

SOLAR AND STELLAR VARIABILITY:  
IMPACT ON EARTH AND PLANETS

IAU SYMPOSIUM No. 264

*COVER IMAGE:*

Illustration of the impact of the solar wind on Earth's magnetosphere (source: SOHO/NASA), and the dome of a new heliometer developed at the Observatório Nacional at Rio de Janeiro to perform accurate measurements of the solar diameter (see the paper by V. A. d'Ávila et al. in these Proceedings).

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INTERNATIONAL ASTRONOMICAL UNION  
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# SOLAR AND STELLAR VARIABILITY: IMPACT ON EARTH AND PLANETS

PROCEEDINGS OF THE 264th SYMPOSIUM OF  
THE INTERNATIONAL ASTRONOMICAL UNION  
HELD IN RIO DE JANEIRO, BRASIL  
AUGUST 3–7, 2009

Edited by

**ALEXANDER G. KOSOVICHEV**  
*Stanford University, Stanford, CA, USA*

**ALEXANDRE H. ANDREI**  
*Observatório Nacional, Rio de Janeiro, Brazil*

and

**JEAN-PIERRE ROZELOT**  
*OCA-Fizeau Dept, CNRS UMR 6525, & Université de Nice-Sophia-Antipolis,  
Grasse, France*



CAMBRIDGE UNIVERSITY PRESS

The Edinburgh Building, Cambridge CB2 8RU, United Kingdom  
32 Avenue of the Americas, New York, NY 10013-2473, USA  
477 Williamstown Road, Port Melbourne, VIC 3207, Australia  
Ruiz de Alarcón 13, 28014 Madrid, Spain  
Dock house, The Waterfront, Cape Town 8001, South Africa

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First published 2010

Printed in the United Kingdom at the University Press, Cambridge

Typeset in System L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>

*A catalogue record for this book is available from the British Library*

*Library of Congress Cataloguing in Publication data*

This book issue has been printed on FSC-certified paper and cover board. FSC is an independent, non-governmental, not-for-profit organization established to promote the responsible management of the world's forests. Please see [www.fsc.org](http://www.fsc.org) for information.

ISBN 9780521764926 hardback  
ISSN 1743-9213

## Table of Contents

Preface .....	xii
Organizing committee .....	xvii
Conference participants .....	xviii

## I. INTRODUCTION

*Chair: C. Fang*

The Sun and stars as the primary energy input in planetary atmospheres..... <i>I. Ribas</i>	3
--	---

## II. OBSERVATIONS OF SOLAR AND STELLAR VARIABILITY

*Chair: A. G. Kosovichev*

One solar cycle of solar astrometry with MDI/SOHO .....	21
<i>M. Emilio, J. R. Kuhn &amp; R. I. Bush</i>	
Helioseismic inferences.....	33
<i>H. Shibahashi</i>	
Variability of the solar spectral irradiance and energetic particles.....	39
<i>A. Silva-Válío</i>	
A solar cycle lengthwise series of solar diameter measurements.....	49
<i>J. L. Penna, A. H. Andrei, S. C. Boscardin, E. Reis Neto &amp; V. A. d'Ávila</i>	
Solar-like stars seismology.....	55
<i>D. Pricopi &amp; M. D. Suran</i>	
Sounding stellar cycles with Kepler – preliminary results from ground-based chromospheric activity measurements.....	57
<i>C. Karoff, T. S. Metcalfe, W. J. Chaplin, S. Frandsen, F. Grundahl, H. Kjeldsen, D. Buzasi, T. Arentoft &amp; J. Christensen-Dalsgaard</i>	
Differential rotation on active late-type stars observed with <i>Corot</i> .....	60
<i>P. Gondoin, M. Fridlund, D. Gandolfi &amp; E. Güenter</i>	
A comparison of measured and simulated solar network contrast.....	63
<i>N. Afram, Y. C. Unruh, S. K. Solanki, M. Schüssler &amp; S. K. Mathew</i>	
Multifractal spectrum of solar active region NOAA 10960 in the H $\alpha$ spectral line	66
<i>D. Batmunkh</i>	
Observed variations of the solar photospheric diameter.....	72
<i>S. C. Boscardin, E. Reis Neto, J. Penna, A. R. Rodriguez Papa, A. H. Andrei &amp; V. A. d'Ávila</i>	
The asymmetric light curves of the GSC 2764 1417 (And), GSC 3355 0394 (Per) and GSC 2537 0520 (Psc).....	75
<i>R. G. Samec, E. R. Figg, R. Melton, C. M. Labadorf, J. Miller, R. McKenzie, D. R. Faulkner &amp; W. Van Hamme</i>	

The EUV spectral irradiance of the Sun from 1997 to date . . . . .	78
<i>G. Del Zanna &amp; V. Andretta</i>	
Semi-harmonic and intermittent solar decimetric spikes . . . . .	81
<i>F. C. R. Fernandes, M. J. A. Bolzan, R. R. Rosa, J. A. S. S. Dutra, J. R. Cecatto, H. Mészárosová &amp; H. S. Sawant</i>	
The periodic variation of 6.7 days for total solar radiation . . . . .	84
<i>W. Q. Gan &amp; Y. P. Li</i>	
Looking for variable stars in galactic open clusters . . . . .	87
<i>C. Greco, N. Mowlavi, L. Eyer, M. Spano, M. Varadi &amp; G. Burki</i>	
Doppler imaging of the active star PW And . . . . .	90
<i>S.-H. Gu, A. C. Cameron &amp; K. M. Kim</i>	
New Improvements of HASTA for the analysis of chromospheric solar events . . . . .	93
<i>L. Leuzzi, C. Francile, M. L. Luoni, M.G. Rovira &amp; J. I. Castro</i>	
Coronal magnetic fields from the inversion of linear polarization measurements . . . . .	96
<i>Y. Liu, H. Lin &amp; J. Kuhn</i>	
Observation of interactions between two erupting filaments . . . . .	99
<i>Y. Liu, J. Su, Y. Shen &amp; L. Yang</i>	
Study of helicity properties of peculiar active regions . . . . .	102
<i>M. C. López Fuentes, C. H. Mandrini &amp; P. Démoulin</i>	
Automatic detection method, forecast and alert of solar proton events . . . . .	105
<i>G. Lin</i>	

### III. SOLAR AND STELLAR CYCLES AND VARIABILITY ON CENTURY TIMESCALE

*Chair: J. Stenflo*

Sunspot cycles and Grand Minima . . . . .	111
<i>D. Sokoloff, R. Arlt, D. Moss, S. H. Saar &amp; I. Usoskin</i>	
Stellar magnetic cycles . . . . .	120
<i>A. F. Lanza</i>	
Do young Suns undergo magnetic reversals? . . . . .	130
<i>S. C. Marsden, S. V. Jeffers, J.-F. Donati, M. W. Mengel, I. A. Waite &amp; B. D. Carter</i>	
Long-term stellar variability . . . . .	136
<i>I. Pagano</i>	
The Cycles of Alpha Centauri . . . . .	146
<i>T. R. Ayres</i>	
Harmonic analysis approach to solar cycle prediction and the Waldmeier effect . . . . .	150
<i>K. Petrovay</i>	
Solar cycles: the past evolution influence . . . . .	155
<i>A. Klutsch &amp; R. Freire Ferrero</i>	

