

AsteroFLAG—from the Sun to the Stars

W. J. Chaplin, T. Appourchaux, J. Ballot, F. Baudin, T. R. Bedding, J. Christensen-Dalsgaard, O. L. Creevey, Y. Elsworth, S. T. Fletcher, R. A. García, D. O. Gough, G. Houdek, S. J. Jiménez-Reyes, H. Kjeldsen, M. Lazrek, C. Neiner, R. New, C. Régulo, D. Salabert, R. Samadi, T. Sekii, T. Toutain, S. Turck-Chièze



Abstract

We stand on the threshold of a critical expansion of asteroseismology of Sun-like stars—the study of stellar interiors by observation of their global acoustic modes of oscillation. The Sun-like oscillations give a very rich spectrum allowing the internal structure and dynamics to be probed down into the stellar cores to very high precision. Asteroseismic observations of many stars will allow multiple-point tests of crucial aspects of stellar evolution and dynamo theory. Our proposed project will make a major contribution to position the field to make optimal use of the expected large quantities of data. We will conduct a comprehensive hare-and-hounds exercise, in which realistic artificial datasets will be used to assess the accuracy and precision of methods that extract the mode parameters. Accurate and precise mode parameters are a vital prerequisite for accurate inference on the stellar interiors. Crucial to our proposal is the transfer of expertise from analysis of data on the Sun (helioseismology), in particular knowledge acquired from the solarFLAG group, which has conducted similar, successful hare-and-hounds exercises for the helioseismic case; and hare-and-hounds exercises conducted as part of the preparation for the CNES COROT mission.

1. Scientific Rationale

1.1 Context

Stars with sub-surface convection zones, like the Sun, display acoustic resonant oscillations. The stochastic excitation mechanism limits the amplitudes of the modes to intrinsically weak values. However, it gives rise to an extremely rich spectrum of modes. The excited pressure (p) modes probe different interior volumes, with the radial and other low angular-degree modes probing as deeply as the core. This differential penetration of the modes allows the internal structure and dynamics to be inferred as a function of position, to extreme levels of precision not usually encountered in astrophysics. The Sun has not surprisingly been the exemplar for the development of seismic methods for probing stellar interiors. The study of the global, resonant p-mode oscillations of the Sun—the field of global *helioseismology*¹—recently celebrated its Silver Anniversary.

The detection of Sun-like oscillations in other stars offers the prospect of our being able to test theories of stellar evolution and stellar dynamos using many stars rather than just one (the Sun)². A wide range of *asteroseismic* targets is on offer at different epochs along stellar evolutionary life cycles. The theories will therefore be subjected to a very exacting examination—how well will they be able to describe the interiors of such a cross-section of stars?

The fact that the Sun-like oscillations have such small amplitudes (*e.g.*, several centimetres-per-second for the most prominent low-degree solar modes) has made the extension of observations to other stars very challenging. However, the ingenuity of the observers is bearing fruit³, with data on Sun-like oscillations now available for more than

fifteen stars, with the confirmed detections ranging from dwarf stars that, like the Sun, have not yet reached the end of the hydrogen core-burning phase, to evolved red-giant stars. These asteroseismic observations have been made at ground-based telescopes⁴ (using spectrographs such as CORALIE, ELODIE, HARPS, UCLES and UVES), and by satellite instruments (WIRE⁵ and MOST⁶). With new space missions soon to be launched (*e.g.*, COROT⁷), others under development (*e.g.*, Kepler⁸) and extension of the ground-based capabilities planned (*e.g.*, the proposed SONG⁹ asteroseismic network), we stand on the threshold of a large increase not only in the number of stars for which data are available, but also in the lengths of those datasets (which are at present typically measured in days to weeks, rather than the many-year sets available for the Sun). As such, our application to ISSI is very timely. Its aim is to make a significant contribution to position the field to make optimal use of the new, and future, asteroseismic data.

