

Four years of HELAS

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The European Coordination Action on HELio- and ASTeroseismology (HELAS) has completed its fourth and final year of initial funding by the European Commission. Set up as a network which combines solar and stellar physics communities in the important and vigorously evolving field of seismology, HELAS has been able to coordinate the efforts of European astronomers with remarkable success. Four large international conferences including the HELAS-IV conference on Lanzarote as well as many workshops were organized with a substantial contribution from HELAS. About a dozen workshops, addressing specialized questions in global and local helioseismology and asteroseismology were entirely organized by HELAS. Data analysis tools to prepare the European communities for the upcoming influx of data from new missions have been prepared, tested and demonstrated. Lecture notes and outreach material have been assembled and prepared for general access. As a result, HELAS has an important impact on the scientific output of the astrophysics seismology communities and significantly increased the visibility of European research in this field. This paper summarizes the activities and accomplishments of HELAS.

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1 Introduction

In the period 2006 April 1–2010 March 31 the European HELio- and ASTeroseismology Network (HELAS) was funded as a Coordination Action by the European Commission's Sixth Framework Programme (FP6). The original proposal was submitted on 2005 March 3 in response to the European Commission's call "Research Infrastructures Action FP6-2004-Infrastructures-5". The network activities described in the HELAS proposal were targeted on coordinating the activities among European institutions and organizations in helio- and asteroseismology. The objective was to enable transfer of knowledge, data, and data analysis techniques in order to ensure European competence and competitiveness in this research area by spreading expertise. This should then lead to an increase in volume and quality of the European scientific output in helio- and asteroseismology, an enhancement of the synergy between helio- and asteroseismology, and to the preparation of the European research community for important future opportunities, e.g.,

CoRoT (CONvection, ROTation and planetary Transits), Kepler, BRITE (BRiGht-star Target Explorer), Picard, SDO (Solar Dynamics Observatory). In addition it was the goal to improve the public understanding and interest in solar and stellar physics.

The means to achieve these objectives were annual meetings at the international level, focused meetings and workshops on specific topics, and a common platform for the exchange of data and software.

The measures to be applied to quantify in the end the success of HELAS were suggested to be the level of international participation at organized conferences, the volume of distributed common software tools and numerical techniques, the number of inter-institutional publications in peer-reviewed journals, the number of proposals for funding scientific projects, and the number of junior scientists and graduate students in the field.

The proposed project budget which comprised the requested contribution by the European Commission of 2.465 million Euro and the own contributions from each partner for a duration of four years was 3.025 million Euro.

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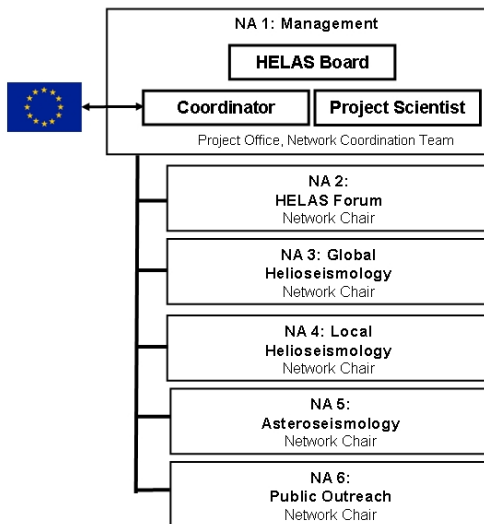


Fig. 1 The management structure of HELAS.

In July 2005 the proposal was accepted almost to full extent. Only, the preparation of new proposals had to be given up – a coordination action is a one-time possibility for a starting community, with no possibility to continue under this program. Furthermore the number of workshops had to be reduced. The granted funding by the EC was 2.265 million Euro for the duration of four years. In the contract negotiation phase, which started in September 2005 with the European Commission, April 1, 2006 was chosen as start date of the network activities.

