FP7-OPTICON PSF reconstruction meeting, Marseille 29-30 January 14

Welcome and introduction

Thierry Fusco
ONERA/LAM

PSF estimation in astronomy

Paulo Garcia
SIM – Universidade do Porto

This talk focus PSF estimation for fields larger than the isoplanatic patch. Extreme adaptive optics and coronography are not addressed. We will start by highlighting the importance of the PSF estimation in astronomy. The requirements on PSF of coming and planned instrumentation will be also addressed. Then, the main packages used by astronomers for PSF estimation will be introduced -- for non-AO and AO data. We will mainly focus the methods, which are generally model fitting of science channel data. Then, we will review the work on PSF reconstruction for AO. In contrast, it relies strongly on AO telemetry. An attempt will be made to compare both methods, highlighting their advantages and limitations, to derive some synergies for future developments.

PSF estimation and galaxy morphology

Marc Huertas
GEPI

WFAO on ELTs will allow to obtain deep and high resolution snapshots of the universe over wide areas. This is particularly interesting for galaxy evolution studies and in particular for galaxy morphology. In my talk, I will review the requirements on the PSF estimation to study galaxy structural parameters at different redshifts based on existing works using ground and space based data.

PSF estimation and parametric modelling from scientific data

Laura Schreiber
INAF

Adaptive Optics has become a key technology for all the main existing telescopes and is considered a kind of enabling technology for future giant telescopes.

The amount of data produced by existing AO instrumentation is rapidly increasing and the exceptional advancement in AO technology and observational capability should be followed by a comparable advancement in the development of data analysis methods.
Almost all the methods for the extraction of high-precision quantitative information from the astronomical data require an accurate knowledge of the system PSF. AO data are however characterized by a structured and complex PSF, often significantly varying in space and time. Two different approaches to face this problem can be found in literature: the PSF can be extracted from the astronomical data or it can be estimated using data from the AO system itself (the PSF reconstruction method). Both the methods present advantages and disadvantages depending on the scientific goal and on the astronomical data characteristics.
We present a brief overview of the present status of the research in AO PSF estimation, focusing in particular on the efforts in PSF extraction from data.

PSFr @ Keck

Laurent Jolissaint
University of Applied Sciences Western Switzerland

Since 2009 we have started a PSF-R campaign on the WM Keck telescopes and Gemini telescopes. Our ultimate objective is PSF-R for laser systems, but we decided to start first with the easier case of natural GS. We have learned a lot, in particular about the strong influence of static aberrations and a few other calibration issues. Our PSF-R method for faint NGS is now mature and is getting implemented on the WM Keck AO system for use by astronomers, and time is ripe to start looking at the LGS case. We will present our conclusions on the NGS, the issues with the static aberrations, and our plans for the LGS case.

PSF reconstruction for the MUSE-Galacsi GLAO mode. Concept, validation in simulation and on sky-tests using Gems

Thierry Fusco
ONERA/LAM

The purpose of this work is then the estimation of the AO response in the particular case of the MUSE /GALACSI instrument (a 3D multi-object spectrograph combined with a Laser-assisted wide field AO system which will be installed at the VLT in 2013-2014). Using telemetry data coming from both AO Laser and natural guide stars, a Point Spread Function (PSF) is derived at any location of the FoV and for every wavelength of the MUSE spectrograph.
The reconstructed PSF accuracy is demonstrated using full and to end simulations but also thanks to on-sky results obtained on Gems (working in a GLAO mode).
We demonstrate, in the two cases, that the concept, the various approximation and thus the final algorithm fulfils the original specifications derived from astrophysical needs.

PSFr GLAO @ CFHT

Olivier Lai
Subaru Telescope/Gemini Observatory

Mauna Kea is reputed to have good free atmosphere seeing and is therefore an ideal site for wide field adaptive optics. There are currently two GLAO projects under way on Mauna Kea: the Imaka demonstrator/prototype at the IfA for the UH88" and the ULTIMATE-Subaru project. After a brief review of the ground layer measurement campaigns, I will describe an analytical model of GLAO PSFs based on power spectral density; this may be useful to provide first order estimates of the PSF based on telemetry data. However there are discrepancies between this simplified model and the instant_GLAO Monte Carlo simulation tool I have developed, which includes many second order effects (such as DM tilt, non-Kolmogorov ground layer, partial correction of the FA, etc) that will be difficult to include if a high accuracy PSF is required over the entire field.

A novel maximum likelihood approach for psf reconstruction

Damien Gratadour
LESIA, Obs. Paris

In this paper we present a new method for psf reconstruction from ao telemetry data based on a maximum likelihood (ml) approach. the ml estimator is built according to a model of shack-hartmann measurements covariance. in this model a number of components cannot be estimated with telemetry data only and require a number of statistical assumptions on the turbulence and the ao system behaviour that can lead to an inaccurate reconstruction. we will give a full description of the method and address the recurring issue of estimating these cross-terms using a new approach, based on a simple model of the AO system temporal evolution.

PSF reconstruction for LGS-assisted MCAO

Carlos Correia[1], Luc Gilles[2]
[1]- Centre for Astrophysics, University of Porto
[2] - Thirty Meter Telescope

We describe a new simulation model based PSF reconstruction technique for LGS-assisted MCAO systems. First results in SCAO mode reported using GeMS.