Our collaboration has heritage in the areas necessary to deliver on the proposed project: Expertise from those involved in the cutting-edge ground-based asteroseismic observations (which have led the way on the new discoveries), and the upcoming COROT space mission; leading theoreticians on the interior structures of stars, and the Sun-like oscillations; and crucial expertise from those involved in the analysis of the so-called Sun-as-a-star data. These helioseismic data come from observations that view the Sun as if it were a star. The observations do not resolve the visible disc, and are sensitive only to the low-degree modes whose oscillations have the simplest spatial structure. Owing to a lack of spatial resolution, the Sun-like asteroseismic data will be limited for the foreseeable future to these same modes. (Nature has therefore been kind to those wishing to test stellar evolution theory, in that these are the modes that probe the deep interiors, and therefore the evolutionary ‘engines’, of the stars.) The Sun-as-a-star analysis methods consequently have *direct* application to data collected on other Sun-like stars. Application to the asteroseismic case of knowledge acquired from years of development and refinement of the Sun-as-a-star analysis lies at the heart of our program, work that is being led by an international collaboration called the solar Fitting at Low Angular degree Group—*solarFLAG*¹⁰. Our *asteroFLAG* group contains key members of solarFLAG, several of whom have already been engaged in transfer of knowledge to the asteroseismic problem through their involvement in COROT.

1.2 The Proposed Project

The input data for probing stellar interiors are the mode parameters. Accurate mode parameter data are a vital prerequisite for robust, accurate inference on the internal structure. Complicated algorithms are used to extract estimates of these parameters, usually by fitting mode structure in power frequency spectra of the observations to complicated multi-parameter models. The specific aim of the *asteroFLAG* project is to quantify how accuracy and precision in the extracted parameters is affected by changes in the intrinsic stellar properties, and dataset properties (*e.g.*, length and signal-to-noise ratio).

The work will be conducted for Main Sequence stars within the framework of a hare-and-hounds exercise, an approach applied with great success in the solarFLAG work. Sets of artificial asteroseismic data will be generated by a modified version of the solarFLAG simulation code. We have considerable expertise in the generation of realistic artificial data, and solarFLAG has shown how these data can be a powerful diagnostic tool for testing the mode fitting codes¹¹. Our program represents a major extension of the hare-and-hounds exercises conducted as part of the preparation for COROT¹². We will be testing a larger

number of stellar models, over a finer parameter grid. We will include the effects of artificial stellar activity cycles in the data. The varying activity shifts the mode parameters, and we know from the solar case that the effects can introduce subtle unwanted bias in the results if they are not properly accounted for. In addition, we will also use our data to look at the implications for observation and analysis of multiple targets in open clusters¹³.

The input mode parameters required to build the asteroFLAG datasets will come from stellar evolution codes. These codes will evolve Sun-like stars of different masses on the lower Main Sequence. Snapshots will be taken at several epochs, up to the end of the hydrogen core-burning phase. This will give a grid of seismic models. Datasets will then be generated using the seismic model parameters as input, with various rotation and stellar-cycle characteristics imposed, at various noise levels, dataset lengths and angles of inclination offered to the observer. The inclination, measured with respect to the rotation axis of the star, has an important impact on the visibility of different mode components, and we know from solarFLAG and other studies¹⁴ that poor modeling of the visibility functions can have an adverse effect on some of the fitted parameters.

The complete grid of spectra will be fitted by the fitting codes of the ‘hounds’ in the group. This will provide an unprecedented opportunity to test how up to ~10 hounds approach the same fitting problem. The fitted parameters will then be carefully analyzed to assess the output accuracy and precision, from comparison not only with the input values, but also the results from hound to hound. This will reveal common sources of systematic bias, and highlight the most favorable fitting strategies. The implications for subsequent use of the mode parameters¹⁵ for inferring the internal structure and dynamics will then be assessed. This will be done for the short, one to a few week datasets currently available, up to the several-month-long sets expected from COROT.

2. Project Schedule

Our schedule will contain two ISSI workshops for the whole group.

- Prior to the first ISSI workshop, working teams will be created within the asteroFLAG group. Team 1 will be responsible for the stellar evolutionary codes, and generation of the seismic inputs; Team 2 for choices made on dataset length and quality. The information from these groups will be used by Team 3 to generate the artificial asteroseismic data. Only Team 3 will have full knowledge of the content of each dataset (and as such, they will be the true ‘hares’). The hounds (Team 4) will then apply their fitting codes, with *a priori* knowledge limited to that available for real data. Accurate mode classification plays an important part in the parameter extraction. This is because one must fit the proper structure (which may comprise of several rotationally split components, of varying visibility) to each mode. The remit of Team 4 will therefore also cover mode identification¹⁶.
- We would expect to hold the first ISSI workshop in the autumn of 2006. The working teams will have already started their activities, and this workshop will develop a clear and coordinated program for each of the teams.
- Over the first half of 2007, Teams 1 to 3 will work on generating the artificial data. At the same time, Team 4 will be provided with ‘strawman’ data, based on solarFLAG, to allow them to test modifications and developments of the fitting codes, which will be needed

for the more general asteroseismic case. They will at the same time seek to refine a general mode-identification package.