2 Organization

The HELAS consortium was formed by ten partners, which were the institutions listed under the list of authors of this paper. Three advisors, Annie Baglin (Observatoire de Paris, France), Yvonne Elsworth (University of Birmingham, UK), and Don Kurtz (University of Central Lancashire, Preston, UK), acted as external council for the HELAS consortium. HELAS was given a lean management structure which is displayed in Fig. 1.

In total six network activities (NA) were defined. These were briefly described in Roth et al. (2007); Roth (2007):

- NA1 “Management” handled the overall coordination and management of the consortium and the project. The HELAS Board consisted of ten representatives, one from each consortium member. The Board set the strategies and took over the financial management and the interaction with the European Commission. The coordinator (Oskar von der Lühe, KIS) and the project scientist (Markus Roth, KIS & MPS) were assisted by an administrative officer and an administrative assistant in the project office, which was located at KIS in Freiburg.
- The second network activity (NA2) “HELAS Forum” served as platform for discussing all network activities

of HELAS and developing the plans of mutual interest. Once a year an international conference was organized. Moreover the HELAS Forum generated and exploited the synergies between the network activities. An internet portal at <http://www.helas-eu.org> allowed the exchange and distribution of software and data (Jiménez-Reyes et al. 2008). The activity was chaired by Pere Pallé and Sebastian Jiménez-Reyes at IAC.

- NA3 “Global Helioseismology” was one of two helioseismology network activities. NA3 was devoted to the elicitation of new and exigent problems and the coordination of the methods and software developments for global helioseismology. Data analysis tools and solar models from the HELAS community were distributed. To coordinate the activities in global helioseismology three workshops were held. The activity was chaired by Michael J. Thompson at UoS.
- NA4 “Local Helioseismology” was the second helioseismology network activity. There it was necessary to identify the needs and to develop actions for structuring research in the field of local helioseismology. The development and distribution of specific software was coordinated in order to provide Europe with the means to participate in the analysis and interpretation of HMI-SDO data. Three workshops were held. This activity was chaired by Laurent Gizon, MPS. Further information can be found in Schunker & Gizon (2008).
- NA5 “Asteroseismology” was the scientific network activity which developed programs to ensure European competitiveness in the field of asteroseismology. This comprised comparisons of model and frequency calculations in order to improve their reliability. Furthermore the developments of stellar modeling software were coordinated and the results distributed within the HELAS community (Østensen 2007; Zima 2008). In total four workshops were organized. NA5 was chaired by Conny Aerts, IvS.
- NA6 “Public Outreach” had the major objectives to coordinate actions that raise awareness and interest in helio- and asteroseismology in the general public and at all levels of the educational system throughout Europe. This included the preparation of state-of-the-art university lectures and other material for further outreach. This activity was chaired by Jørgen Christensen-Dalsgaard, IFA.

3 What has HELAS done?

3.1 Conferences and workshops

The organization of workshops was one of the important HELAS activities to bring the research community together. In total four international conferences were organized under the auspices of the “HELAS Forum”:

1. “HELAS-I: Beyond the Spherical Sun”, Sheffield, August 2006;

2. “HELAS-II: Helioseismology, Asteroseismology, and MHD Connections”, Göttingen, August 2007;
3. “HELAS-III: 1st CoRoT Symposium”, Paris, February 2009;
4. “HELAS-IV: Seismological Challenges for Stellar Structure”, Lanzarote, February 2010.

In addition the following workshops were organized in the network activities NA3 – NA6:

1. “HELAS Public Outreach Meeting”, Aarhus, Denmark, September 2006;
2. “Roadmap for European Local Helioseismology”, Nice, France, September 2006;
3. “Future of Asteroseismology”, Vienna, Austria, September 2006;
4. “Solar/Stellar Models and Seismic Analysis Tools”, Porto, Portugal, November 2006;
5. “The Low Degree and Low Frequency Modes”, La Palma, Spain, September 2007;
6. “Local Helioseismology and Solar MHD Processes”, Freiburg, Germany, January 2008;
7. “Interpretation of Asteroseismic Data”, Wrocław, Poland, June 2008;
8. “The Solar Acoustic Cycle”, Birmingham, United Kingdom, January 2009;
9. “The subsurface structure of sunspots”, Berlin, Germany, May 2009;
10. “Synergies between Solar and Stellar Modelling”, Rome, Italy, June 2009;
11. “New Insights Into the Sun”, Porto, Portugal, Sep 2009.