**IV. MAGNETIC ACTIVITY AND DYNAMO MECHANISMS***Chair: V. Martinez-Pilet*

Towards understanding the global magnetism of the Sun and solar-like stars . . .	161
<i>A. S. Brun</i>	
The stellar magnetic dynamo during the evolution across the main sequence . . .	171
<i>S. Hubrig</i>	
Helicity of solar magnetic field from observations . . . . .	181
<i>H. Zhang</i>	
Probability distribution functions for solar and stellar magnetic fields . . . . .	191
<i>J. O. Stenflo</i>	
Oscillatory migratory large-scale fields in mean-field and direct simulations . . . .	197
<i>D. Mitra, R. Tavakol, A. Brandenburg &amp; P. J. Käpylä</i>	
Prediction of solar activity cycles by assimilating sunspot data into a dynamo model. . . . .	202
<i>I. N. Kitiashvili &amp; A. G. Kosovichev</i>	
Transport of open magnetic flux between solar polar regions . . . . .	210
<i>A. A. Pevtsov &amp; V. I. Abramenko</i>	
Surface temperature maps for II Peg during 1999–2002 . . . . .	213
<i>M. Lindborg, M. J. Korpi, I. Tuominen, T. Hackman, I. Ilyin &amp; N. Piskunov</i>	
‘Negative’ surface differential rotation in stars having low Coriolis numbers (slow rotation or high turbulence) . . . . .	219
<i>K. L. Chan</i>	
Evolution of the large-scale magnetic field over three solar cycles . . . . .	222
<i>J. T. Hoeksema</i>	

**V. PHYSICAL MECHANISMS OF SOLAR AND STELLAR VARIABILITY***Chair: H. Shibahashi*

Mechanisms for total and spectral solar irradiance variations . . . . .	231
<i>M. Haberreiter</i>	
Large-scale patterns and ‘active longitudes’ . . . . .	241
<i>V. N. Obridko</i>	
Is there more global solar activity on the Sun? . . . . .	251
<i>J. X. Wang, Y. Z. Zhang, G. P. Zhou, Y. Y. Wen &amp; J. Jiang</i>	
Magnetic energy release: flares and coronal mass ejections . . . . .	257
<i>C. H. Mandrini</i>	
RS CVn binary IM Peg - investigation of stellar activity and surface flows . . . . .	267
<i>H. Korhonen, M. Weber, M. Wittkowski, T. Granzer &amp; K. G. Strassmeier</i>	
The mechanism of the light variability of chemically peculiar stars. . . . .	270
<i>J. Krťička, Z. Mikulášek, J. Zverko, J. Žižňovský, G. W. Henry, J. Skalický &amp; P. Zvěřina</i>	

Analysis of the event of 2004 November 10 . . . . .	273
<i>Yuan Ma &amp; Liying Zhu</i>	
Study of the structures of the explosive events in the UV . . . . .	276
<i>R. T. Niembro-Hernandez, J. E. Mendoza-Torres &amp; K. Wilhelm</i>	
Nonlinear analysis of decimetric solar bursts . . . . .	279
<i>R. R. Rosa, M. J. A. Bolzan, F. C. R. Fernandes, H. S. Sawant &amp; M. Karlický</i>	
Plasma heating in the initial phase of solar flares . . . . .	282
<i>P. Rudawy, M. Siarkowski &amp; R. Falewicz</i>	
The influence of spicules in the solar radius at multiple radio wavelengths . . . . .	285
<i>C. L. Selhorst, A. Silva-Válio, P. A. Martins, D. B. Seriacopi, P. Kaufmann &amp; H. Levato</i>	
Stellar flare diagnostics from multi-wavelength observations . . . . .	288
<i>A. V. Stepanov, Y. T. Tsap &amp; Y. G. Kopylova</i>	
The non-radial propagation of coronal streamers in minimum activity epoch . . . . .	292
<i>A. G. Tlatov &amp; V. V. Vasil'eva</i>	
The formation of an equatorial coronal hole . . . . .	295
<i>L. Yang, Y. Jiang &amp; J. Zhang</i>	
<b>VI. EFFECTS ON SPACE WEATHER AND CLIMATE</b>	
<i>Chair: L. van Driel-Gesztelyi</i>	
New findings increasing solar trend that can change Earth climate . . . . .	301
<i>J.-P. Rozelot, C. Damiani &amp; S. Lefebvre</i>	
Thermospheric temperature and density variations . . . . .	310
<i>H. Fujiwara, Y. Miyoshi, H. Jin, H. Shinagawa, Y. Otsuka, A. Saito &amp; M. Ishii</i>	
Are there variations in Earth's global mean temperature related to the solar activity? . . . . .	320
<i>O. Kjeldseth-Moe &amp; S. Wedemeyer-Böhm</i>	
The CME link to geomagnetic storms . . . . .	326
<i>N. Gopalswamy</i>	
Lower and middle atmosphere and ozone layer responses to solar variation . . . . .	336
<i>A. G. Elias</i>	
Possible traces of solar activity effect on the surface air temperature of mid-latitudes . . . . .	343
<i>A. Kilcik, A. Özgüç &amp; J.-P. Rozelot</i>	
Influence of the solar radiation on Earth's climate using the LMDz-REPROBUS model . . . . .	350
<i>S. Lefebvre, M. Marchand, S. Bekki, P. Keckhut, F. Lefèvre, C. Claud, D. Cugnet, G. Thuillier &amp; A. Hauchecorne</i>	
Solar cycle changes of large-scale solar wind structure . . . . .	356
<i>P. K. Manoharan</i>	



Rapid solar wind and geomagnetic variability during the ascendant phases of the 11-yr solar cycles . . . . .	359
<i>G. Maris &amp; O. Maris</i>	
Observation of non-Gaussianity and phase synchronization in intermittent magnetic field turbulence in the solar-terrestrial environment . . . . .	363
<i>R. A. Miranda, A. C.-L. Chian, S. Dasso, E. Echer, P. R. Muñoz, N. B. Trivedi, B. T. Tsurutani &amp; M. Yamada</i>	
Observation of magnetic reconnection and current sheets in the solar wind . . . . .	369
<i>P. R. Muñoz, A. C.-L. Chian, R. A. Miranda &amp; M. Yamada</i>	