- The artificial spectra will be fitted by Team 4, and the results analyzed by Team 3, in the second half of 2007. The second ISSI workshop would be held in the autumn of 2007, at which a full analysis of the results would be presented. This workshop will be concerned with reaching clear consensus on the conclusions and implications of the results.

3. Expected Outputs

- We expect to submit several papers to refereed academic journals. For example, there would be a paper to explain in detail the framework of the hare-and hounds exercise, and how the artificial seismic data were generated; and several papers that will discuss the results of the exercise, and the implications for analysis of extant, and future, asteroseismic data on Main Sequence stars, and open clusters. These papers will be supplemented by internal reports, with additional detail on procedures and results.
- We would aim to present an overview of the project at the major biennial helioseismology and asteroseismology conference (SOHO18/GONG 2006/HELAS I), being held in Sheffield (UK) in 2006 August; and to make a presentation of preliminary results at the HELAS II Conference, being held in Göttingen in 2007 August.
- We will also seek to make the artificial datasets available to the wider asteroseismic community, via the Virtual Observatory (by collaboration with the UK/PPARC Astrogrid project).

4. List of Participants

T. Appourchaux (Institut d'Astrophysique Spatiale/Orsay, France)
J. Ballot (Max Planck Institut für Astrophysik/Garching, Germany)
F. Baudin (Institut d'Astrophysique Spatiale/Orsay, France)
T. R. Bedding (University of Sydney, Australia)
W. J. Chaplin (University of Birmingham, UK; coordinator)
J. Christensen-Dalsgaard (University of Aarhus, Denmark)
O. L. Creevey (High-Altitude Observatory/Boulder, USA)
Y. Elsworth (University of Birmingham, UK)
S. T. Fletcher (University of Birmingham, UK)
R. A. García (Service d'Astrophysique CEA/Saclay, France)
D. O. Gough (Institute of Astronomy/Cambridge, UK)
G. Houdek (Institute of Astronomy/Cambridge, UK)
S. J. Jiménez-Reyes (Instituto de Astrofísica de Canarias/Tenerife, Spain)
H. Kjeldsen (University of Aarhus, Denmark)
M. Lazrek (LPHEA/Marrakech, Morocco)
C. Neiner (Observatoire de Meudon/Paris, France)
R. New (Sheffield Hallam University, UK)
C. Régulo (Instituto de Astrofísica de Canarias/Tenerife, Spain)
D. Salabert (High-Altitude Observatory/Boulder, USA)
R. Samadi (Observatoire de Meudon/Paris, France)
T. Sekii (National Astronomical Observatory of Japan/Tokyo, Japan)
T. Toutain (University of Oslo, Norway)
S. Turck-Chièze (Service d'Astrophysique CEA/Saclay, France)

5. ISSI is the Preferred Implementation Site

Members of asteroFLAG have participated in other ISSI working groups, for example the currently active Phoebus Group¹⁷. We have been impressed by the facilities, on-site support, and smooth running of the workshops. We feel that the ISSI provides an excellent working environment, free from institutional pressures and other diversions. This allows the group members to concentrate fully on the proposed project. Continuous spans of one week of such high-quality time are invaluable for enabling clearly focussed discussion and planning on a project of the type proposed by the asteroFLAG group.

6. Requested Facilities

We will require a meeting room capable of holding up to 23 scientists (the full asteroFLAG contingent), with internet access and data projection facilities. It would also be advantageous to have access to ~2 smaller rooms, to allow splinter meetings of working teams. We would like access to a small number (say 3) of ISSI PCs (having both Windows and Linux operating systems), and a local printer. Group members will bring their own laptops.

7. Requested Financial Support

We request 30 scientist-days of financial support to cover accommodation and *per diem* costs of 15 scientists at each of the two proposed ISSI asteroFLAG workshops, at the usual ISSI rates. Travel costs for the team leader (Chaplin) should not exceed €750. [Note: We will meet travel costs for the participants, and accommodation and *per diem* costs for numbers in excess of 15, from our own institutional funds and held grants, together with a contribution from the European Helio- and Asteroseismology Network (HELAS).]

