EUROPEAN INTERFEROMETRY INITIATIVE*

Eric J. Bakker
Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands
bakker@strw.leidenuniv.nl

Alain Chelli
LAOG, BP-53 F-38041 Grenoble, Cedex 9, France
chelli@obs.ujf-grenoble.fr

Andreas Quirrenbach
Leiden Observatory, P.O. Box 9513, 2300 RA Leiden, The Netherlands
quirrenb@strw.leidenuniv.nl

Paulo Garcia
Centro de Astrofsica da Universidade do Porto, P.O. Box 4150- 4150-762, Porto, Portugal
pgarcia@astro.up.pt

Thomas Henning
Max-Planck-Institut für Astronomie Königstuhl 17, D-69117 Heidelberg, Germany
henning@mpia.de

Abstract Scientists active in the field of optical interferometry in Europe have created a vehicle called the **E**uropean **I**nterferometry **I**nitiative (EII) in order to bring optical interferometry into mainstream astronomy and to prepare for the next generation of an interferometric infrastructure.

A description is presented on how the EII is structured and how the funding has been secured through OPTICON. Two funded activities are in progress. A joint research project which has well defined deliverables among which are concept studies for the next generation VLTI instruments, fringe sensing algorithms and techniques, and data

*paper has appeared in the proceedings of the JENAM conference of 2004 (Granada, Spain)

analysis software. The second funded activity is networking, which has the objectives to foster interaction among astronomers and to develop a forward look on the next generation of optical interferometers. A Marie Curie proposal is described which contains a plan to organize data reduction schools, thematic schools on an astrophysical topic, and publish a text book on optical interferometry.

Keywords: Optical, infrared, interferometry, Very Large Telescope Interferometer, DARWIN, instrumentation, software, schools, education

1. Introduction

Optical interferometry for astronomy has been developed at a relative small number of places in Europe and has resulted in amongst others the VLTI, GI2T, and COAST. Technology and reliability of operations has now reached a level that an optical interferometer is available as a facility instrument (VLTI/MIDI and VLTI/AMBER) allowing non-specialists to conduct science with an optical interferometer. It could be argued that optical interferometry has reached maturity and has entered a new era. By reaching out to the astronomical community at large the fraction of astronomers involved in optical interferometry is expected to grow considerably in the coming years. Those involved in instrument building at this stage are anticipating this change and are making an additional effort to bring optical interferometry into main stream astronomy through a collaborative effort called the "European Interferometry Initiative".

2. European interferometry initiative

Scientists active in the field of optical interferometry in Europe have created a vehicle called the **E**uropean **I**nterferometry **I**nitiative (EII) to bring optical interferometry into mainstream astronomy and to prepare for the next interferometric infrastructure. To achieve these objectives the European Interferometry Initiative intend to:

1 Facilitate communications and collaborations between European scientists and institutes working on optical long-baseline interferometry for astronomy;

2 Exploit synergy within Europe in order to produce world leading science in the field of optical long-baseline interferometry;

3 Work towards integration of educational activities on an European scale, both for professional astronomers and at the graduate level, through workshops and symposia;

4 Work towards developing a European vision for the long-term future of optical long-baseline interferometry.

Additional information on the activities of the EII can be found at http://www.strw.leidenuniv.nl/~eurinterf

Organizational structure

The European Interferometry Initiative has two funded activities: the Joint Research Activity (JRA) and the Network Activity (NA). Both are funded under the 6^{th} framework project OPTICON. A third activity, the Marie Curie Action (MC) yet remains unfunded. These three activities are linked through the common EII science council and EII extended board. According to article 6 of the EII Memorandum of Understanding (MoU) the responsibilities of the science council (EII_SC) are (see also Fig. 1 and Table 1):

1 To define the general strategy and scientific orientation of EII activities;

2 To initiate subsidiary activities consistent with the mission statements;

3 To accept or reject any such new subsidiary activities, their goals and/or structure in the EII;

4 To provide long-term strategic and scientific leadership to the activities;

5 To monitor long-term progress within these three activities.

Where the science council is most concerned with the strategic issues of optical interferometry in Europe, the extended board is most concerned with the day to day activities. Article 11 of the MoU describes the responsibilities of the extended board (EII_EB) as:

1 To provide the oversight necessary to achieve the goals of the activities;

2 To help and to advise the different activities to communicate and have convergent objectives;

3 To assist in preparing the agendas for scientific councils meetings;

4 To organize, if necessary, any EII general assemblies (EII_GA).

Each activity has its own management board consisting of the project coordinator and the relevant work package leaders.

