Proc. International Conference on Space Optical Systems and Applications (ICSOS) 2012, 6-4, Ajaccio, Corsica, France, October 9-12 (2012)

Space Laser Communication Network

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***Abstract*—With the number of satellite cluster, space station and planet detector is sharply increasing, the next challenge we face is to set up space laser communication network.However, it is not only difficult but also cumbersome to use point-to-point laser communication terminal as a data node terminal antenna. The characteristics of rotational paraboloid is that light beam incident from any direction to the parabolic focus will reflect on surface of parabolic,the beam propagation direction is parallel to the symmetry axis of paraboloid ,this structure of optical antenna to overcome constraint of ATP subsystem,when multiple platforms communicate with each other at same time. In this paper we designed an antenna which can meet demand that at least two terminals communicate to it , and next work is we make rotational paraboloid improvement according to space platform orientation.**

***Index Terms*—Space laser communication;optical antenna; network; rotational paraboloid**

I. INTRODUCTION

Free space laser communication has many unique advantages, such as high bit rate, large capacity, anti-interference, anti-interception, boost light weight, and attracts ever increasing attention[1].With the number of satellite cluster, space station and planet detector is sharply increasing , there is an urgent need to build space laser communication network, Laser communication network is extremely difficult because the characteristics of the laser.If segment host want to achieve multi-point to communicate with other terminals , in accordance with the current terminal structure, platform need multiple optical antennas and multiple ATP structures , it is not a good way in the space missions.

Rotational paraboloid is a special optical components, it widely used in the panoramic camera[2], we can take it advantage to design a multi-point optical communications antenna.

II. OPTICAL PROPERTIES OF ROTATING PARABOLIC

People often use rotational paraboloid in difference areas , if a light source placed at the paraboloid focus, we will receive parallel light. As shown in the Figure.1,optical line FP emitted from the focus F will reflect at the point P, PL is the reflected light ,and its direction is parallel to the X-axis.In contrast with this, we used the outside surface of the paraboloid, KP is the incident optical line to the focus F, NP is the reverse extending line of PL.Therefore, we must demonstrate that NP is the reflected light of KP at point P.

From Fig.1we know that :

$$\angle MPL = \angle NPJ$$
$$\angle JPF = \angle KPM$$
$$\theta = \angle NPF = \angle NPJ + \angle JPF =$$
$$\angle KPL = \angle KPM + \angle MPL$$

assuming parabolic curve equation, where is a point on the parabola, then. $C: y^2 = 4cx$, the tangent through point p is:

$$L: y_0 y = 2p(x + x_0) \Rightarrow 2px - y_0 y + 2px_0 = 0$$

and the intersection of line L and X-axis is $J(-x_0, 0)$, while $|PF| = \sqrt{(x_0 - c)^2} = |x_0 + c|$ and $|FJ| = |x_0 + c|$, so $|PF| = |FJ|$, $\angle JPF = \angle MPL$

we proved that incident light from any direction to focus when the reflected light at the outer surface of paraboloid will parallel the optical axis of rotational paraboloid, so we can design optical antenna according to this conclusion.

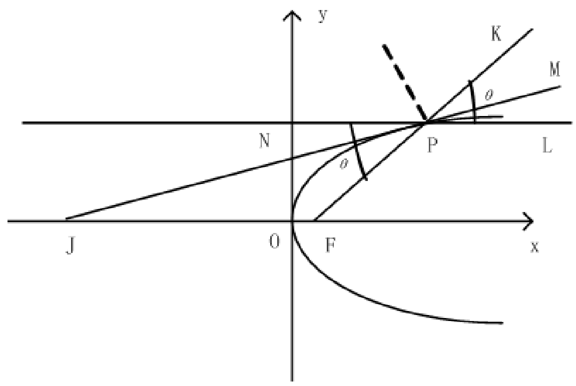

Fig. 1. Parabolic optical principle diagram

III. PARABOLIC OPTIMIZED AND MIRROR SPLICING

We known that characteristic of the paraboloid from section II, however,the actual beam is divergent after reflection which is extremely negative for laser communications,as Fig.2.

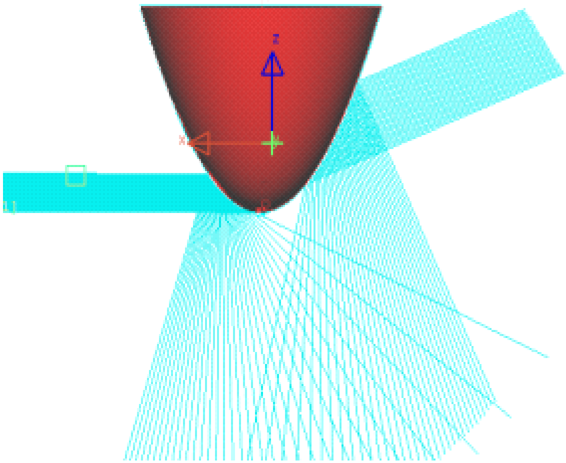

Fig. 2. Ray tracing of the parabolic

Therefore, the edge surface of the parabolic must be optimized,the most reasonable approach is to use stitching multi-mirror to approximate the shape of the parabolic, of course, the more mirrors and the smaller the area of each unit, the surface is approximation with the original based on the integration principle.In fact, for the laser network, we can determine the number of stitching mirrors, and each mirror size according to the the other terminal,Splicing method was shown in Fig.3.Each mirror has a control unit, it can be controlled by the servomechanism so as to ensure that the beam parallel to the optical axis[3].