List of References

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⁸ Borucki W. J. et al., 2005, AAS, 207, 153.01

⁹ SONG website URL <http://astro.phys.au.dk/SONG/>

¹⁰ solarFLAG website URL <http://bison.ph.bham.ac.uk/~wjc/Research/FLAG.html>

¹¹ Chaplin W. J., Appourchaux T., Baudin F., et al., 2006, MNRAS, in the press

¹² Appourchaux T., 2003, Ap&SS, 284, 109

¹³ Piau L., Ballot J., Turck-Chièze S., 2005, A&A, 430, 571

¹⁴ Ballot J., García R. A., Lambert P., 2006, MNRAS, in the press

¹⁵ Di Mauro M. P., in: Proceedings of SOHO14/GONG 2004, 'Helio- and Asteroseismology: Towards a Golden Future', ed. D. Dansey, ESA SP-559, Noordwijk, Netherlands, p. 186

¹⁶ Lambert P., Pires S., Ballot J., García R. A., Starck J.-L., Turck-Chièze S., 2006, A&A, submitted

¹⁷ Phoebus Group ISSI website URL <http://www.issi.unibe.ch/teams/GModes/>

Appendix 1: Full Addresses of Applicants

Thierry Appourchaux

Institut d'Astrophysique Spatiale
Batiment 121
91045 Orsay Cedex, France
Thierry.Appourchaux@ias.u-psud.fr
Phone: +33 1 69 85 86 29
Fax: +33 1 69 85 87 01

Jérôme Ballot

Max Planck Institut für Astrophysik
Karl-Schwarzschild-Str. 1
Postfach 1317
D-85741 Garching, Germany
jballot@MPA-Garching.mpg.de
Phone: +44 89 30000 2195
Fax: +44 89 30000 2235

Frédéric Baudin

Institut d'Astrophysique Spatiale
Batiment 121
91045 Orsay Cedex, France
Frederic.Baudin@ias.u-psud.fr
Phone: +33 1 69 85 86 07
Fax: +33 1 69 85 87 01

Tim Bedding

School of Physics
University of Sydney 2006
Australia
bedding@physics.usyd.edu.au
Phone: +61 2 9351 2680
Fax: +61 2 9351 7726

William Chaplin

School of Physics and Astronomy,
University of Birmingham,
Edgbaston, Birmingham B15 2TT, UK
w.j.chaplin@bham.ac.uk
Phone: +44 121 414 4599
Fax: +44 121 414 4601

Jørgen Christensen-Dalsgaard

Department of Physics and Astronomy,
University of Aarhus
Ny Munkegade, Building 520
DK-8000 Aarhus C, Denmark
jcd@phys.au.dk
Phone: +45 89 42 36 14
Fax: +45 86 12 07 40

Orlagh Creevey

High Altitude Observatory, NCAR
P.O. Box 3000, Boulder
CO 80307-3000, USA
Creevey@ucar.edu
Phone: +1 303 497 1524
Fax: +1 303 497 1589

Yvonne Elsworth

School of Physics and Astronomy,
University of Birmingham,
Edgbaston, Birmingham B15 2TT, UK
y.p.elsworth@bham.ac.uk
Phone: +44 121 414 4575
Fax: +44 121 414 4601

Stephen Fletcher

School of Physics and Astronomy,
University of Birmingham,
Edgbaston, Birmingham B15 2TT, UK
stfltech@bison.bham.ac.uk
Phone: +44 121 414 4597
Fax: +44 121 414 4601

Rafael García

Service d'Astrophysique CEA Saclay
L'Orme des merisiers, Bat. 709
91191 Gif-sur-Yvette Cedex
France
rgracia@cea.fr
Phone: +33 1 69082725
Fax: +33 1 69086577

Douglas Gough

Institute of Astronomy,
Cambridge University,
Madingley Road, Cambridge
CB3 0HA, UK

