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## A European Helio- and Asteroseismology Network

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Funded as a Coordination Action  
by the European Commission

### Participants

Kiepenheuer Institut für Sonnenphysik (KIS),  
Freiburg, Germany

Instituto de Astrofísica de Canarias (IAC),  
La Laguna, España

Department of Applied Mathematics (UoS),  
Sheffield, U. K.

Institut for Fysik og Astronomi (IFA),  
Århus, Denmark

Centro de Astrofísica da Universidade do Porto (CAUP),  
Porto, Portugal

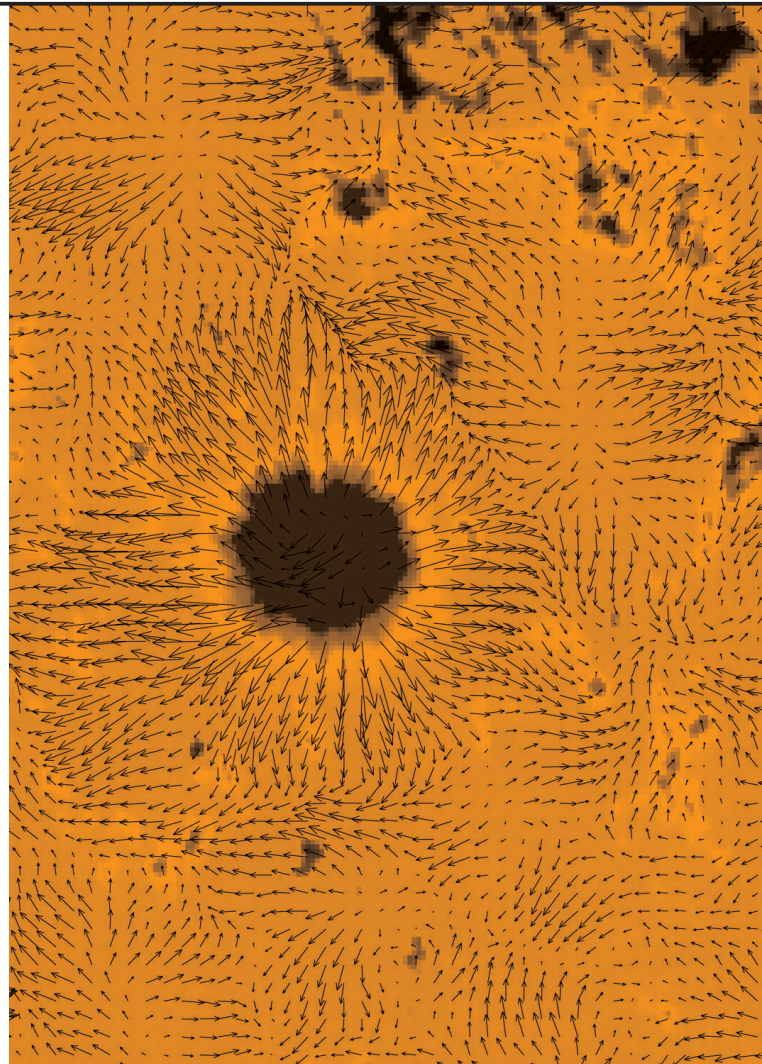
Max-Planck-Institut für Sonnensystemforschung (MPS),  
Katlenburg-Lindau, Germany

Istituto Nazionale di Astrofisica (INAF),  
Roma, Italy

Instituut voor Sterrenkunde (IvS),  
Leuven, Belgium

Instytut Astronomiczny Uniwersytet Wrocławski (IAUWr),  
Wrocław, Poland

Observatoire de la Côte d'Azur (OCA),  
Nice, France



# HELAS

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## PREFACE

It is a great pleasure to introduce a new European initiative, the *European Helio- and Asteroseismology Network HELAS*, with this brochure.