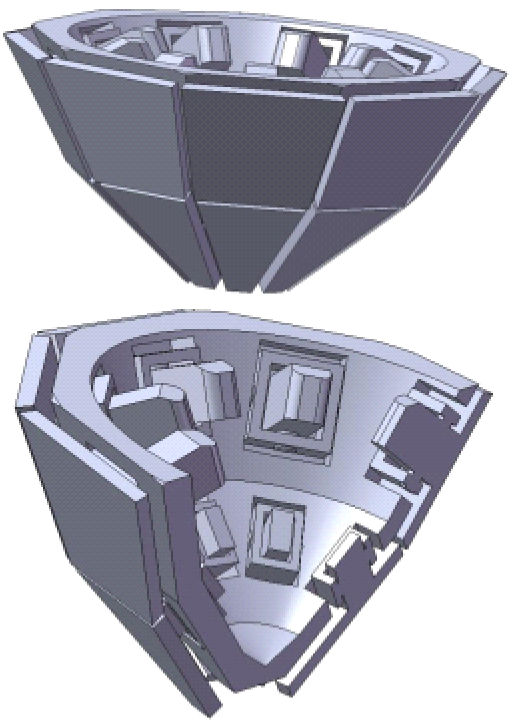

Fig. 3. Mirror splicing

IV. ANTENNA STRUCTURE

Multi-point laser communication terminal consists of two parts, as shown in Fig.4, the front-end a splicing paraboloid and relay Cassegrain optical system.Laser beam from different directions reflect on the parabolic , the reflected beam will be parallel to the optical axis, then beam incident into the relay optical system. Since the optical beam aperture from the rotational paraboloid multi-mirrors is large, so relay optical system needs to be designed . The reflecting structure can be adopted to avoid chromatic aberrations derived from multi wavebands. The proposed relay system adopts the Cassegrain structure, as shown in Fig.5[4]. This ensures the structure having high optical quality, and effectively reduce the volume. As the Cassegrain system has a central obscuration, and there is also some blind area in the transceiver optical antenna center, match has to be ensured and reduce energy loss.

Communication light from different terminals wavelength respectively are λ_1 , λ_2 , λ_3 , λ_4 .Thus the detector determine terminal position based on the received signal wavelength, and according to the ephemeris or GPS positioning tool.

When transmitted signal the laser fiber the injection shot side by the motor control, it can move to achieve the emission field of view the choice of focal plane position in the emission optical system, thus avoiding the launch of the full field different emission beam directly superimposed to form a stray light affect the communication performance.

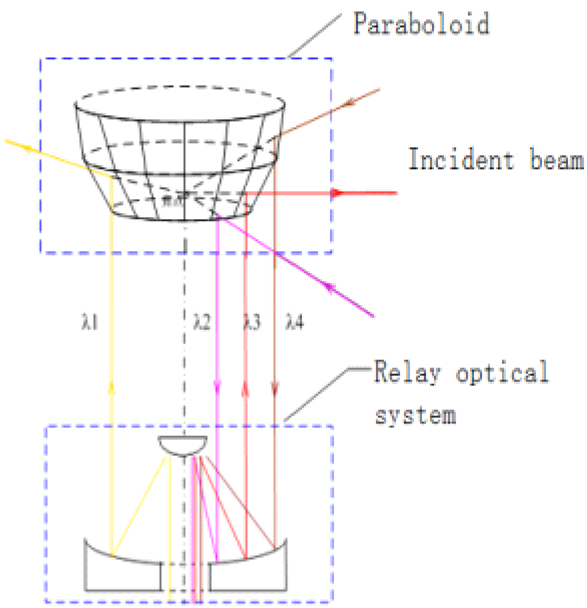

Fig. 4. multi-point laser communication device

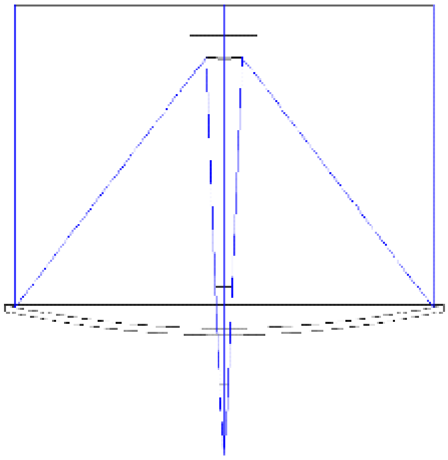

Fig. 5. Relay optical system

Three-dimensional structure of the multi-point communications antenna system is as follows, Fig.6.

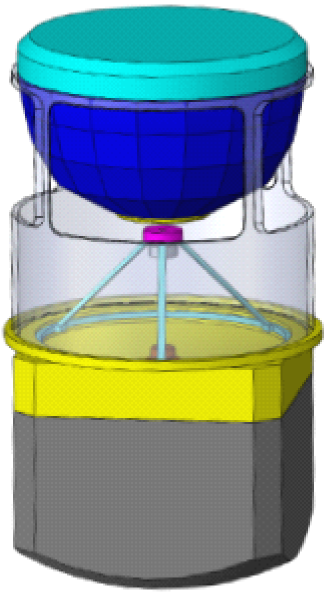

Fig. 6. Three-dimensional structure

V. CONCLUSION

The next development stage of space laser communications must be changed from point-to-point model to network model ,as internet. However , it is a great challenge to build free space laser communication network, in this paper,according to the characteristic of the paraboloid, we designed a kind of optical antenna for multiple points bi-directional laser communications based on splicing mirrors. This antenna breakthrough the structural limitations of the conventional antenna, so it can be applied in space laser communication network as a node terminal.

ACKNOWLEDGMENT

This work is supported by the major national science and technology projects.

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