## VII. EFFECTS OF MAGNETIC ACTIVITY ON PLANET FORMATION AND EVOLUTION

*Chair: S. Hasan*

Magnetic activity, high-energy radiation and variability: from young solar analogs to low-mass objects . . . . .	375
<i>M. Güdel</i>	
Stellar activity and magnetic shielding. . . . .	385
<i>J.-M. Grießmeier, M. Khodachenko, H. Lammer, J. L. Grenfell, A. Stadelmann &amp; U. Motschmann</i>	
Detailed characterization of stellar high energy (FUV/EUV/X-ray) radiation fields during protoplanetary system formation . . . . .	395
<i>A. Brown</i>	
Impact of the solar magnetic cycle on a protoplanetary disk . . . . .	401
<i>A. G. Tlatov</i>	
Solar-terrestrial energy transfer during sunspot cycles and mechanism of Earth rotation excitation . . . . .	404
<i>Y. Chapanov &amp; D. Gambis</i>	
Common 22-year cycles of Earth rotation and solar activity . . . . .	407
<i>Y. Chapanov, J. Vondrák &amp; C. Ron</i>	
Manifestations of dark energy in the dynamics of the Solar system . . . . .	410
<i>M. Krížek &amp; J. Brandts</i>	
Polarimetric search for exoplanets with a tangential transit . . . . .	413
<i>L. V. Ksanfomality</i>	

## VIII. IMPACT OF SOLAR AND STELLAR VARIABILITY ON PLANETARY ATMOSPHERES AND CLIMATE

*Chair: A. H. Andrei*

Biological damage due to photospheric, chromospheric and flare radiation in the environments of main-sequence stars . . . . .	419
<i>M. Cuntz, E. F. Guinan &amp; R. L. Kurucz</i>	
Influence of the Schwabe/Hale solar cycles on climate change during the Maunder Minimum. . . . .	427
<i>H. Miyahara, Y. Yokoyama &amp; Y. T. Yamaguchi</i>	

STRESS – STEREO TRansiting Exoplanet and Stellar Survey . . . . .	434
<i>V. Sangaralingam, I. R. Stevens, S. Spreckley &amp; J. Debosscher</i>	
The influence of starspots activity on the determination of planetary transit parameters . . . . .	440
<i>A. Silva-Valio</i>	
UV habitability and dM stars: an approach for evaluation of biological survival . . . . .	443
<i>X. C. Abrevaya, E. Cortón &amp; P. J. D. Mauas</i>	
Evidence for climate variations induced by the 11-year solar and cosmic rays cycles . . . . .	446
<i>W. Bruckman &amp; E. Ramos</i>	
Synchronous manifestation of 160-min pulsations of the ground pressure and Z-component of geomagnetic field at Moscow, Apatity, Oulu, Yakutsk and Tixie . . . . .	449
<i>V. Ye. Timofeev, D. G. Baishev, L. I. Miroshnichenko, S. N. Samsonov &amp; N. G. Skryabin</i>	
Manifestation of the Jupiter’s synodic period in the solar wind, interplanetary magnetic field and geophysical parameters. . . . .	452
<i>S. N. Samsonov &amp; N. G. Skryabin</i>	
Exoplanet environments to harbour extremophile life . . . . .	455
<i>E. Janot-Pacheco, C. A. S. Lage &amp; I. G. P. Lima</i>	

## IX. CURRENT AND FUTURE SPACE MISSIONS AND GROUND-BASED OBSERVING PROGRAMS

*Chair: C. Mandrini*

Space solar missions. . . . .	459
<i>J.-C. Vial</i>	
First thoughts on stellar variability from Kepler commissioning data. . . . .	469
<i>L. M. Walkowicz &amp; G. Basri</i>	
Does the lunar regolith contain secrets of the Solar System? Using the Moon as a cosmic witness plate. . . . .	475
<i>D. S. McKay, L. Riefrio &amp; B. L. Cooper</i>	
X-exoplanets: an X-ray and EUV database for exoplanets. . . . .	478
<i>J. Sanz-Forcada, D. García-Álvarez, A. Velasco, E. Solano, I. Ribas, G. Micela &amp; A. Pollock</i>	
Surveying RFI for a new Brazilian Solar Spectroscopy site . . . . .	484
<i>J. R. Cecatto, P. C. G. Albuquerque, I. O. G. Vila, A. B. Cassiano, C. Strauss &amp; F. C. R. Fernandes</i>	
The development of the Heliumeter of the Observatório Nacional. . . . .	487
<i>V. d’Ávila, E. Reis, J. Penna, L. C. Oliveira, A. Coletti, V. Matias, A. H. Andrei &amp; S. Boscardin</i>	
Brazilian Decimetric Array (BDA) project - Phase II . . . . .	493
<i>C. Faria, S. Stephany, H. S. Sawant, J. R. Cecatto &amp; F. C. R. Fernandes</i>	
Catalogs of variable stars, current and future . . . . .	496
<i>N. N. Samus, E. V. Kazarovets &amp; O. V. Durlевич</i>	

The Indian National Large Solar Telescope (NLST) . . . . .	499
<i>S. S. Hasan</i>	

**X. SUMMARY, OPEN DISCUSSION, AND CLOSING  
REMARKS**

*Chair: J.-P. Rozelot*

Concluding remarks on solar and stellar activities and related planets . . . . .	507
<i>S. Turck-Chièze</i>	

Author index . . . . .	525
------------------------	-----

Subject index . . . . .	529
-------------------------	-----

## Preface

The Sun is a variable star. Understanding the physical mechanisms of the variability and its effects on the Earth and planets is one of the central and long-standing problems of astronomy and astrophysics. Variability of a similar type has been observed in other stars. It is essential to investigate the similarities and differences between solar and stellar variability in order to understand the physical mechanisms and impacts on planets.

During the past decade multi-wavelength observations from several solar and stellar space missions and ground-based observatories have provided a tremendous amount of new information about the physical processes associated with magnetic activity and variability on the Sun and solar-type stars. Key observational results, new theoretical ideas, and models discussed at Symposium 264 are presented in this volume.

Solar observations have provided new data about the solar cycle variations of the structure and dynamics from the interior to the corona and heliosphere. Intriguing connections exist between the interior dynamics, surface magnetism and coronal phenomena. However, despite the great amount of new data, it is still unclear where and how magnetic fields are generated in the Sun, and why it has a regular 22-year magnetic cycle. Can observations of other stars help us to understand the solar magnetic cycle, which is so important not only for astrophysics but also for our life and society? What are the essential components of the solar variability?

Recent optical, UV and X-ray observations of other stars with significant subsurface convection zones (lower main sequence stars with masses smaller than 1.5 solar masses and cool post-main-sequence stars) reveal starspots and other surface and atmospheric structures that are similar to solar magnetic features. In many cases, the long-term evolution of these features is similar to the solar cycle. Advances in the Doppler imaging technique have enabled mapping of starspot distributions and the tracking of their evolution. This led to the first accurate measurements of stellar differential rotation, a key property of dynamo mechanisms. In addition, UV and X-ray observations detected stellar coronas similar to the solar corona.