Astronomers have only very few tools to probe the interior of stars – the truly “enlightening” constituents of the Universe, which are also the source of chemical elements heavier than lithium. The entire complex chemistry in our environment, including life on Earth, originates from the stellar evolution in our Milky Way. Naturally, understanding stars means understanding our origins. Stars appear to be deceptively simple physical bodies; however, a quite complex set of mathematical equations and material properties describes what we believe the physics of their interior to be. It is impossible to look directly at the centre of a star, except with the help of the elusive neutrino, to verify our understanding of the relevant laws of physics. However, sound waves propagate through the stellar body, carrying minute signatures of its internal state with their frequencies. It is the careful analysis of the sound waves observed at the stellar surfaces – helioseismology for the case of the Sun and asteroseismology for other stars – which has become the prime technique probing the interior of stars during the past 30 years.

HELAS is a stroke of luck for helio- and asteroseismology in Europe. For the first time, a project devoted to the investigation of the solar interior and generally to the seismic probing of the structure of stars receives substantial funding from the European Commission for a period of four years. Based on this funding and the established work programme, HELAS offers a unique

chance to advance helio- and asteroseismology further, and to proceed with the future steps in a well prepared manner. HELAS comes quite timely. Exciting projects and space missions are about to become operational, delivering overwhelming amounts of data on the Sun and the stars. Researchers in Europe must be in a position well prepared to process the data with high efficiency.

Many researchers in Europe will have the opportunity to exchange their knowledge and their experience within the frame offered by HELAS. They will be able to coordinate efforts and to share resources. We consider HELAS a unique opportunity for helio- and asteroseismology research groups all over Europe to achieve a leading position in the seismology of the stars.

## HELAS ORGANIZATION

The HELAS management structure consists of the HELAS Board, the Coordinator, the Project Scientist and the Network Activity Chairs. The Coordinator is assisted by the Network Coordination Team and a Project Office.

The HELAS Board is responsible for making top-level strategic decisions regarding the execution and development of the Coordination Action. The Board is composed of one member from each of the participating institutions. Each institution appoints its representative to the Board. The members of the Board annually elect a Chairperson from among its members. The Board meets at least once a year to decide, review and update the strategic plan for HELAS, including proposals for new members and the financial issues. The present membership of the Board is listed below.

The HELAS Coordinator, Oskar von der Lühe (KIS), carries out the responsibilities of the coordinator as set out in the EC Contract. These responsibilities include, among others, signature of the Contract with the European Commission after authorization by the participating institutions, collection of all required statements for submission to the European Commission from all Contractors, preparing the required reports and project documents and ensuring prompt delivery of all deliverables. The Coordinator is responsible for the proper execution of the Coordinated Action and for the implementation of the strategic decisions of the Board. He implements the strategic decisions and recommendations of the Board and decides on all issues concerning the implementation of the Project Plan. He monitors the Project progress with particular regard to budget and schedule, and receives progress and financial reports from the Network Chairs. In accordance with the strategic priorities set by the Board he determines the distribution of resources, reviews the

balance of the Project as required by the EC, and prepares reports for approval by the Board.

The Project Office carries out the day-to-day management of the Project under the direction of the Coordinator. An administrative officer assists the Coordinator and the HELAS Board. The Project Office provides the management, financial and administrative expertise and full EU accountability across all HELAS activities, servicing and supporting the top level decision-making and oversight bodies and supporting the various elements of the Project.

The Project Scientist, Markus Roth (MPS), assists the Coordinator and takes over his responsibilities in case of absence. He carries out immediate actions, organises and attends all HELAS Board meetings, defining their agenda, and assures proper information flow between the Project Office and the Network Chairs.

The Network Coordination Team assists the Coordinator in day-to-day matters of the Project on an ad-hoc basis, in the times between meetings of the Board. The team provides advice to the Coordinator and supports the decision making process. The team consists of the Project Scientist, the Chair of the Board, and two additional members appointed by the Board.

Each Network Activity is directed by a Network Chair. The Board appoints the Network Chairs who are responsible for the execution of the planned activities within the Network according to schedule and within allocated resources. They assure proper information flow between the participating institutions and provide to the Coordinator all information and documents required in order for the Coordinator and the Board to fulfil their obligations to this Project.