Douglas@ast.cam.ac.uk

Phone: +44 1223 337 518

Fax: +44 1223 337 523

Günter Houdek

Institute of Astronomy,
Cambridge University,
Madingley Road, Cambridge
CB3 0HA, UK

hg@ast.cam.ac.uk

Phone: +44 1223 766 099

Fax: +44 1223 337 523

Sebastián Jiménez-Reyes

Instituto de Astrofísica de Canarias
38200 La Laguna, Tenerife, Spain

Sebastian.jimenez@iac.es

Phone: +34 92 260 5268

Fax: +34 92 2605 210

Hans Kjeldsen

Department of Physics and Astronomy,
University of Aarhus
Ny Munkegade, Building 520
DK-8000 Aarhus C, Denmark

hans@phys.au.dk

Phone: +45 8942 3779

Fax: +45 8612 0740

Mohamed Lazrek

Université Cady Ayyad de Marrakech
FSSM, Dept Physique, LPHEA
B. P. 2390

Marrakech, Morocco

Lazrek@unice.fr

Phone: +212 61 24 97 88

Fax: +212 44 43 74 10

Coralie Neiner

GEPI, bat. Copernic A
Observatoire de Meudon
5, place Jules Janssen
91195 Meudon Cedex

Coralie.Neiner@obspm.fr

Phone: +33 1250 777 85

Fax: +33 1450 778 72

Roger New

Faculty of Arts, Computing,
Engineering and Sciences,
Sheffield Hallam University
City Campus,

Sheffield S1 1WB, UK

r.new@shu.ac.uk

Phone: +44 114 225 3034

Fax: +44 114 225 3066

Clara Régulo

Instituto de Astrofísica de Canarias
38205 La Laguna, Tenerife, Spain

crr@iac.es

Phone: +34 92 260 5186

Fax: +34 92 2605 210

David Salabert

High Altitude Observatory, NCAR
P.O. Box 3000, Boulder
CO 80307-3000, USA

Salabert@ucar.edu

Phone: +1 303 497 1594

Fax: +1 303 497 1589

Réza Samadi

LESIA Observatoire de Meudon
Bat. 12, 5 place Jules Janssen
F-92195, Meudon, France

Reza.Samadi@obspm.fr

Phone: +33 1 45 07 78 48

Fax: +33 1 45 07 78 72

Takashi Sekii

National Astronomical Observatory

Mitaka, Tokyo 181-8588, Japan

Sekii@solar.mtk.nao.ac.jp

Phone: +81 422 34 3712

Fax: +81 422 34 3700

Thierry Toutain

Institute of Theoretical Astrophysics

Postboks 1029 Blindern

0315 Oslo, Norway

tierry.toutain@astro.uio.no

Phone: +47 22 85 42 87

Fax: +47 22 85 65 05

Sylvaine Turck-Chièze

Service d'Astrophysique CEA Saclay

L'Orme des merisiers, Bat. 709

91191 Gif-sur-Yvette Cedex

France

turck@hep.saclay.cea.fr

Phone: +33 1 69084387

Fax: +33 1 69086577

Appendix 2: Brief CVs of the Applicants

Thierry Appourchaux

Professional Education

PhD in Astronomy and Space Techniques, University of Paris VI, 1984

Present Position

Head of the Solar and Stellar Physics Group of the Institut d'Astrophysique Spatiale
Directeur de Recherche of CNRS

Research Interests and Expertise

Helioseismology; search for g-modes, excitation of p- and g-modes.

Asteroseismology

Space instrumentation

More than 40 refereed papers, more than 60 conference papers

International Collaborations, Affiliations

Co-I of SOHO VIRGO investigation

Instrument Scientist of the LOI, subsystem of VIRGO

Co-I of the COROT mission (Asteroseismology and Exoplanets)

Co-I of the PICARD mission (Solar diameter and g modes)

Coordinator of Phoebus Group

Member of solarFLAG

Member of the DUC of the GONG network

Associated scientist of SOI/MDI aboard SOHO

Jérôme Ballot

Professional Education

PhD, Université Paris XI, Orsay, 2004

Present Position

Post-doctoral position, Max-Planck-Institut für Astrophysik, Garching, Germany

Research Interests and Expertise

Global helioseismology and asteroseismology

Numerical simulations of stellar interiors

6 refereed papers, 13 conference papers

International Collaborations, Affiliations

Co-I of COROT (Seismology Working Group)

Collaborator on the GOLF data analysis

Frédéric Baudin

Professional Education

Ph.D. in Physics, University of Paris XI/Orsay, 1993

Present Position:

Associated Astronomer, Institut d'Astrophysique Spatiale, France

Research Interests and Expertise

Global and local helioseismology, data analysis
44 publications including 18 refereed papers