The impacts of solar variability on Earth, particularly on the terrestrial atmosphere and climate, have fueled significant debates in recent years. There is no doubt that solar radiation is the major source of terrestrial energy. The solar activity cycle also causes changes in Earth's atmospheric temperature and density, especially in the thermosphere. Energetic particles, which also vary with the solar cycle, cause geomagnetic storms and deposit energy into the magnetosphere and the polar regions of the atmosphere. Variations of the energy input may trigger changes in the climate. However, the complete chain of the impact of the solar variability is not understood.

The unusually long and deep current minimum of solar activity has significantly increased the interest in the mechanisms of solar and stellar variability and the impact of such long periods of low activity on planets. It is well known that a long interval of low solar activity between 1645 and 1715, the Maunder Minimum, coincided with a significant climate change called the "Little Ice Age". Can this happen again? Observations of other Sun-like stars indicate that long periods of low activity are quite common. Various attempts to predict the next solar cycle indicate that it will be significantly weaker than the previous cycle. Some researchers even go so far as to suggest that the Sun is entering a prolonged period of low activity, similar to the Maunder Minimum.

While the first few magnetic sunspot regions of the new solar cycle have appeared on the surface, the solar minimum still continues. The Sun is still mostly spotless. In 2008, 265 days were without sunspots. In the past 160 years of regular solar observations,

only 1878, 1901 and 1913 have had more such days. The long solar minimum has had a significant impact on the Earth's space environment and atmosphere. The solar wind pressure is at a 50-year low. This resulted in an increase of the flux of cosmic rays, which are believed to play a significant role in cloud formation. In addition, the total solar irradiance dropped to a 30-year low, the lowest since monitoring from space began. The decrease of UV radiation is particularly significant, about 6%. This caused a reduction of the Earth's atmosphere heating, and decreased its height. Thus, perhaps unexpectedly, investigations of the Sun in a low activity state have become critically important.

Of course, these studies are not only of great practical importance, but are also directly related to some of the most important astronomical problems: what are the basic physical mechanisms of solar and stellar activity, and how does stellar variability affects planetary systems and their habitability?

Perhaps, the most significant highlight of the Symposium, which received coverage in science news, was the presentation of new results showing that newly formed stars spin faster and generate stronger magnetic fields than middle-aged stars like the Sun. These active young stars emit much more intense levels of X rays, ultraviolet light, and charged particles all of which affect the formation and evolution of planetary atmospheres and must have a dramatic effect on the development of emerging life forms.

This highly interdisciplinary Symposium provided an excellent opportunity for astronomers from various fields solar, stellar and planetary physics to establish important connections, discuss mutual ideas and develop partnerships. In particular, this was a unique opportunity to establish collaborations with astronomers from Brazil and other Latin American countries.

The Symposium coincided with the completion of a new heliometer to perform accurate measurements of the solar diameter at the Observatório Nacional in Rio de Janeiro. The LOC organized an excursion to the completion ceremony at the Observatório Nacional. This was one of the most interesting and memorable events of the Symposium.

*Alexander G. Kosovichev, Alexandre H. Andrei and Jean-Pierre Rozelot, co-chairs SOC  
Rio de Janeiro, August 3, 2009*



Participants of IAUS 264 at the completion ceremony of a new heliometer at the Observatório Nacional in Rio de Janeiro. Professor Paolo Benevides-Soares (right) and Dr. Christian Delmas (left) receive commemorative medals from Dr. Jucira Penna, Chair of the LOC.





The heliometer of the Observatório Nacional and its creators, Drs Victor d'Ávila (right) and Eugenio Reis (left).



The LOC members (from left to right): Drs. Eugenio Reis, Jucira Penna and Victor d'Ávila



A group of participants after a discussion (left to right): Victor Matias (sitting), Ricardo Dunna (standing), Carlos Eduardo Portela, Eugenio Reis, Todd Hoeksema, Maria Cristina Rabello-Soares, Jucira Penna, Sergio Lomonaco and Victor d'Ávila.



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### Acknowledgements

The symposium is sponsored and supported by the IAU Divisions II (Sun & Heliosphere), III (Planetary Systems Sciences) and IV (Stars).

The Local Organizing Committee operated under the auspices of the  
Observatório Nacional of Brazil

Funding by the  
International Astronomical Union,  
and  
Observatório Nacional, Brazil  
is gratefully acknowledged.