**Project office members.**

Oskar von der Lühe, *Coordinator*; Ute Rynarzewski, *Administrative Officer*;

Cornelia Betz, *Administrative Assistant*; Markus Roth, *Project Scientist*

## HELAS Board members

Oskar von der Lühe (*Coordinator*, KIS)  
Pere Pallé (IAC)  
Michael J. Thompson (UoS)  
Jørgen Christensen-Dalsgaard (IFA)  
Mário J. P. F. G. Monteiro (CAUP)  
Laurent Gizon (MPS)  
Maria Pia Di Mauro (INAF)  
Conny Aerts (lvS)  
Jadwiga Daszyńska-Daszkiewicz (IAUWr)  
Thierry Corbard (OCA)  
Markus Roth (*Project Scientist*, MPS)

## HELAS Board guests

Annie Baglin (CoRoT)  
Yvonne Elsworth (BiSON)  
Don Kurtz (UCLAN)

## Project Office

Ute Rynarzewski (*Administrative Officer*, KIS)  
Cornelia Betz (*Administrative Assistant*, KIS)



## NETWORK ACTIVITIES

### Global Helioseismology

Helioseismology has opened a new window on the interior of the Sun, enabling solar physicists to investigate the structure and dynamics of the previously inaccessible solar interior, from the central core to the surface. Global helioseismology uses observations of motions of the solar surface to measure very precisely the frequencies of normal modes of oscillation of the whole Sun. These are analogous the resonant frequencies of a musical instrument. The frequencies depend on the interior properties of the Sun, and so from the measured frequencies inferences can be drawn about the solar interior, such as its stratification with depth and how the rotation rate of the interior varies with position. Global helioseismology can also make use of other measurable properties of the resonant modes, such as their lifetimes. The inferences from global helioseismology are complementary to those from local helioseismology.

The Global Helioseismology Network Activity aims to coordinate the methods and software developments for global helioseismology across the various European groups working in this field. It aims to distribute data analysis tools and solar models in the HELAS community. Finally, and importantly, it aims to share expertise and techniques with asteroseismology (see also the Asteroseismology Network Activity).

### Local Helioseismology

Local helioseismology uses measurements of wave motions on the Sun's surface to make three dimensional images of the solar interior. It is quite similar to ultrasonic computed tomography, used in medicine to image the human body. The basic idea is to measure the time it takes for solar waves to propagate through the interior between any two locations on the surface: wave travel times contain

the seismic signature of buried inhomogeneities and mass motions situated along the propagation paths. Internal flows also leave a signature in the frequencies of solar oscillations extracted from time-series of local areas on the Sun. Local helioseismology has been used to probe the subsurface structure of sunspots, internal flows and their temporal evolution, and even magnetic activity on the far side of the Sun. It is believed that local helioseismology will provide important clues in our quest to understand the mechanism of the eleven-year solar magnetic cycle. The Local Helioseismology Network Activity aims at consolidating this field of research in Europe, to organize scientific meetings, and to facilitate the distribution of solar oscillation data and the tools for their analysis. An important goal is to provide Europe with the means to analyze data from the Solar and Heliospheric Observatory (SOHO) and the Global Oscillation Network Group (GONG), as well as to prepare for upcoming space missions – the Solar Dynamics Observatory (SDO) and the Solar Orbiter.

### Asteroseismology

Asteroseismology uses measurements of wave motions on the surface of stars to derive their interior properties. The tiny stellar surface motions reveal themselves in observed time series of brightness or velocity variations from which the wave frequencies can be deduced. The goal is to unravel the way in which stellar waves propagate through the star. The travel time of the waves depends on the properties of the stellar gas, in particular on its density, temperature, rotation, mixing and chemical composition. Both smooth and sharp changes in these quantities imprint specific signatures in the wave propagation and thus in the observed frequencies. Modelling of the wave properties thus allows astrophysicists to disentangle the details of the gas properties which in their turn determine the life and evolution of the stars.