International Collaborations, Affiliations

Co-I of the COROT mission (Asteroseismology and Exoplanets)
Associate Scientist of GOLF
Member of solarFLAG
Member of Phoebus group

Tim Bedding**Professional Education**

PhD, School of Physics, University of Sydney, 1992
Graduate Certificate in Higher Education, University of Sydney, 2003

Present Position

Associate Professor, School of Physics, University of Sydney

Research Interests and Expertise

Asteroseismology; Optical interferometry
About 75 publications in refereed journals; about 80 in conference proceedings

International Collaborations, Affiliations

Member of Australian Gemini Steering Committee
PI of two Discovery Grants from the Australian Research Council
Member of SONG project

William Chaplin**Professional Education**

PhD, School of Physics & Astronomy, Birmingham, 1993
Postgraduate Certificate in Learning and Teaching in Higher Education, University of Birmingham, 2001

Present Position

Senior Lecturer, School of Physics & Astronomy, University of Birmingham

Research Interests and Expertise

Global helioseismology, and asteroseismology
About 60 publications in refereed journals; about 40 in conference proceedings

International Collaborations, Affiliations

Co-I of BiSON
Coordinator for solarFLAG collaboration
Co-I on two PPARC E-science projects (eSDO and Data Mining Algorithms)
Member of PPARC Astrogrid Science Advisory Group
Member of Phoebus group

Jørgen Christensen-Dalsgaard

Professional Education

MSc, University of Aarhus, 1975

PhD, Department of Applied Mathematics and Theoretical Physics, Cambridge University, 1978

Present Position

Professor of Helio- and Asteroseismology, Department of Physics and Astronomy, University of Aarhus, Denmark

Research Interests and Expertise

Stellar structure and evolution

Stellar oscillations

Global helioseismology, and asteroseismology

About 120 publications in refereed journals; about 170 in conference proceedings

International Collaborations, Affiliations

Co-I of MDI and GOLF on SOHO

Head of Danish AsteroSeismology Centre

Member of ESA Science Programme Committee

Member of Board of Nordic Optical Telescope

Member of SONG project

Orlagh Creevey

Professional Education

Present: PhD student Astrophysics

Diploma de Estudios Avanzados, 'Física del Cosmos', University of La Laguna, Tenerife

MSc, Mathematics, National University of Ireland Maynooth (NUIM), Ireland

HDipEd Higher Diploma in Education (Teaching), NUIM

Present Position

PhD student of the University of La Laguna, Tenerife, Spain

Scholarship to conduct research at HAO (NCAR), Boulder, CO, USA

Research Interests and Expertise

Asteroseismology of solar-like stars, Delta Scuti stars.

Pulsating stars in binary systems

2 refereed journal publications, 3 proceedings

International Collaborations, Affiliations

Collaborator of IAC, Tenerife, Spain

Collaborator of CAUP, Porto, Portugal

Yvonne Elsworth

Professional Education

PhD, Victoria University of Manchester, 1976

Present Position

Professor of Helioseismology at the University of Birmingham

Head of High-Resolution Spectroscopy Group, University of Birmingham

Research Interests and Expertise

Helioseismology: BiSON network that observes the Sun at low-degree

Data analysis, interpretation

About 65 publications in refereed journals, 60 in conference proceedings

International Collaborations, Affiliations

PI of the BiSON project

Co-I of eSDO PPARC E-science project

Member of solarFLAG

Member of Phoebus group

Stephen Fletcher**Professional Education**

Present: PhD student, helioseismology and asteroseismology

MSci Degree (first class) in Physics and Astronomy, School of Physics & Astronomy, Birmingham, 2002

Present Position

PhD student and post-graduate teaching assistant, School of Physics & Astronomy, Birmingham

Research Interests and Expertise

Global helioseismology and asteroseismology

Power spectrum and time-series analysis

2 publications in refereed journals; 1 in conference proceedings

International Collaborations, Affiliations

Member of solarFLAG collaboration

Rafael García**Professional Education**

PhD, in Astronomy and Astrophysics, Universidad de La Laguna, Tenerife, Spain, 1996