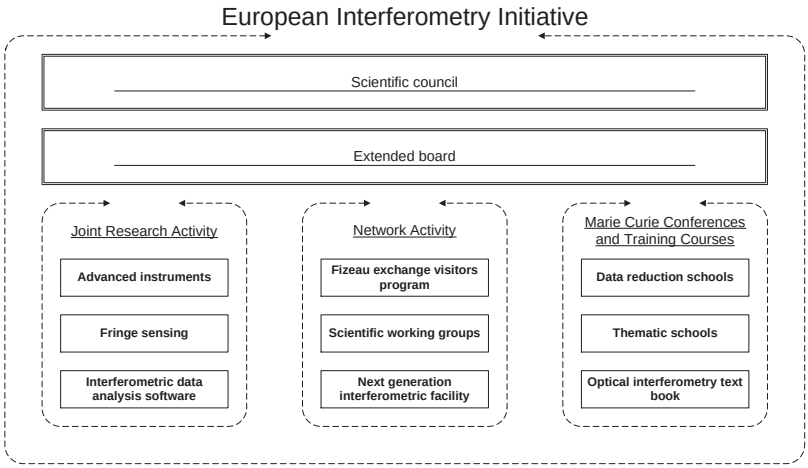


Figure 1. Management structure of the EII.

OPTICON

The European Interferometry Initiative participates in the European Union funded 6^{th} framework program OPTICON (Davies, 2004) with a Joint Research Project and a Network Activity. These two interferometric activities amount to 7.7 % of the total OPTICON budget. The other activities within OPTICON are:

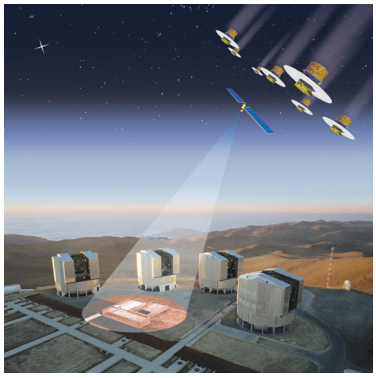
Networking activities: coordination of European northern observatory facilities; structuring European astronomy; extremely large telescopes; ultra-violet astronomy network; high-time resolution astronomy; interoperability; key technologies; software; synergy in space-ground coordination; interferometry forum; telescope network;

Transnational access: the OPTICON access programme;

Joint research activities: second generation adaptive optics for 8-10 meter telescopes; fast optical detectors for adaptive optics; fast readout high performance optical detectors; optical interferometry; smart focal planes volume; phase holographic gratings.

In the next three sections each of the activities will be described. Starting with the largest, leading to the smallest (measured in the amount of efforts invested in the activities).

(a) Logo for the European Interferometry Initiative. This logo has been designed by Gilles Duvert from LAOG.



(b) Synergy between the VLTI and DARWIN.

Table 1. Members of the EII scientific council of the European Interferometry Initiative.