The Asteroseismology Network Activity aims at integrating and documenting existing analysis tools for the interpretation of seismic data of stars and at delivering these tools, as well as data and models, to the whole European community. This delivery will be achieved through a flexible and efficient internet gateway, which will also serve the purpose of a toolbox for graduate training. An important aspect is to assist the community in the optimal exploitation of the space data from the European space mission CoRoT and to prepare Europe for future large-scale ground-based and space projects for solar and stellar physics.

### Public Outreach

Helio- and asteroseismology cover broad areas of solar and stellar physics, from the structure and evolution of all types of star over the details of solar evolution to the dynamics of solar activity. Thus HELAS provides an excellent platform for coordinating outreach in these areas, presenting the fascinating aspects of the dynamic life of the stars. The goal of these activities is to make available material for outreach in the broadest sense, addressing the general public, schools at all levels and university education. In addition, we shall inform our astrophysical colleagues about the activities of HELAS at international conferences and similar occasions. The present brochure is an example of the material produced as part of the HELAS outreach activities for this purpose.

All HELAS nodes have extensive outreach programmes with high-quality material. Through the HELAS outreach activities we shall organize this material and make it available to the HELAS, and the broader, community in a convenient form. This will include images, animations and sound files, as well as complete presentations which may serve as inspiration to others. In addition, we shall make available lecture notes in the areas covered by HELAS. We may also coordinate the production of new

material at the HELAS nodes. Another relevant activity will be to coordinate the production and distribution of press releases on special occasions, such as the launch of the CoRoT satellite. Finally, we plan to produce a web-based 'Who is Who' of the HELAS community, with pictures, contact information and brief descriptions of research interests. This may later be extended to the broader helio- and asteroseismic communities.

### HELAS Forum

In order to promote and to ensure a proper dissemination of the knowledge, an effective degree of coordination and a correct and easy access to the information – primarily inside the helio- and asteroseismology community but also to other scientific communities and to the general public – it was considered necessary to develop a specific network activity to address the above goals: the "HELAS Forum".

The HELAS Forum network activities will be focused in three main aspects: a) To develop, maintain and operate an IT platform ([www.helas-eu.org](http://www.helas-eu.org)), aimed to be "the" reference site and also the reference gateway, for the helio- and asteroseismology community. The IT tool shall provide information (who is who in the community, where they are and what are their activities and skills, projects, programs, initiatives, meetings and related events, publications, job opportunities, locations and description of available data sets and the specific HELAS activities and their progress), products (basic helio- and asteroseismic observational data, software packages, theoretical frequencies, models, inversion tools and multimedia outreach and educational material) and an open IT forum tool to exchange information and ideas. b) To increase visibility and coordination of the existing initiatives in these fields and to encourage incipient or new ones. c) To maximize the attendance and the scientific output of the annual HELAS International Conferences.

## Participating Institutions





### Kiepenheuer-Institut für Sonnenphysik

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The Kiepenheuer-Institut für Sonnenphysik (KIS), a member of the Leibniz association, is the largest German institute specialized in solar physics. The institute operates the German solar telescopes at the Observatorio del Teide, Tenerife, and leads the construction of the 1.5m solar telescope GREGOR. It participates in several international instrumentation projects for the ground and space. The number of employees (scientific, technical and administrative) is about 55. The research at the KIS is focused on the observational and theoretical description of the magnetic solar activity. The KIS has a long-standing history in helioseismology, dating back to the pioneering work of Franz-Ludwig Deubner, who detected the standing-wave character of the “five-minute oscillations”. Currently, the helioseismic research at the KIS is concentrated on the development of new techniques for inferring information on the origin of the solar activity. This includes studies of the solar interior dynamics and their temporal variation.

### Instituto de Astrofísica de Canarias

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The Instituto de Astrofísica de Canarias (IAC) is a highly internationalized research centre comprising the Instituto de Astrofísica, as the Headquarters in La Laguna; the La Palma Centre of Astrophysics and Teide and Roque de los Muchachos Observatories. The IAC Helio- and Asteroseismology Group consists of 12 members (6 staff, 2 postdocs and 4 PhD students) and is responsible for the “SolarLab” at the Observatorio del Teide, the only site hosting devoted instrumentation belonging to all existing ground-based helioseismology networks (GONG, BiSON, TON, ECHO), some major coordinated asteroseismology experiments (STARE) and multi-site campaigns (STEPHI). The team has been involved in those projects at observing, interpretation and scientific exploitation levels, and therefore acquired a unique expertise. Furthermore, the IAC Team has been involved as partner consortium in the construction, operation, and scientific exploitation of two European experiments aboard SOHO (GOLF and LOI/VIRGO) and it is involved in the CoRoT mission.