## Participants

Hebe Cremades, UTN-FRM/CONICET, Argentina	hebe.cremades@hotmail.com
Eduardo Fernandez Lajus, Fac. Ciencias Astronómicas y Geofísicas - UNLP, Argentina	eflajus@fcaglp.unlp.edu.ar
Luciano Garcia, Observatorio Astronomico de Cordoba, Argentina	lucianog@oac.uncor.edu.ar
Ana G. Elias, UNT-CONICET, Argentina	aelias@herrera.unt.edu.ar
Anahi Granada, Universidad nacional de La Plata, Argentina	granada@fcaglp.unlp.edu.ar
Cristina H. Mandrini, Instituto de Astronomia y Fisica del Espacio, Argentina	mandrini@iafe.uba.ar
Olga Pintado, INSUGEO-CONICET, Argentina	olga.pintado@gmail.com
Alejandra Daniela Romero, Instituto de astrofísica La Plata, Argentina	aromero@fcaglp.unlp.edu.ar
Emanuel Sainz, Observatorio Astronomico de Cordoba, Argentina	sainz@mail.oac.uncor.edu
Pablo Daniel Sisterna, Universidad Nacional de Mar del Plata, Argentina	sisterna@mdp.edu.ar
Michael Ashley, University of New South Wales, Australia	m.ashley@unsw.edu.au
Paul Cally, Monash University, Australia	paul.cally@sci.monash.edu.au
Allan Ernest, Charles Sturt University, Australia	aernest@csu.edu.au
David Jauncey, Australia Telescope National Facility, CSIRO, Australia	david.jauncey@csiro.au
Stephen Marsden, Anglo-Australian Observatory, Australia	scm@ao.gov.au
Tiago M. D. Pereira, Australian National University, Australia	tiago@mso.anu.edu.au
David Warren, Astronomy Australia Ltd., Australia	david.warren@astronomyaustralia.
Günter Houdek, University of Vienna, Austria	gunter.houdek@univie.ac.at
Werner Weiss, University Vienna, Austria	weiss@astro.univie.ac.at
Shaig Nabiye, Shamakhy Astrophysical Observatory, Azerbaijan	snebiyev@qafqaz.edu.az
Emile Biemont, University of Liège, Belgium	e.biemont@ulg.ac.be
Anne Lemaitre, University of namur (FUNDP), Belgium	anne.lemaitre@fundp.ac.be
Alex Lobel, Royal Observatory of Belgium, Belgium	alobel@sdf.lonestar.org
Marcos Antonio Albarracian Manrique, Universidade Federal do ABC, Brazil	marcos.manrique@ufabc.edu.br
Silvia Alencar, UFMG, Brazil	silvia@fisica.ufmg.br
Victor Alves Alencar, Universidade Federal do Ceara, Brazil	victoralencar@fisica.ufc.br
Leonardo Almeida, Instituto Nacional de pesquisas Espaciais, Brazil	leonardo@das.inpe.br
Joao Antonio Amarante, UFRJ, Brazil	amarante@astro.ufrj.br
Diana Andrade-Pilling, Pontificia Universidade Católica do Rio de Janeiro, Brazil	dianaufjr@gmail.com
Alexandre Humberto Andrei, Observatório Nacional/MCT, Brazil	oat1@on.br
Silvia Calbo Aroca, Instituto de Fisica de São Carlos, Brazil	silviaaroca@uol.com.br
Victor Avila, Observatório Nacional, Brazil	victor@on.br
Julio Daniel Blanco Zarate, Observatório Nacional, Brazil	jblando@on.br
Heloisa Maria Boechat-Roberty, Universidade Federal do Rio de Janeiro, Brazil	heloisa@astro.ufrj.br
Bernardo Borges, IAG/USP, Brazil	bernardo@astro.iag.usp.br
Sergio Boscardin, Observatório Nacional, Brazil	sergio.boscardin@on.br
Albert Bruch, Laboratorio Nacional de Astrofisica, Brazil	albert@lna.br
Leonardo Wencioneck Cacholi, Universidade Federal de Viçosa, Brazil	klamanter@hotmail.com
Denise Castro, Observatório Nacional, Brazil	denise@on.br
Joao Paulo Nogueira Cavalcante, Observatório Nacional, Brazil	jpncavalcante@yahoo.com.br
Abraham Chian, National Institute for Space Research, Brazil	achian@dge.inpe.br
Gabriela Conde Saavedra, Observatório do Valongo / UFRJ, Brazil	gconde@astro.ufrj.br
Wagner J B Corradi, Universidade Federal de Minas Gerais, Brazil	wag@fisica.ufmg.br
Jonathan Cristiano Costa, UEPG, Brazil	jonathanuepg@yahoo.com.br
Flavio D'Amico, INPE, Brazil	damico@das.inpe.br
Elisabete de Gouveia Dal Pino, IAG Universidade de São Paulo, Brazil	dalpino@astro.iag.usp.br
Gabriel Dalmaso, Universidade Federal do Rio de Janeiro, Brazil	gdalmaso@gmail.com
Marcos Diaz, IAG, Brazil	marcos@astro.iag.usp.br
Isadora Chaves Bicalho Domingos, UNB, Brazil	isadora.bicalho@gmail.com
Alessandro Saldanha Chantre Dutra, Observatório Nacional, Brazil	ascdutra@on.br
Marcelo Emilio, Universidade Federal de Ponta Grossa, Brazil	marcelo_emilio@yahoo.com
Francisco Fernandes, UNIVAP, Brazil	guga@univap.br
Marcelo Leal Ferreira, UFRJ-Observatorio de Valongo, Brazil	mllferreira@gmail.com
Leticia Dutra Ferreira, Observatorio de Valongo-UFRJ, Brazil	leticia@astro.ufrj.br
Vanessa Ferreira, Universidade Federal de Itajuba, Brazil	vanessaflisi@gmail.com
Ana Monica Ferreira-Rodrigues, Catholic University of Rio de Janeiro, Brazil	anamonica.rodrigues@gmail.com
Douglas Galante, Universidade de São Paulo, Brazil	douglas@astro.iag.usp.br
Luiz Paulo Carneiro Gama, Observatório Nacional, Brazil	luizpaulo@gmail.com
Luiz Garcia de Andrade, UERJ, Brazil	-
Luan Ghezzi, Observatório Nacional, Brazil	luan@on.br
Altair Ramos Gomes Junior., Observatorio de Valongo, Brazil	altairastronomia@hotmail.com
Jorge Gonzales, Observatório Nacional, Brazil	gonzales@on.br
Guilherme Grams, Southern Regional Space Research Center, Brazil	ggrams@lacesm.ufsm.br
Marcia Regina Guimarães Guedes, UNIFEI, Brazil	mrguedes@gmail.com
Marcelo Guimaraes, UFMG, Brazil	mng@fisica.ufmg.br
Pedro Henrique A Hasselmann, Observatório Nacional, Brazil	pedrohasselmann@gmail.com
Luiz Jafelice, UFRN, Brazil	jafelice@gmail.com
Eduardo Janot-Pacheco, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Brazil	janot@astro.iag.usp.br
Flavia Luzia Jasmim, Observatório Nacional, Brazil	flavialuzia@on.br
Vera Jatenco-Pereira, USP, Brazil	jatenco@astro.iag.usp.br
Tiago Jota, UFMG, Brazil	jotaatiago@ufmg.br
Natalia Landin, Federal University of Minas Gerais, Brazil	nlandin@fisica.ufmg.br
Nathalia Lia, UFRJ, Brazil	nlia@astro.ufrj.br
Dennis Lima, Observatorio Astronomico Christus, Brazil	dwastronomia@yahoo.com.br
Dalton Lopes, Observatório Nacional, Brazil	dalton@on.br
Victor de Souza Magalhaes, Universidade de Brasilia, Brazil	victor.magalhaes.2802@gmail.com
Manuel Malheiro, Instituto Tecnológico de Aeronautica, Brazil	malheiro@ita.br
Rubens de Melo Marinho Jr., Instituto Tecnológico de Aeronautica, Brazil	marinho@ita.br
Eder Martioli, Instituto Nacional de Pesquisas Espaciais, Brazil	edermartioli@gmail.com
Thiago Matheus, Inst. de Astronomia, Geofísica e Ciências Atmosféricas da USP, Brazil	thiago@astro.iag.usp.br
Pauline McGinnis, Universidade Federal de Minas Gerais, Brazil	pauline@fisica.ufmg.br
Gustavo Frederico Porto de Mello, Universidade Federal do Rio de Janeiro, Brazil	gustavo@astro.ufrj.br
Vinicius Melo, UFRJ, Brazil	viniciusvbm@hotmail.com
Carlo Miceli, IFGW, Unicamp, Brazil	carlomicoli@gmail.com
Manoel Moraes, IAG - USP, Brazil	mcmvjr@astro.iag.usp.br
Decio Mourao, UNESP, Brazil	dcm134@uol.com.br