The funding of the EC also allowed to support in addition the following events:

1. “First AsteroFLAG Workshop”, Bern, Switzerland, January 2007;
2. “Second AsteroFLAG Workshop”, Bern, Switzerland, February 2008;
3. “First KASC Workshop”, Orsay, France, October 2007;
4. “GIRMA Workshop”, La Palma, Spain, January 2008;
5. “Reunión Ibérica de Sismología Estelar y Planetaria”, Granada, Spain, May 2008;
6. “Second KASC Workshop”, Aarhus, Denmark, June 2008;
7. “38th Liège International Colloquium”, Liège, Belgium, July 2008;
8. “JENAM 2008 Symposium No. 4”, Vienna Austria, September, 2008;
9. “Getting Ready for PICARD Helioseismology Program”, Nice, France, December 2008;
10. “Third AsteroFLAG Workshop”, Bern, Switzerland, December 2008;
11. “2nd Iberian Meeting on Asteroseismology”, Vila Pouca da Beira, Portugal, April 2009.

3.2 Monographs

The events organized by HELAS resulted in the following conference proceedings:

1. “HELAS-I: Beyond the Spherical Sun”, ESA SP, Vol. 624, 2006;
2. “Roadmap for European Local Helioseismology”, *Astronomische Nachrichten*, Vol. 328, 2007;
3. “Future of Asteroseismology”, *Communications in Asteroseismology*, Vol. 150, 2007;
4. “Solar/Stellar Models and Seismic Analysis Tools”, EDP Sciences, EAS Publications Series, Vol. 26, 2007;
5. “Evolution and Seismic Tools for Stellar Astrophysics”, (ed.) Monteiro, M.J.P.F.G., ISBN 978-1-4020-9439-2, Springer, 2009;
6. “The Low Degree and Low Frequency Modes”, *Astronomische Nachrichten*, Vol. 329, 2008;
7. “Interpretation of Asteroseismic Data”, *Communications in Asteroseismology*, Vol. 157, 2008;
8. “Proceedings of the HELAS II International Conference”, *Journal of Physics: Conference Series*, Vol. 118, 2008;
9. “Helioseismology, Asteroseismology, and MHD Connections”, (ed.) Gizon, L., Cally, P., Leibacher, J., ISBN 978-0-387-89491-2, Springer, 2009; Reprinted from *Solar Physics Topical Issue* Vol. 251, Nos. 1–2, 2008;
10. “HELAS-III: 1st CoRoT Symposium Paris”, *Astronomy & Astrophysics*, Vol. 506, 2009;
11. “The Solar Acoustic Cycle” (ed.) Elsworth, Y. & Thompson, M.J., 2009, on CD-ROM;
12. “Synergies between Solar and Stellar Modelling”, to appear in *Astrophysics and Space Science*, 2010;
13. “New Insights Into the Sun” (ed.) Cunha, M., & Monteiro, M.J.P.F.G., 2010, on CD-ROM;
14. “HELAS-IV: Seismological Challenges for Stellar Structure”, *Astronomische Nachrichten*, this volume.

These monographs and in addition the workshop proceedings of the NA4 workshops, “Local Helioseismology and Solar MHD Processes” in Freiburg and “The subsurface structure of sunspots” in Berlin, are accessible via the HELAS web page. In addition HELAS funded from spring 2008 until March 2010 the language editing of the journal “Communications in Asteroseismology”, which has become an important media for asteroseismology (Aerts 2008).