### Department of Applied Mathematics

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### Institut for Fysik og Astronomi

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The Sheffield team is part of the Solar Physics and upper-Atmosphere Research Group in the Department of Applied Mathematics. The team has extensive experience in inversion of global and local helioseismic data to study the internal structure and dynamics of the Sun. It is currently developing inverse techniques for asteroseismic data and grid-based technologies for exploiting the forthcoming helioseismic observations from the Solar Dynamics Observatory satellite. It has a strong track record of training research students and postdoctoral researchers. The team's particular strengths are in helioseismic and asteroseismic modelling and inversion, and in modelling the effects of magnetic fields on solar oscillations.

The Aarhus team is part of the Department of Physics and Astronomy, with a total scientific staff of around 59, and consists of three permanent staff members, two postdocs and one PhD student. The Aarhus group has a long history in the use of helioseismic techniques to determine solar internal structure and rotation, including investigations of the equation of state and opacity. Great emphasis has been placed on the development of reliable techniques for computing stellar models. The team has been leading in ground-based observations of solar-like oscillations in other stars. A recent important contribution has been the study of oscillations in the A and B components of the alpha Centauri binary system. The theoretical activities of the team now also emphasize asteroseismology, including the development of techniques for fitting or inverting stellar oscillation data. The team will take part in the CoRoT and the NASA Kepler missions, in the latter case with prime responsibility for the interpretation of the asteroseismic data. The IFA team has made substantial contributions to public outreach, including the organization of planetarium shows in collaboration with the local planetaria.

### Centro de Astrofísica da Universidade do Porto

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### Max-Planck-Institut für Sonnensystemforschung

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CAUP is the largest institute for astronomy in Portugal with a team of about 20 researchers and over 40 postgraduate students working on two broad areas: stellar astrophysics, extragalactic astronomy and cosmology. It hosts several postgraduate programmes in astronomy and provides support to the undergraduate degree in Astronomy in the University of Porto. CAUP participates in several European Consortia funded by the European Commission. The Stellar Structure and Evolution team at CAUP includes four senior researchers and several PhD students that participate in asteroseismology (CoRoT and MOST) and helioseismology (SOHO) missions.

The team's expertise centres on the seismic analysis of the Sun and other solar-type and intermediate mass stars, from the pre-main sequence up to more advanced stages of evolution. The research focuses on the seismic study of convection and overshoot, chemical composition, stellar modelling and magnetic effects on the frequencies of the oscillations.

The Max Planck Institute for Solar System Research (MPS) is one of 78 institutes and research facilities maintained by the Max Planck Society across Germany. Scientific work at the MPS can be split into three major fields of research: The Sun and heliosphere, planets and comets, and magnetospheres. The solar research group has extensive experience in observations of photospheric magnetism, studies of solar variability and climate, numerical modelling of solar convection, and dynamo theory. A new independent research group in solar and stellar seismology was created in 2005. An essential part of the Institute's activities is the development and construction of instrumentation for space missions. The institute has played a leading role in about 80 successful space missions since 1965, including Helios, Giotto, Cluster, SOHO, Mars Pathfinder, Cassini, and Rosetta, to mention a few of the most significant.

### Istituto Nazionale di Astrofisica

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The asteroseismology group of the INAF (Istituto Nazionale di Astrofisica - National Institute for Astrophysics) consists of several institutes of astrophysics in Italy. The team was established in 2001 with the idea to gather people with complementary skills in studies of helio and astero-seismology. The group is involved in the study of stellar variability with regards to photometric and spectroscopic observations and data analysis, particularly of solar-type, delta Scuti, gamma Doradus, sdB stars and white dwarfs. The theoretical work focuses on expertise in the interpretation of the oscillation spectrum of the Sun and solar-like stars, by including effects such as rotation and overshoot from convective zones. The group is involved in the application and development of helioseismic inversions techniques useful to unveil solar and stellar internal regions. The team has developed a stellar evolution code with the aim to study the internal structure of the stars in various phases of their evolution.