Raquel Santiago Nascimento, Universidade federal de Santa Cruz, Brazil  
 Natalia Amarinho Nunes, Universidade Federal de Itajubá - UNIFEI, Brazil  
 Diego Lorenzo de Oliveira, UFRJ, Brazil  
 Alex Dias Oliveira, Universidade Federal do Rio de Janeiro, Brazil  
 Alessandra Pacini, Instituto Nacional de Pesquisas Espaciais, Brazil  
 Andres Reinaldo Rodriguez Papa, Observatório Nacional, Brazil  
 Jucira L. Penna, Observatório Nacional, Brazil  
 Eduardo Penteado, Universidade Federal do Rio de Janeiro, Brazil  
 Fabio Pereira Santos, ICEx/UFMG, Brazil  
 Andres Felipe Perez Sanchez, Observatorio do Valongo - UFRJ, Brazil  
 Tereza Satiko Nishida Pinto, INPE, Brazil  
 Sarah Carvalho Pinto, Observatório Nacional, Brazil  
 Raul Eduardo Puebla Puebla, IAG/Universidade de São Paulo, Brazil  
 Jean-Pierre Raulin, Universidade Presbiteriana Mackenzie, Brazil  
 Mauricio Redaelli, UFRGS, Brazil  
 Eugenio Reis Neto, Observatório Nacional, Brazil  
 Leandro Rimulo, Universidade Federal de Minas Gerais, Brazil  
 Artur Justiniano Roberto Junior, Univ. Federal de Alfenas, Brazil  
 Helio Jaques Rocha-Pinto, Observatório de Valongo, Brazil  
 Luiz Teixeira Rodrigues, OAB/RJ, Brazil  
 Thaise da Silva Rodrigues, UFRJ, Brazil  
 Gustavo Rojas, Universidade Federal de São Carlos, Brazil  
 Fabiano Rollo, Observatório Nacional, Brazil  
 Reinaldo Roberto Rosa, INPE, Brazil  
 Marcelo Rubinho, IAG, Brazil  
 Maria de Fátima Oliveira Saraiva, Univ. Federal do Rio Grande do Sul, Brazil  
 Hanumant Sawant, INPE, Brazil  
 Nelson Jorge Schuch, INPE, Brazil  
 Caius Lucius Selhorst, CRAAM - Univ. Presbiteriana Mackenzie, Brazil  
 Felipe Serro, -, Brazil  
 Joao Victor Silva, Observatório Nacional, Brazil  
 Loloano Silva, UFRJ, Brazil  
 Wallace Silva, Universidade Federal do Rio de Janeiro, Brazil  
 Telma C. Couto da Silva, Universidade federal de mato Grosso, Brazil  
 Alana Paixão Sousa, UFMG, Brazil  
 Elton Rodrigues de Souza, Observatorio do Valongo, Brazil  
 Tardelli Ronan Coelho Stekel, Universidade Federal de Santa maria, Brazil  
 Carlos Alberto Torres, Laboratório Nacional de Astrofísica/MCT, Brazil  
 Flavia dos Prazeres Trindade, UFRJ, Brazil  
 Adriana Valio, Univ. Presbiteriana Mackenzi, Brazil  
 Luiz Paulo Ribeiro Vaz, Universidade Federal de Minas Gerais, Brazil  
 Aline Vidotto, University of São Paulo, Brazil  
 Sergio Murilo Rezende Vieira, UFTJ, Brazil  
 Lucas Vieira, Universidade Federal de Santa Maria, Brazil  
 Jaime Fernando Villas da Rocha, UNIRIO, Brazil  
 Silvio de Andrade, Universidade Federal do Rio de Janeiro, Brazil  
 Juarez Barbosa de Carvalho, UNIFEI, Brazil  
 Marcelo Vargas dos Santos, Universidade Federal do Rio de Janeiro, Brazil  
 Yavor Chapanov, Bulgarian Academy of Sciences, Bulgary  
 Matthew Browning, Canadian Inst. for Theoretical Astrophysics, Canada  
 Eugene F. Milone, University of Calgary, Canada  
 Richard Querel, University of Lethbridge, Canada  
 Slavek Rucinski, University of Toronto, Canada  
 James Silvester, RMC & Queen's University, Canada  
 Gregg Wade, Royal Military College, Canada  
 Taner Akgun, Pontificia Universidad Católica de Chile, Chile  
 Melina Bersten, Universidad de Chile, Chile  
 Claudio Caceres, European Southern Observatory, Chile  
 Carlos Contreras, Pontificia Universidad Católica de Chile, Chile  
 Alexandre Gallenne, ESO, Chile  
 Karen Kinemuchi, Universidad de Concepcion / Univ. of Florida, Chile  
 Cristian Lopez, Universidad de Chile, Chile  
 Gautier Mathys, European Southern Observatory, Chile  
 Maria Jose Maureira, Universidad de Chile, Chile  
 David Orellana, Cerro Tololo Inter-American Observatory, Chile  
 Lara Rodrigues, Depto Astronomia/Astrofísica. PUC, Chile, Chile  
 Klaus Simon Rubke Zuniga, Universidad de Chile, Chile  
 Maria Teresa Ruiz, Universidad de Chile, Chile  
 Matthias R Schreiber, Universidad de Valparaiso, Chile  
 Simon Silva, Universidad de Chile, Chile  
 Eer Afrad, Yunnan Astronomical Observatory, China  
 Kwing L Chan, Hong Kong U. of Science and Technology, China  
 Cheng Fang, Nanjing University, China  
 Weiqun Gan, Purple Mountain Observatory, China  
 Cheng-Li Huang, Shanghai Astronomical Observatory, China  
 Guangli Huang, Purple Mountain Observatory, China  
 Cheng Huang, Shanghai Astronomical Observatory, China  
 Lifang Li, National Astronomy Observatories, Yunnan Observatory, China  
 Ganghua Lin, National Astronomical Observatoires, China  
 Yu Liu, Yunnan Astronomical Observatory, China  
 Xiaoming Lu, Beijing Academy of Science and Technology, China  
 Yuehua Ma, Purple Mountain Observatory, China  
 Yuan Ma, Yunnan Astronomical Observatory, China  
 Zongjun Ning, Purple Mountain Observatory, China  
 Shengbang Qian, National Astron. Observatories Yunnan Observatory, China  
 Yuhua Tang, Nanjing University, China  
 Jingxiu Wang, National Astronomical Observatories, China  
 Yongqi Xia, Beijing Academy of Science and Technology, China  
 Yihua Yan, National Astronomical Observatories, China  
 Shuhong Yang, National Astronomical Observatories, China  
 Liheng Yang, Yunnan Observatory, China  
 Hong-Xin Yin, Shandong University at Weihai, China  
 Xizhen Zhang, National Astronomical Observatories, CAS, China  
 natalia\_astro@unifei.edu.br  
 diegolorenzo83@gmail.com  
 aoliveira@astro.ufrj.br  
 pacini@dge.inpe.br  
 papa@on.br  
 jucira@on.br  
 monfpent@astro.ufrj.br  
 fbpsantos@gmail.com  
 aperez@astro.ufrj.br  
 tereza.satiko@gmail.com  
 sarah@on.br  
 raul@astro.iag.usp.br  
 raulin@craam.mackenzie.br  
 maukeyboard@gmail.com  
 eugenio@on.br  
 lrrimulo@fisica.ufmg.br  
 arturjustiniano@yahoo.com.br  
 helio@astro.ufrj.br  
 luizadvogado@hotmail.com  
 tsrodrigues@astro.ufrj.br  
 grojas@ufscar.br  
 fabiano.gr@hotmail.com  
 reinaldo@lac.inpe.br  
 esteemue@mail@gmail.com  
 fatima@if.ufrgs.br  
 sawant@das.inpe.br  
 njschuch@lacesm.ufsm.br  
 caiuslucius@gmail.com  
 fserro@hotmail.com  
 joaovictor@on.br  
 loloano@if.ufrj.br  
 wllc.silva@yahoo.com.br  
 tccs@ufmt.br  
 alanasousa@ig.com.br  
 elton@astro.ufrj.br  
 tardelli@lacesm.ufsm.br  
 beto@lna.br  
 flaviapf07@astro.ufrj.br  
 adivalio@gmail.com  
 lpv@fisica.ufmg.br  
 aline@astro.iag.usp.br  
 murilo\_rezende9@yahoo.com.br  
 lucasfisio@gmail.com  
 jfvroch@pq.cnpq.br  
 silviodeandrade@gmail.com  
 juarezbarvalho@gmail.com  
 Vargas@if.ufrj.br  
 astro@bas.bg  
 browning@cita.utoronto.ca  
 milone@ucalgary.ca  
 richard.querel@uleth.ca  
 rucinski@astro.utoronto.ca  
 james.silvester@rmc.ca  
 wade-g@rmc.ca  
 akgun@astro.cornell.edu  
 melina@das.uchile.cl  
 ccaceres@eso.org  
 ccontrer@astro.puc.cl  
 agallenn@eso.org  
 kkinemuchi@astro-udec.cl  
 clopez@das.uchile.cl  
 gmathys@eso.org  
 mmaureir@das.uchile.cl  
 dorellana@ctio.noao.edu  
 lara@astro.puc.cl  
 krubke@hotmail.com  
 mtruib@das.uchile.cl  
 matthias@dfa.uv.cl  
 ssilva@das.uchile.cl  
 xjq-wuhan@yahoo.com.br  
 maklchan@nst.hk  
 chengfang38@yahoo.com.cn  
 wqgan@pmo.ac.cn  
 chuang@shao.ac.cn  
 ghuang@pmo.ac.cn  
 hc@shao.ac.cn  
 llf@yao.ac.cn  
 lgh@bao.ac.cn  
 lyu@yao.ac.cn  
 angelinxiao@gmail.com  
 yhma@pmo.ac.cn  
 mayuan@yao.ac.cn  
 ningzongjun@pmo.ac.cn  
 qsb@yao.ac.cn  
 yhtang@nju.edu.cn  
 wangjx@bao.ac.cn  
 angellinxiao@hotmail.com  
 yyh@bao.ac.cn  
 shuhongyang@ourstar.bao.ac.cn  
 yangliheng@yao.ac.cn  
 yinhx@sdu.edu.cn  
 zxz@bao.ac.cn