Present Position

Research engineer, Service d'Astrophysique CEA/Saclay, France

Research Interests and Expertise

Global helioseismology, asteroseismology

About 30 publications in refereed journals; about 60 in conference proceedings

International Collaborations, Affiliations

Co-I of GOLF/SOHO; Responsible at the CEA/Saclay for the instrument

Co-I of MDI/SOHO

Co-I of GONG

Co-I of COROT

Scientific Manager of GOLF-NG prototype

Member of solarFLAG

Member of Phoebus group

Member of the Seismology Working Group of COROT

Douglas Gough

Professional Education

PhD, University of Cambridge, 1966

Present Position

Professor of Theoretical Astrophysics, University of Cambridge, UK
Honorary Professor of Astronomy, Queen Mary and Westfield College, University of London, UK

Fellow Adjoint, Joint Institute for Laboratory Astrophysics, Boulder, USA

Visiting Professor, Department of Physics, Stanford University, USA

Research Interests and Expertise

Stellar fluid dynamics, solar and stellar structure, stellar pulsation

Helioseismology and asteroseismology, inverse theory

More than 140 refereed papers, more than 160 conference papers

International Collaborations, Affiliations

Co-I on SOI/MDI, VIRGO and GOLF on SOHO

Co-I on HMI/SDO

Member of GONG

Member of Phoebus group

Günter Houdek

Professional Education

PhD, Astrophysics, Institute for Astronomy, University of Vienna, 1997

Present Position

Postdoctoral Research Fellow, Institute of Astronomy, Cambridge

Research Interests and Expertise

Stellar fluid dynamics, solar and stellar structure, stellar pulsation

Helioseismology and asteroseismology

About 20 publications in refereed journals; about 20 in conference proceedings

International Collaborations, Affiliations

Member of GONG

Member of ENEAS

Sebastián Jiménez-Reyes

Professional Education

PhD, La Laguna University, Spain, 2001, funded by the High Altitude Observatory (Boulder, USA)

Masters Thesis, La Laguna University, Spain, 1996

Present Position

Postdoctoral Research, Instituto de Astrofísica de Canarias, Spain

Research Interests and Expertise

Sun: activity, atmosphere, helioseismology, magnetic fields, rotation

Stars: asteroseismology, eclipsing binaries, low-mass, brown dwarfs

About 20 publications in refereed journals; about 28 in conference proceedings

International Collaborations, Affiliations

Co-I of one PNE science projects
Member of HELAS
Member of GOLF-team and ECHO-team
Member of solarFLAG

Hans Kjeldsen

Professional Education

Cand Scient, MSc Astronomy from University of Aarhus, Denmark
(Hovedfag and speciale in Astronomy), 1989
PhD in Astronomy from University of Aarhus, Denmark, 1992

Present Position

Lektor (Associate Professor) at Institut for Fysik og Astronomi (Department of Physics and Astronomy), Aarhus Universitet, Denmark

Research Interests and Expertise

Asteroseismology of main-sequence stars: solar-type stars (including the Sun), α Cen stars, delta Scuti stars and beta Cephei stars. Asteroseismology of EC 14026 stars (sdB stars) and red giants. High-precision photometry and spectroscopy. Time series and Fourier analysis using statistical weights. Theoretical models of main sequence stars. Development of high-precision instrumentation for Space (Rømer ESA EDDINGTON, COROT and Kepler satellite missions). Astronomy education and public outreach.
51 publications in refereed journals; 69 publications in conference proceedings

International Collaborations, Affiliations

Member of European Southern Observatory Scientific Technical Committee (ESO STC)
Member of Nordic Optical Telescope Council
Member of Nordic Optical Telescope Scientific Technical Committee (NOT STC)
Member of the International Scientific Committee (CCI) of the Roque de los Muchachos and Teide Observatories.
Co-I of COROT
Member of ENEAS
Danish AsteroSeismology Centre
Member of SONG Project

Mohamed Lazrek

Professional Education

PhD, Liège, Belgium, 1993

Present Position

Professor, UCAM, University of Marrakech, Morocco

Research Interests and Expertise

Global helioseismology, and asteroseismology; Site testing
About 20 publications in refereed journals; about 15 publications in conference proceedings

International Collaborations, Affiliations

Co-I of IRIS

Co-I of GOLF/SOHO

Member of solarFLAG

Member of the Moroccan group in charge of the site testing in Anti-Atlas Mountains within framework of 'ELT Design Study' (Extremely Large Telescope)

Coralie Neiner**Professional Education**

PhD in astronomy, University of Strasbourg, France, 2002

PhD in astronomy, University of Amsterdam, The Netherlands, 2002

Present Position

Researcher (CR2) at the CNRS, GEPI laboratory, Observatoire de Paris-Meudon, France