### Instituut voor Sterrenkunde

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The Institute of Astronomy of Leuven University contains a large gender-balanced and diverse team in asteroseismology, composed of 8 PhD students, 6 postdocs, 1 software engineer and 1 staff member. This team has a long tradition in observational studies of heat-driven oscillation modes of main sequence stars, from the cool F-type Gamma Doradus stars up to the hot massive B-type Beta Cephei stars. It has recently also been heavily involved in the discovery of stochastically-excited oscillation modes in solar-like stars and in red giants. Specific expertise includes development and application of methodology for empirical mode identification from multicolour photometry and from high-resolution line-profile variations. Two of the team members are co-Investigator of the CoRoT space mission, with responsibilities on B-type pulsators and red giants respectively. The team is also involved in the automated classification of variable stars from light curves in the framework of the CoRoT and Gaia space missions.

**Instytut Astronomiczny, Uniwersytet Wrocławski**

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The Wrocław Institute hosts experts in observations as well as in the theory of pulsating stars, in a strong collaboration with astronomers from Warsaw. The group consists of nine permanent staff members and two PhD students. The research concentrates on the search for B-type variables in young open clusters, particularly for beta Cep, SPB, Be and sdB stars. To this end, multicolour photometry is carried out, and data from the MACHO and OGLE projects are analyzed. One of the main results of these studies is the discovery of the first beta Cep and SPB stars in Magellanic Clouds. Stellar parameters and metallicities are determined using spectra from the ground-based observations and from space missions. The theoretical work focuses on modelling of stellar evolution and non-adiabatic pulsations. The Warsaw-Wrocław team developed the method of non-adiabatic photometric observables for the mode identification. Moreover, the team invented another method, which, besides the mode identification, yields a new asteroseismic probe giving constraints on stellar parameters, convection, chemical composition and atomic data (opacity).

**Observatoire de la Côte d'Azur**

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The Côte d'Azur Observatory (OCA) is ruled under the French education ministry in partnership with CNRS (Centre National de la Recherche Scientifique) and has close relationship with Nice University where several researchers are also teaching. It is made of about 200 people working in three scientific departments. The solar and stellar physics group of OCA has been leaders in the earliest development of ground based and spatial helioseismology. They are now involved as co-investigators in the CNES PICARD micro-satellite mission for solar shape measurements and in the CNES/ESA asteroseismic mission CoRoT. They are also contributing in developing local helioseismology methods for studying notably the meridional circulation and the correlation between sub-surface dynamics and magnetic activity. Theoretical studies include models of stellar evolution, stellar structure and pulsation, solar turbulence, MHD, dynamo theories and photospheric magnetism.

## HELAS Overview

HELAS	NA 1	NA 2	NA 3	NA 4	NA 5	NA 6
KIS						
Oskar von der Lühe	CHAIR	X	X	X	X	X
IAC						
Pere L. Palle	X	CHAIR	X	X	X	X
UoS						
Michael J. Thompson	X	X	CHAIR	X	X	X
IFA						
Jørgen Christensen-Dalsgaard	X	X	X	X	X	CHAIR
CAUP						
Mário J. P. F. G. Monteiro	X	X	X		X	X
MPS						
Laurent Gizon	X	X	X	CHAIR	X	X
INAF						
Maria Pia Di Mauro	X	X	X		X	X
IvS						
Conny Aerts	X	X			CHAIR	X
IAUWr						
Jadwiga Daszynska	X	X			X	X
OCA						
Thierry Corbard	X	X	X	X	X	X

NA1 – Management.

NA2 – HELAS Forum

NA3 – Global Helioseismology

NA4 – Local Helioseismology

NA5 – Asteroseismology

NA6 – Public Outreach