- Jin Zhu, Beijing Planetarium, China  
 Liyang Zhu, National Astronomical Observatories Yunnan Observatory, China  
 Equinio Alberto Taborda Martinez, Secretaria de Educ. del Depart. del Atlantico, Colombia  
 Jorge Zuluaga, Universidad de Antioquia, Colombia  
 Guy Kabongo Leba, Université Pédagogique Nationale, Congo  
 Andrea Kotrlova, Silesian University in Opava, Czech Republic  
 Michal Krizek, Institute of Mathematics, Czech Republic  
 Cyril Ron, Astronomical Institute, Academy of Sciences, Czech Republic  
 Marek Vandas, Astronomical Institute, Academy of Sciences, Czech Republic  
 Jan Vondrak, Astronomical Institute, Acad. Sci., Czech Republic  
 Åke Nordlund, University of Copenhagen, Denmark  
 Laurits Leedjarv, Tartu Observatory, Estonia  
 Jaan Pelt, Tartu Observatory, Estonia  
 Marjaana Lindborg, University of Helsinki, Finland  
 Dagmara Anna Oszkiewicz, Observatory, University of Helsinki, Finland  
 Ilkka Tuominen, University of Helsinki, Finland  
 France Allard, Centre de Recherche Astrophysique de Lyon, France  
 Philippe Bendjoya, Laboratoire H. Fizeau UNS-OCA-CNRS, France  
 Marcelo Borges Fernandes, Observatoire de la Cote d'Azur, France  
 Jean-Louis Bougeret, Observatoire de Paris-CNRS, France  
 Carine Briand, Observatoire de Paris, France  
 Allan Sacha Brun, CEA, Saclay, France  
 Armando Domiciano, Université de Nice, France  
 Anne Dutrey, Laboratoire d'Astrophysique de Bordeaux, France  
 Rubens Freire Ferrero, Observatoire Astronomique de Strasbourg, France  
 Rafael A Garcia, Service d'Astrophysique, CEA, France  
 Dominique Gilles, CEA, France  
 Guillaume Hebrard, CNRS, France  
 Sandrine Lefebvre, CNRS, France  
 Stephane Mathis, CEA/DSM/IRFU, France  
 Thierry Montmerle, Laboratoire d'Astrophysique de Grenoble, France  
 Coralie Neiner, Observatoire de Paris-Meudon, France  
 Jean-Claude Pecker, College de France, France  
 Bernard Rouge, CESBIO, France  
 Jean-Pierre Rozelot, Université de Nice Sophia-Antipolis, France  
 Alain Sarkissian, LATMOS, France  
 Sylvaine Turck-Chieze, CEA, France  
 Jean-Claude Vial, Institut d'Astrophysique Spatiale, France  
 Maria Bergemann, Max-Planck Institute for Astrophysics, Germany  
 Gregory Herczeg, Max-Planck-Institut für extraterrestrische Physik, Germany  
 Heidi Korhonen, ESO, Germany  
 Joachim Krautter, Landessternwarte - Zent. für Astron. Univ. Heidelberg, Germany  
 Markus Mugrauer, AIU Jena, Germany  
 Theodor Pribulla, Friedrich-Schiller - University Jena, Germany  
 Andreas Quirrenbach, Landessternwarte, Germany  
 Ulf Seemann, ESO, Germany  
 Michael Weber, Astrophysikalisches Institut Potsdam, Germany  
 Kristof Petrovay, Eotvos University, Hungary  
 Sirajul Hasan, Indian Institute of Astrophysics, India  
 Parag Mahajani, Milkyway Citizens, India  
 Ehsan Moravvji, Institute for Advanced Studies in Basic Sciences, Iran  
 Giuseppe Galletta, Università de Padova, Italy  
 Giuseppina Micela, INAF, Italy  
 Giovanni Peres, Università di Palermo, Italy  
 Salvatore Sciortino, INAF, Italy  
 Giuseppe Severino, INAF, Italy  
 Alessandro Sozzetti, INAF, Italy  
 Beate Stelzer, INAF - Observatorio Astronomico di Palermo, Italy  
 Hitoshi Fujiwara, Tohoku University, Japan  
 Kanya Kusano, JAMSTEC, Japan  
 Hiroko Miyahara, The University of Tokyo, Japan  
 Yuko Motizuki, RIKEN Nishina Center, Japan  
 Hiromoto Shibahashi, University of Tokyo, Japan  
 Hitoshi Yamaoka, Kyushu University, Japan  
 Damin Batmunkh, Research Centre of Astronomy and Geophysics, Mongolia  
 Johnson Urama, University of Nigeria, Nsukka, Niger  
 Gyan Bahdur Shrestha, Tribhuvan University, Nepal  
 Willem Brouw, Kapteyn Institute, Netherlands  
