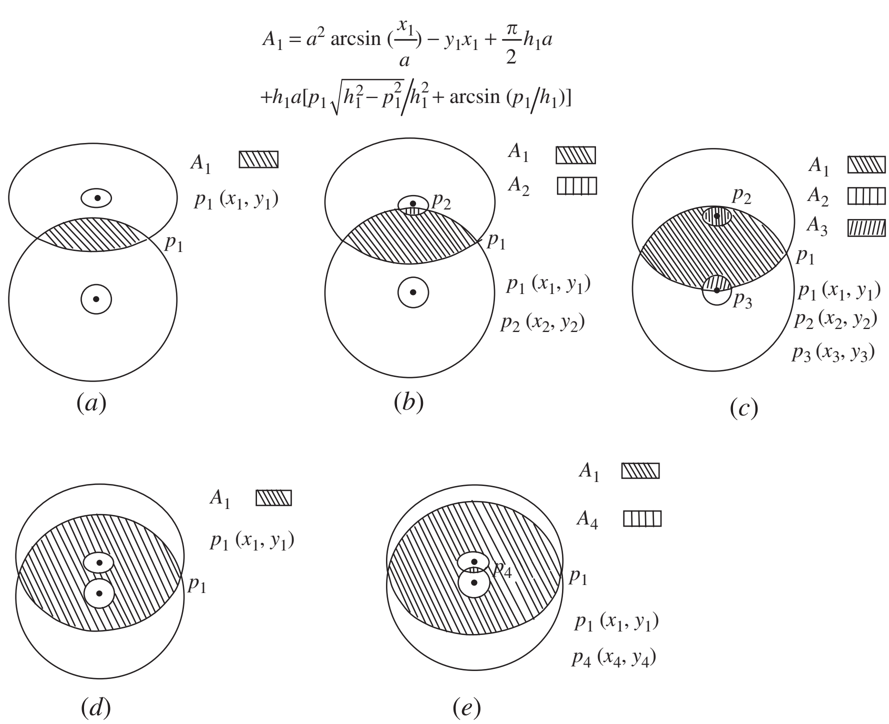

Fig. 2. The receiving spot of antenna.