Beam focusing of a laser guide star

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ABSTRACT

It is foreseen that Extremly Large Telescope (ELT) will include Adaptive Optics Systems to provide diffraction-limited images in the near infrared. The preliminary atmospheric turbulence properties which affects laser guide star (LGS) generation are presented following. The results of modern model developed in optical communication through atmosphere is used to evaluate LGS size for many different atmospheric situation, with the turbulence intensity concentrate to different heights. This introduce the focusing problem and requirements above the observatory where the adaptive optics system with a reference source will be installed. To focus a laser in the mesosphere is impossible in a generic place. In high altitude observatories this is factable, like in canarian ones. We took 6 experimental turbulence profiles to evaluate the beam radius versus altitude. A mean value of 0.2 m is found for the diameter of mesospheric volume illuminated by the laser. This is small enough to create an useful LGS for adaptive optics purposes.

Keywords: laser guide star size, laser propagation, atmospheric turbulence, canarian observatories

1. INTRODUCTION

The idea of generating a Laser Guide Star (LGS) was first proposed by Foy in 1985. Since then, many groups have undertaken the task of implementing LGS systems applicable for adaptive optics in astronomical observatories. In the adaptive optics systems the size of laser beacon at the mesosphere is an important parameter to get the best reference source. The fundamental principle of LGS creation is exciting with a laser beam the mesospheric sodium layer to get a backscattered signal returned which tests the turbulence atmosphere to apply a correction of the astronomical image.
As part of preliminary studies for LGS design at European Northen Observatory (ENO), we are developing a study of the atmospheric turbulence properties in the generation of the reference source. The size of the LGS is basically determined by the properties of the sodium layer and the geometry of the laser beam. In this paper, an analysis of the results of LGS size above this observatories has been done, specially focusing our attention in the different turbulence effects in LGS generation. The diameter of the beam at the mesosphere should be as small as possible in order to get a point-like source. For this purpose, a beam expander has to be used in the instrumental arrangement in order to focus the waist of the source beacon in the centre of the sodium layer. In this way, the power return is optimised and the shape of the LGS is more useful for wavefront corrections techniques.

In section 2, we define the focusing problem in laser guide star, in connection with the sodium layer properties and the beam geometry. In section 3, effects of sporadic layers are considered. These kind of events have been observed in the routinary observations overtaken at Teide Observatory for our group. We determine the LGS size for different sporadic layer geometry and with laser beam propagation in vacuum conditions. In the following section, to solve this problem when the laser goes through a turbulent media, we apply the theoretical model of Andrews[1] which provide us of a method to calculate the effective beam radius. In section 5, with experimental measurements of turbulence above canarian observatories, the radius profile of a LGS is evaluated. There are not many datum of C_n^2 and it does not represent a meaningful statistical study of the observatory, but it is enough to present the focusing problem described in this paper. The quality of the image taken with an adaptive optics system depends on characteristics of the atmosphere. In site-testing campaigns for ELT is important to elaborate a systematic study of the turbulence, this parameter is important to know if a laser could be focused above this site and the quality of the reference guide star.

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