Fast approximations of shift-variant blur

Loic Denis
Université St. Etienne

Image deblurring is an essential step to reach high angular resolutions in astronomy. Shift-invariant blur is fully characterized by a single point-spread-function (PSF). Blurring is modeled by a convolution, leading to efficient algorithms for blur simulation and removal that rely on fast Fourier transforms. In many different contexts, blur cannot be considered constant throughout the field-of-view. It is then necessary to model variations of the PSF with the location. These models must trade off the accuracy that can be reached thanks to their flexibility and the computational efficiency.

Several fast approximations of blur have been proposed in the literature. I will review them in the light of matrix decompositions of the blurring operator. This will help establish the connection between computational tricks and the corresponding approximations expressed in terms of equivalent PSF. I will describe a new approximation that keeps the same desirable low complexity but offers an optimal approximation error.

Cn^2 profile estimation with GeMS

Benoît Neichel
Laboratoire d'Astrophysique de Marseille

We describe the data pre-processing and reduction methods together with SLOpe Detection And Ranging (SLODAR) analysis and wind profiling techniques for the Gemini South Multi-Conjugate Adaptive Optics System (GeMS).
The wavefront gradient measurements of the five GeMS Shack–Hartmann sensors, each pointing to a laser guide star, are combined with the deformable mirror (DM) commands sent to two DMs optically conjugated at 0 and 9 km in order to reconstruct pseudo-open loop slopes.
These pseudo-open loop slopes are then used to reconstruct atmospheric turbulence profiles, based on the SLODAR and wind-profiling methods. We introduce the SLODAR method, and how it has been adapted to work in a closed-loop, multi-laser guide star system. We show that our method allows characterizing the turbulence of up to 16 layers for altitudes spanning from 0 to 19 km. The data pre-processing and reduction methods are described, and results obtained from observations are presented. The wind profiling analysis is shown to be a powerful technique not only for characterizing the turbulence intensity, wind direction and speed, but also as it can provide a verification tool for SLODAR results. Finally, problems such as the fratricide effect in multiple laser systems due to Rayleigh scattering, centroid gain variations, dome seeing and limitations of the method are also addressed.

Atmospheric optical turbulence profiling towards extremely large telescope scales

James Osborn
Durham University

I will review current standards in atmospheric optical turbulence profiling and outline potential problems and solutions as we extrapolate towards ELT scales. I will also discuss recent results from Stereo-SCIDAR, a modified SCIDAR system capable of significantly higher altitude resolution and sensitivity.

Measurement of Atmospheric Turbulence Parameters and Implications on HAR techniques

Aziz Ziad
Laboratoire J.L. Lagrange-UMR 7293,
Université de Nice Sophia-Antipolis, CNRS, OCA,
06108 Nice, France

A new generation of instruments for measurement of atmospheric turbulence parameters (ATP), particularly the C_N^2 profile with high altitude resolution, will be presented. Statistics & results of these ATP parameters will be also presented and their pertinence & implications in regards of HAR techniques will be discussed.

A Cn2 Profiler for the AOF

Aurea Garcia-Rissmann
European Southern Observartory

Telemetry data can provide a vast source of diagnostics for adaptive optics systems. It allows a real-time and/or posterior evaluation of the system performance and a glimpse on the nature of the turbulence in the observing site. Tools have been under development in the context of the Adaptive Optics Facility (AOF) to allow an efficient testing of important parameters for its sub-systems. One of these tools consists of a Cn2 profiler that uses the slopes and commands retrieved by SPARTA to reconstruct the turbulence distribution in altitude, an important input for some PSF reconstruction algorithms. The specific algorithm to be used with AOF has been adapted from the code originally developed by a collaboration between PUC (Santiago) and Gemini for the GeMS geometry. I describe in this talk the extensive list of tests carried out through Octopus simulations to assess the sensitivity and limitations of the code applied to AOF.

Cn² estimation @ ONERA

Clélia Robert/Jean-Marc Conan
ONERA

We will present the improved CO-SLIDAR reconstruction method of the Cn2 profile and the first on-sky results. The estimated profiles demonstrate the accuracy of the method, showing sensitivity to low and high altitude layers. These profiles compare to turbulence profiles estimated from meteorological data. Beside, a CO-SLIDAR profiler to measure the horizontal turbulence spatial distribution is calibrated during a multi-instruments campaign using scintillometry.

Status and plans of Canary

Eric Gendron
LESIA – Observatoire de Paris

Canary is a demonstrator of MOAO installed on the 4.2m WHT telescope in La Palma. Canary is using an open-loop control for the DM, and uses 7 wavefront sensors (WFS) for the tomographic control, 4 of them being raleigh laser guide stars WFSs. Canary has demonstrated sucessful on-sky operation as soon as 2010, and a review of the results will be presented. In order to perform well, Canary has developped a number of algorithms for identifying turbulence and instrument models, and particular methods that will also be presented. A presentation of the current status and future plans will also be drawn.

On-sky LQG control with vibration mitigation on Canary MOAO pathfinder: performance, stability margins and robustness to priors mismatch

Jean-Marc Conan[1], Henri-François Raynaud[2]
[1] – ONERA, [2] – IOGS

We will present the performance obtained on-sky with full LQG control (on all modes) on Canary during the 2012 and 2013 runs. We demonstrate the efficiency of vibration identification and rejection, and we quantify the stability margins. Robustness to priors mismatch is analyzed (Cn2, wind norm, noise levels), and means to improve performance (use of wind direction...) and associated calibration issues are discussed.

Status of the Raven science and technology demonstrator

Carlos Correia
Centre for Astrophysics, University of Porto

Raven is the first MOAO science and technology demonstrator to be installed on a 8m (Subaru telescope). We present the general status and options taken to perform atmospheric tomography and overall system calibration.