Country	Member	Status
Austria	Josef Hron	
Belgium	Jean Surdej	
Switzerland	Didier Queloz	
Czech republic	Pavel Koubsky	
Germany	Thomas Henning	President EII_SC
Spain	Carlos Eiroa	
France	Christian Perrier	
United Kingdom	David Buscher	
Hungary	Lajos Balazs	
Italy	Mario Gai	
Israel	Erez Ribak	
Netherlands	Eric J. Bakker	Deputy president EII_SC
Poland	Andrzej Niedzielski	
Portugal	Paulo Garcia	
ESO	Guy Monnet	
ESA	Malcolm Fridlund	Observer

3. Joint research activities

The objectives of JRA is to ensure that Europe will play a leading role in the developments of optical interferometry over the next decade and to enable European astronomers to fully exploit the scientific potential of existing and planned large facilities. The near-term scientific productivity of interferometers is limited mainly by:

1 The inherent limitations of the existing focal-plane instrumentation and the difficulties of phasing and co-phasing the elements of interferometric arrays;

2 The lack of adequate algorithms and tools for the analysis and interpretation of the data;

3 Limitations of component technologies and modelling tools.

The participants of JRA will address areas (1) and (2) through the coordinated development of advanced analysis software, and targeted initiatives to further the design of next-generation focal-plane instrumentation and fringe tracking devices.

The project coordinator for the JRA is Alain Chelli. The latest information on the JRA can be found at
http://eii-jra4.ujf-grenoble.fr

Specific activities within the joint research project are (1) concepts to pre-design studies, (2) co-phasing algorithms, (3) European optical long-baseline interferometry software system.

Concepts to pre-design studies. The new interferometers are currently being equipped with first-generation focal-plane instruments which have consciously been designed to be relatively simple and limited in their capabilities. The JRA supports seven initial studies for advanced instruments which cover a wide range of concepts. These studies will identify the most promising of these concepts and assess their technical and financial viability. The highest-priority concepts will be studied in more detail through feasibility and pre-design studies. The project selected are:

A1: PRIMA (phase referenced imaging);

B1: IFSPEC with CRIRES/UVES;

B2: APRESMIDI (VLTI mid infrared 4-way beam combiner);

C1: VITRUV (8-way beam combiner with integrated optics);

C2: VIDA (8-way beam combiner with densified pupils);

C3: 8-way beam combiner with bulk optics;

C4: 6-way homothetic beam combiner for DARWIN and VLTI.

Co-phasing algorithms. The sensitivity of fringe trackers is one of the most important characteristics of an interferometer. Improvements over the current state of the art can be achieved mainly in two areas: fringe tracking algorithms and detectors. Fringe tracking algorithms optimized for the particular operating conditions of large facilities will improve the co-phasing ability beyond those of the current adaptations from small-aperture interferometers. Studies will be conducted centered on the following 11 themes:

T1: Analysis of performances of current fringe tracking systems;

T2: Fringe sensors hardware improvements;

T3: High sensitivity operations;

T4: Fringe sensors detection schemes;

T5: Optical path length difference measurements filtering;

T6: High-precision astrometric calibrations;

T7: Baseline & wavelength bootstrap;

T8: Multi-beams fringe sensor concepts;

T9: Identification of technology developments requirements;

T10: Analysis of applicability of advanced detectors (e.g. near-infrared super tunnel junction (STJ));

T11: Analysis of applicability of integrated optics (in bands J, K, N, M).

European optical long-baseline interferometry software system. The JRA will develop a dedicated software package for the analysis of data from optical & infrared interferometers. This package will be referred to as the European optical long-baseline interferometry (OLBI) software system. This data analysis package will contain utilities for input & output, general data manipulation such as sort & merge, data display and editing routines. It will provide tools for fitting simple geometrical models to sparse data sets and to estimate best-fit parameters of physical source models. It will provide facilities for astrometric data analysis which includes routines to determine the interferometer

and source geometry from the data, to determine stellar proper motions and parallaxes, and to fit orbits of binary stars and planetary companions. A variety of image reconstruction algorithms will be offered based on adaptations of familiar existing methods and on new techniques optimized for use with optical interferometer data.

4. Networking

The network activities intend to ensure that Europe will play a leading role in the development of optical interferometry. Both for ground and in space-based interferometry, now and in the foreseeable future. The focus of the activities is centered on:

1 To exploit the scientific opportunities of existing facilities;

2 To integrate interferometry with more traditional astronomical techniques and make interferometry accessible to non-specialists;

3 To develop a long-term scientific perspective for optical & infrared interferometry well into the next decade.

The project coordinator is Andreas Quirrenbach and the latest information on the network activities can be found at
http://www.strw.leidenuniv.nl/~eurinterf

Specific activities within the network are (1) Fizeau visitors program, (2) working groups, (3) next-generation interferometric facility.