3.3 HELAS Forum

Besides the organization of four large international conferences (HELAS I–IV) and the support for new coordinated initiatives, a monthly newsletter was provided to the HELAS community. The researchers interested in the HELAS activities were able to register on the HELAS Web Site, which was constructed and maintained by the HELAS Forum.

3.4 HELAS Outreach

The HELAS Outreach activity addressed mainly the general public by creating flyers and posters describing HELAS.

Press releases were released in connection with special events, e.g. the start of CoRoT, Kepler, and SDO, as well as interesting scientific events, e.g. publication of a Nature paper on the first asteroseismic detection of a planet (Silvotti et al. 2007). Furthermore, open door events, planetarium shows, and public lectures were organized under the auspices of the HELAS Outreach.

For the scientific community HELAS Outreach provided a collection of lecture notes and general presentations related to helio- and asteroseismology. In addition multimedia material and tools for creating multimedia were made available.

3.5 Behind the lines

Behind the lines visible for the general research community, the HELAS Board held regular meetings twice per year. Beside this the Consortium fostered an intense e-mail exchange. Furthermore the Consortium reported in four annual reports to the European Commission on its activities and the spending of EC's financial contribution in the single years. HELAS underwent a mid-term review in May 2008, which resulted in an excellent evaluation of the project. The referees stated in their report on HELAS:

“HELAS has been an outstanding success so far in every respect. This is a network of high quality which is making a huge difference to the effectiveness of the solar and stellar seismology community in Europe. In particular the management is extremely effective and the leaders of the Network Activities are all performing their duties very well indeed.”

In order to lay the paths for a possible future of HELAS the HELAS Board established close contacts to the European Commission, the European Parliament and its scientific committees, politicians and national funding agencies. We will describe in Sect. 5 how future initiatives could look like.

4 What has HELAS accomplished?

In the proposal to the EC, one of the measures of success for HELAS was the number of publications in the field. Making use of the search facilities offered by the SAO/NASA Astrophysics Data System (<http://adsabs.harvard.edu>), it is possible to count the numbers of publications which originate from “helioseismology” or from “asteroseismology” by searching for the respective keywords. Figure 2 gives an overview of the number of publications worldwide in the two research areas of HELAS. Compared to the years 1997–2006 there is a significant increase in the number of publications in recent years. On average the total number of publications was around 75–100 papers per year. In 2009 this number has increased by a factor of ≈ 2.5 . We can clearly speculate about the origins of this increase. The new asteroseismology space missions and their preparation probably

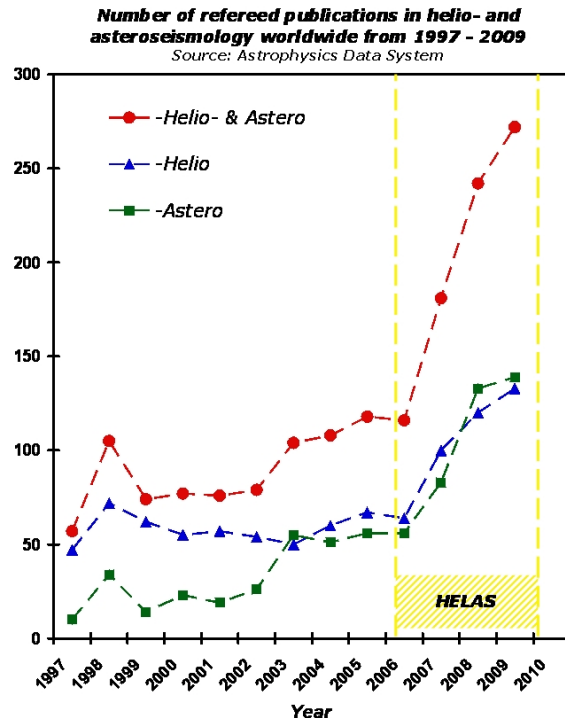


Fig. 2 (online colour at: www.an-journal.org) Annual publications in either helioseismology or asteroseismology since 1997. The yellow area marks the period in which the HELAS activities took place (Courtesy: S. Jiménez-Reyes, IAC).