Research Interests and Expertise

Asteroseismology of hot stars and solar-like stars

Expertise: spectroscopy, spectropolarimetry, modeling

About 15 publications in refereed journals; about 35 publications in conference proceedings

International Collaborations, Affiliations

Co-I of COROT

PI of a long-term PNPS program on magnetic fields in hot stars

WP manager of GAIA and coordinator of the GHOST for Gaia

Roger New**Professional Education**

PhD, University of Birmingham, 1979

Present Position

Senior Academic, Sheffield Hallam University, Sheffield

Research Interests and Expertise

Global helioseismology, and asteroseismology; spectroscopy of plasmas

About 50 publications in refereed journals and 40 in conference proceedings

International Collaborations, Affiliations

Co-I of BiSON

Member of solarFLAG

Clara Régulo**Professional Education**

Ph.D., Universidad de La Laguna, Tenerife, Spain, 1987

Scholarship at Instituto de Astrofísica de Canarias from 1983 till 1986

Present Position

Assistant Professor, Universidad de La Laguna, Tenerife

Research Interests and Expertise

Global helioseismology, and asteroseismology

About 45 publications in refereed journals and 40 in conference proceedings

International Collaborations, Affiliations

Participation in 12 research projects with public financing.

David Salabert**Professional Education**

PhD, University of Nice-Sophia Antipolis, Nice (France), 2003

Postgraduate Certificate in Astrophysics (Majors: Imagery and Teledetection), University of Nice-Sophia Antipolis, Nice (France), 1999

Present Position

Postdoctoral Fellowship, National Center for Atmospheric Research/High Altitude Observatory, Boulder CO (USA)

After March 31st 2006: Postdoctoral Research Associate, Global Oscillation Network Group Program, National Solar Observatory, Tucson AZ (USA)

Research Interests and Expertise

Global helioseismology (both full-disc and spatially-resolved observations), and asteroseismology

About 10 publications in refereed journals; about 10 in conference proceedings

International Collaborations and Affiliations

Member of solarFLAG

Réza Samadi**Professional Education**

PhD, Pierre and Marie Curie University, Paris, 2000

Present Position

Astronomer Assistant (Astronome Adjoint), Observatoire de Paris, Meudon, France

Research Interests and Expertise

Helioseismology and asteroseismology; convection in stars

17 publications in refereed journals and 16 in conference proceedings

International Collaborations, Affiliations

Co-I of COROT

Takashi Sekii**Professional Education**

PhD, University of Tokyo, 1990

Present Position

Associate Professor, National Astronomical Observatory of Japan

Research Interests and Expertise

Global- and local-helioseismology, asteroseismology, inverse theory

60 publications: 20 refereed papers

International Collaborations, Affiliations

Co-Investigator of Solar-B Project
Co-Investigator of HMI/SDO Project
Member of GONG collaboration
Member of SOI/MDI collaboration
Member of solarFLAG
Member of Phoebus Group

Thierry Toutain**Professional Education**

PhD Thesis, University of Paris VI, 1990

Present Position

Chargé de recherché CNRS, Observatoire de la Côte d'Azur
Research Fellow, High-Resolution Spectroscopy Group, University of Birmingham

Research Interests and Expertise

Helio and asteroseismology: data analysis
54 publications: 23 refereed papers

International Collaborations, Affiliations

Co-I of the VIRGO/SOHO experiment
Co-I of the COROT mission (Asteroseismology and Exoplanets)
Co-I of the PICARD mission (Solar diameter and g modes)
Member of solarFLAG
Member of Phoebus Group

Sylvaine Turck-Chièze**Professional Education**

PhD Physics, Orsay, 1985

Present Position

Research Director CEA, Chief of the laboratory Nuclear Astrophysics and Stellar Plasmas in Service d'Astrophysique au CEA Saclay France

Research Interests and Expertise

Stellar modelling, Global helioseismology, Asteroseismology
Plasma properties and neutrino properties, Nuclear physics
More than 50 publications in refereed journals and more than 100 in conference proceedings (including invited talks): about 3000 citations

International Collaborations, Affiliations

Co-I on GOLF
GOLFNG/DynaMICS collaboration
Co-I COROT
Plasma Physics: connection with plasma physics and ITER