Fizeau visitors program. Grants are available for visits of researchers (ranging from master and Ph.D. students to staff astronomers) to other institutes within the European Union to perform collaborative work on one of the active topics of the European Interferometry Initiative. The visit has a typical duration of 1 months whereas the dead-lines for application are yearly at 15 February and 15 September.

Working groups. Two working groups are established: one on "visibility modelling from radiative transfer codes" and the other on "interferometric tests of stellar model atmospheres". Theoretical models which have been developed over the years by many astronomers worldwide do not always have the diagnostics available which are required for interpretation of interferometric data. These working groups aim to interest non-interferometric astronomers with a theoretical interest to include interferometric diagnostics in their models. As a result the impact of interferometric observables in answering scientific questions could be improved.

Next-generation interferometric facility. Each year a workshop will be organized. The first in 2004 will deal with the science case, in 2005 with the technology road-map, and in the years after the workshop will focus on a proposal to build a next generation optical interferometer.

5. Marie Curie activity

The Marie Curie activities of the European Interferometry Initiative have the objective to provide training and education on optical interferometry to all levels of astronomers: master, Ph.D., post-doc, and staff astronomers. A proposal is under consideration at the EU for a Marie Curie program in the field of optical interferometry. The coordinator is Paulo Jorge Garcia.

Specific activities within the Marie Curie proposal are (1) VLTI data reduction training courses, (2) thematic astrophysical schools, (3) optical long-baseline interferometric textbook.

VLTI data reduction training courses. Schools will be organized to provide hands-on experience and form proficient users of the European ground based facility VLTI. Europeans now have the best interferometric facility operating in the infrared and are planning to build ambitious space interferometers. This project aims at providing an integrated and structuring approach to the European training in optical interferometry by forming new generations of young astronomers able to carry out scientific programs at the VLTI (from preparation to data reduction and analysis) through a periodic series of schools; by placing interferometry in context with other techniques in key astronomical areas.

Thematic astrophysical schools. These schools will address key astrophysical challenges where optical interferometry is expected to play an important role. Their goal is to complement the data reduction schools by placing optical interferometry in perspective together with other techniques. Synergy's between several high angular resolution techniques and facilities (VLTI, VLT, adaptive optics, radio interferometry at mm/cm VLBI/ALMA, HST) with optical interferometry will be addressed within outstanding thematic questions of astrophysics.

Optical long-baseline interferometry textbook. Currently there is no standard textbook on optical long-baseline interferometry that could be used in advanced undergraduate or graduate studies. Many scientists entering the field are faced with review articles and proceedings most of which lack the coordination, level of detail and coverage.

We plan to use the editions of the school series to produce a top-level textbook to fill this gap

6. Summary

Optical interferometry is reaching maturity. It is available as a facility instrument at the VLTI through the normal call for proposals. Education of a large base of main stream astronomers in the capabilities of optical interferometry and where interferometry they can help to answer open scientific questions in astronomy is one of the factors that determine the success of optical interferometry in the near- and long-term future. The European Interferometry Initiative has been set-up to facilitate communications and collaborations between European scientists and institutes working on optical long-baseline interferometry for astronomy, to exploit synergy within Europe in order to produce world leading science in the field of optical long-baseline interferometry; to work towards integration of educational activities on an European scale; to work toward developing a European vision for the long-term future of optical long-baseline interferometry.

Two funded activities are currently underway within the context of the OPTICON project funded by the European Union.

Acknowledgements

EJB is supported by NEVEC, a project of NOVA, the Netherlands Research School For Astronomy. OPTICON is supported by the European commission under contract RII3-CT-2004-001566.

References

[1] J.K. Davies, 2004, "OPTICON. The optical infrared co-ordination network for astronomy", This proceeding.