Scientific Report

First name / Family name	Fabio Corrente
Nationality	Italian
Name of the *Host Organisation*	Univesidad Politécnica de Madrid
First Name / family name of the *Scientific Coordinator*	Pablo Benítez
Period of the fellowship	01/03/2012 to 28/02/2013

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

The scientific activity of this fellowship at CeDInt – UPM can be split in three parts: a first training during which Simultaneous Multiple Surfaces (SMS) design method was studied together with software tools, both commercial and internal. A second part focused on the aberration theory of the SMS design and improving a previous work based on functional analysis. The third part was used to write code to analyze selected SMS designs, to test the hypothesis done in the previous part and correcting the model. Geometric Optics is that part of Optics describing the behaviour of light in the limit of small wavelengths and it is used to design optical systems. Lens system design is a complex engineering task, which cannot be achieved by an analytical approach except for some simple cases: to design a device giving sharp images it is needed to vanish or minimize its aberrations, "the defects" of the device, and for this task several combinations of lenses are needed. Classic imaging design methods depend heavily on multi-parametric optimization techniques. The SMS method is a direct-design method of optical systems, both in two-dimensions (rotational optics) and three-dimensions (free-form optics), it provides an effective way of reducing the total number of parameters, thus avoiding the appearance of many undesired local minimums and it permits to design directly up to four aspherical surfaces using meridional and skew ray bundles and in this case we speak, for example, of SMS 1M2S if we used one meridional and two skew ray bundles to design the system. From a mathematical point of view an SMS system is designed imposing the wave aberration functions vanishes for certain set of rays. The analyzed designs are 2M, 3M, 4M and 1M2S. Starting from some general hypothesis and considerations on the functional form the functional expression of the wave aberration functions were written and tested. For the first analyzed designs some corrections were needed but this was helpful to write faster the wave aberration functions of the others. Connection with aberration theory was studied and during this part of the work a new and simpler notation was introduced. In particular this notation has the advantage that does not require complicate restrictions on the power of the used variables. Then these expressions were tested in several ways, first of all discrepancies plots and chi squared evaluation and also this step was useful to improve the expression of the wave aberration function for several designs. The definitive expression of the wave aberration function of an SMS3M design was used to study the optimization process of a selected design resulting very useful to make prediction and to plot the RMS spot diameter as function of the field of view. Currently some SMS designs are being tested to to improve the accuracy of their wave aberration functions. Finally, since the tasks associated to the study and analysis of the SMS aberrations have taken longer and deeper than expected, the planned development of an algorithm of the SMS 3D designs has not been carried out during this training.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

"A mathematical approach to aberrations in SMS-3M designed systems"
Fabio Corrente; Pablo Benítez; Wang Lin; Juan Carlos Miñano and Fernando Muñoz
- Submitted to Optics Express.

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Abstract

Initially born to Nonimaging Optics application the Simultaneous Multiple Surface (SMS) is now also applied to Imaging Optics. It has been found that the SMS aberrations can be analyzed with a small set of parameters, often three. The connection of this model with conventional aberration expansion is also presented. To verify this mathematical model an SMS design system the data of ray tracing were analyzed also by studying the quadratic average error and the discrepancy errors. Moreover the evolution of the coefficients during the optimization process were studied and the RMS spot dimensions was calculated both before and after the optimization process. There is very good agreement in alla the tests between the model and the data.

"SMS design and aberrations theory"

Fabio Corrente; Pablo Benítez; Wang Lin; Juan Carlos Miñano and Fernando Muñoz, Proc. SPIE 8550, Optical Systems Design 2012, 855010 (December 18, 2012) Accepted

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Abstract

The SMS, Simultaneous Multiple Surfaces, design was born to Nonimaging Optics applications and is now being applied also to Imaging Optics. In this paper the wave aberration function of a selected SMS design is studied. It has been found the SMS aberrations can be analyzed with a little set of parameters, sometimes two. The connection of this model with the conventional aberration expansion is also presented. To verify these mathematical model two SMS design systems were raytraced and the data were analyzed with a classical statistical methods: the plot of discrepancies and the quadratic average error. Both the tests show very good agreement with the model for our systems.

III – ATTENDED SEMINARS, WORKSHOPS, CONFERENCES

- SMETHODS training session of Domain 2, Nonimaging Optics, from 18 to 22 of April 2012 in Madrid.

- SPIE Optical Systems Design | Latest Technological Advances in Optical Design and Engineering 26 - 29 November 2012 CCIB - Centre Convencions Internacional Barcelona, Barcelona, Spain

IV – RESEARCH EXCHANGE PROGRAMME (REP)

Isaac Newton Group of Telescopes, United Kingdom, Telescope & Instrument Engineering, Diego Cano. From 14/10/2012 to 18/10/2012

Thanks to this visiting period I could get in touch with typical problematic of large scientific instruments, I learned about experimental problems of measurement instrument and their solutions. Moreover I made a presentation of great interest for the hosting team about SMS free form design of illumination system.

Vrije Universiteit Brussel, Belgium, Brussels Photonics Team (B-PHOT) TONA, Youri Meuret. From 05/11/2012 to 09/11/2012.

I visited a team with several contact with my hosting group in Madrid. In particular I worked with a Ph.D. student to write a script to obtain the data I needed to investigate the SMS design I was studying. Also in this case I made a presentation of my research with a more mathematical approach compared to the precedent one.