had an effect, in particular on the publications in asteroseismology. This is visible in the “asteroseismology” curve for the years 2002–2006. But in helioseismology the publication rate remains constant around 50 publications per year within that period. However, since the establishment of HELAS in 2006 the publication rates of both fields go in lock-step. Bringing together the scientists in workshops to allow discussions and exchange of knowledge, and allowing all scientists in the field to work with common standards, data, and tools as it was fostered by the HELAS activities seem to have had the planned positive effect on the scientific output.

In this sense we would like to note that HELAS has established a closer contact and a vigorous exchange between the solar and stellar communities. In addition HELAS established a closer interaction between theoreticians and experimentalists as the HELAS workshop proceedings demonstrate. We also note that the map in Fig. 3 supports the conjecture that Europe plays a major role in helio- and asteroseismology.

5 Where do we go from here?

In the next years various innovative experiments will start delivering data that allow expecting exciting scientific results about solar and stellar interiors. An unprecedented volume of data will be collected by new space experiments aboard the Solar Dynamics Observatory, the asteroseismic



Fig. 3 (online colour at: www.an-journal.org) Map of the Earth indicating the locations of those institutions which host scientists that registered on the HELAS internet platform. The red markers are the institutions of the HELAS consortium members, the yellow markers are universities, and the green markers are research centres.

missions CoRoT and Kepler, and high-tech ground-based observatories, e.g. SONG (Stellar Observations Network Group).

Europe hosts an important fraction of scientists active worldwide in helio- and asteroseismology with various active research groups spread over many countries. In order to make optimal use of these large amounts of solar and stellar seismic data, European scientists from helio- and asteroseismology as well as from other related disciplines require the best intellectual integration, efficiently to structure their investigations. A concerted action like HELAS that would continue bringing together scientists from those disciplines and allowing to structure and rationalize their efforts is needed to have a sustainable effect in Europe.

However, as it was already noted earlier, under the funding lines of the European Commission a Coordination Action is a once-in-a-lifetime opportunity for a community. There are neither an extension nor a second proposal possible. The European Community expects substantially more comprehensive activity as a result from a funded Coordination Action. The only possibility for HELAS to continue would be an Integrative Infrastructures Initiative (I3) proposal, which is of a bigger scope. However, the current FP7 work program for infrastructures does not include a specific opportunity for helio- and asteroseismology. The HELAS Board has started to work on getting this situation changed. This requires the support of the European research community, which we urge to talk to the respective national representative on the Infrastructures Program Committee. The national contact points can be found on the FP7 website: http://cordis.europa.eu/fp7/ncp_en.html

5.1 What would an I3 have to look like?

An I3 consists of three elements:

- Networking, i.e., the activities that HELAS covered in the previous years. In the future these activities would be adapted to the new needs of the scientific community.

- Access and service program, which is intended to allow access to research facilities for researchers from Europe and associated countries who have no own access right. These research facilities could be, for example, real installations, e.g. telescopes or computing facilities, or virtual research facilities like data bases or networks. The access program can provide the funding of researcher support to use the facility as well as the costs for the facility operations.
- Joint Research Activities, which aim at research and development for new or improved research facilities. Those joint research activities are focused on the subjects in the network activities and the access program. Often a joint research activity is carried out with industrial or SME partners.

Obviously, an I3 will require a broader participation than it is the case in the current HELAS with its 10 partners. At least twice as many consortium members would be expected for an I3. As a consequence a significantly higher funding can also be expected. Thinking about setting up an I3 it has to be noted that all the three aspects (networking, access, and joint research) need to be covered. As it was demonstrated so far networking should not be a problem, and the joint research activities should not either as there are already demands on new helio- and asteroseismology observing facilities. The more difficult aspect is to define a research facility to which access is offered. The current research facilities in helioseismology are on the one hand space based observatories like the instruments MDI, GOLF, and VIRGO aboard the Solar and Heliospheric Observatory (SOHO), which is close to the end of the mission. Moreover the data are freely accessible. The same access policy will be the case with SDO/HMI and Picard. Solar Orbiter will probably not become operational before 2017. Similarly, there exist the dedicated ground-based networks GONG and BiSON, which also have an open data access policy.

In asteroseismology space based observatories are riding on the “exoplanetology” wave. The present space mis-

sions are MOST, CoRoT, and Kepler, and they may be followed up by PLATO. On the ground, facilities exist that can be used to form ad-hoc networks of small to medium-sized ground-based telescopes. The SONG network will be a dedicated installation for such a use.

The question which needs to be discussed is whether centres for helio- and asteroseismology data analysis will be of use for the scientific community. Such centres should then also include computing facilities for high performance numerical modeling of the processes in the Sun and the stars.

Another point which has to be taken into account is that neither asteroseismology nor helioseismology are considered as “big telescope science”. The ERA-NET “Astronet” has made detailed description of future astronomy and astrophysics to be carried out with large installations. Helioseismology and asteroseismology were below the threshold of Astronet as the following statement of the “Science Vision” document demonstrates:

“(4.3.1.1) While the small & medium size facilities (SMFs) are not part of the large infrastructures addressed by ASTRONET, they do have a role to play on their own in supporting the programs of the Science Vision (see Sect. 4.3.1.2 below). There is, however, clearly room for optimizing their scientific impact and cost effectiveness by strategic planning and coordination at the European level. [...]

(4.3.1.2) One can contemplate at least the following four areas where SMFs have a role to play: [...]

- Telescope networks for continuous photometric, spectroscopic or temporal coverage [...]

Astronet’s “Infrastructures Roadmap” describes:

“(5.4) Some of the goals in the Science Vision are best accomplished with smaller facilities that fall below the cost limit of this Infrastructure Roadmap. An important example is a global network of ground-based, synoptic instruments that continuously monitor magnetic and velocity fields as well as spectrally resolved radiative output over the full solar disk with sufficient spatial resolution. [...]

To ensure the scientific productivity of these smaller facilities / instruments, it is vital that their development, construction, and operation are well coordinated among each other and with space missions.”

In this sense the research facilities for solar and stellar seismology still have a potential which can be improved. For example in asteroseismology space and ground observations are complementary. Space missions have their own mechanisms for involving the community. However, there is potential to improve this involvement for ground-based facilities by a close coordination of observing programs to enable networking and a close coordination of post-focus instrument capabilities and data quality. A continuing HELAS could provide the means for such coordination.

Concentrating on research facilities for helioseismology, it seems that there is no European observational facility other than BiSON at this time. Efforts are under way to set up a major centre for the interpretation of SDO helioseismology data at MPS in Germany. With the fast increase of data volumes, helioseismology requires very significant computational resources. It might be now also the time to start working on an adequate ground or near-Earth complement to Solar Orbiter.

6 Conclusions

Establishing the European Helio- and Asteroseismology Network (HELAS) in 2006, funded as Coordination Action under the EC’s Sixth Framework Programme, resulted in a steady increase of visibility and impact of European scientific research in this area. The productivity and innovation rate have markedly increased through the efforts of HELAS. Looking back, the first four years of HELAS were a success. HELAS has become a trademark. The funding of the HELAS Coordination Action under FP6 ended by 2010 March 31. No complementary funding will then exist. The goals of HELAS, preparing the astrophysical community for the opportunities of the next decade, continue to be relevant and must be carried through that period. A continuation of HELAS along the same funding line means a coordinated effort of the stellar seismology community. We call on this stellar seismology community to contact their respective national representatives on the European Commission’s Research Capacities/Infrastructures Program Committee to present HELAS and its importance and relevance to the European Research Area. In addition we would appreciate if you could contribute your views and ideas to the HELAS discussion forum at: <http://www.helas-eu.org>

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