 Matteo Cantiello, Institute for Astronomy Utrecht, Netherlands  
 Jean-Mathias Griessmeier, ASTRON, Netherlands  
 Isa Oliveira, Leiden University, Netherlands  
 Daniel Risquez, Leiden Observatory, Netherlands  
 Mats Carlsson, University of Oslo, Norway  
 Oyvind Sorensen, The Norwegian Academy of Sciences and Letters, Norway  
 Sven Wedemeyer-Bohm, University of Oslo, Norway  
 Jesus Antonio Dalmau Cam, Instituto Geofísico del Peru, Peru  
 Walter Guevara Day, Universidad Nacional Mayor de San, Peru  
 Jose Luis Ricra Mayorca, Universidad Nacional de Ingeniería, Peru  
 Jadwiga Daszynska-Daszkiwicz, Uniwersytet Wroclawski, Poland  
 Jerzey M. Kreiner, Pedagogical University, Poland  
 Bogumil Pilecki, Warsaw University Observatory, Poland  
 Milena Ratajczak, Polish Academy of Sciences, Poland  
 Pawel Rudawy, Uniwersytet Wroclawski, Poland  
 Piotr Sybilski, Polish Academy of Sciences, Poland  
 Dorota Szczygiel, Warsaw University Observatory, Poland  
 Krzysztof Ulaczyk, Warsaw University Observatory, Poland  
 Edwin Wnuk, Adam Mickiewicz University, Poland  
 Jorge Melendez, Centro de Astrofísica da Universidade de Porto, Portugal  
 Joana Sousa, CAUP-Centro de Astrofísica da Universidade do Porto, Portugal  
 William Bruckman, University of Puerto Rico at Humacao, Puerto Rico  
 Young-Woon Kang, Sejong University, Republic of Korea
- jinzhu@bjp.org.cn  
 zhuly@ynao.ac.cn  
 erquiniot.74@yahoo.com  
 zuluagajorge@gmail.com  
 geekale@gmail.com  
 andrea.kotrlova@seznam.cz  
 krizek@cesnet.cz  
 ron@ig.cas.cz  
 vandas@ig.cas.cz  
 vondrak@ig.cas.cz  
 aake@nbi.dk  
 leed@aai.ee  
 pelt@aai.ee  
 marjaana.lindgorg@helsinki.fi  
 dagmara.oszkiewicz@helsinki.fi  
 ilkka.tuominen@helsinki.fi  
 fallard@ens-lyon.fr  
 bendjoya@unice.fr  
 marcelo.borges@obs-azur.fr  
 jean-louis.bougeret@obspm.fr  
 carine.briand@obspm.fr  
 sach.brun@cea.fr  
 armando.domiciano@unice.fr  
 anne.dutrey@obs.u-bordeaux1.fr  
 freire@astro.u-strasbg.fr  
 rgarcia@cea.fr  
 dominique.gilles@cea.fr  
 hebrard@iap.fr  
 sandrine.lefebvre@latmos.ipsl.fr  
 stephane.mathis@cea.fr  
 montmerle@obs.ujf-grenoble.fr  
 coralie.neiner@obspm.fr  
 j.c.pecker@wanadoo.fr  
 rougebe@free.fr  
 rozelot@obs-azur.fr  
 alain.sarkissian@latmos.ipsl.fr  
 cturck@cea.fr  
 jean-claude.vial@ias.u-psd.fr  
 mbergema@mpa-garching.mpg.de  
 gregoryh@mpe.mpg.de  
 hkorhone@eso.org  
 j.krautter@lsw.uni-heidelberg.de  
 markus@astro.uni-jena.de  
 pribulla@astro.uni-jena.de  
 a.quirrenbach@lsw.uni-heidelberg  
 usemann@eso.org  
 mweber@aip.de  
 k.petrovay@astro.elte.hu  
 hasan@iap.res.in  
 milkywaycitizen@yahoo.co.in  
 moravvji@iasbs.ac.ir  
 giuseppe.galletta@unipd.it  
 giusi@astropa.inaf.it  
 peres@astropa.unipa.it  
 sciorti@astropa.inaf.it  
 severino@na.astro.it  
 sozzetti@oato.inaf.it  
 stelzer@astropa.unipa.it  
 fujiwara@pat.geophys.tokohu.ac.j  
 kusano@jamstec.go.jp  
 hmiya@icrr.u-tokyo.ac.jp  
 motizuki@riken.jp  
 shibahashi@astron.s.u-tokyo.ac.j  
 yamaoka@phys.kyushu.ac.jp  
 btmnhd@yahoocom.com  
 johnson@hartrao.ac.za  
 gbstha@hotmail.com  
 w.n.brouw@rug.nl  
 m.cantiello@un.nl  
 griessmeier@astron.nl  
 oliveira@strw.leidenuniv.nl  
 risquez@strw.leidenuniv.nl  
 mats.carlsson@astro.uio.no  
 oyvind.sorensen@dnva.no  
 svenwe@astro.uio.no  
 antoniodalmau@gmail.com  
 walter@conida.gob.pe  
 jricram@uni.pe  
 daszynska@astro.uni.wroc.pl  
 sfkreine@cyf-kr.edu.pl  
 pilecki@astrouw.edu.pl  
 milena@ncac.torun.pl  
 rudawy@astro.uni.wroc.pl  
 sybilski@ncac.torun.pl  
 dszczyg@astrouw.edu.pl  
 kulaczyk@astrouw.edu.pl  
 wnuk@amu.edu.pl  
 jorge@astro.up.pt  
 jsousa@astro.up.pt  
 miguelwillia.bruckman@upr.edu  
 kangywo@sejong.ac.kr

- Georgeta Maris, Institute of Geodynamics, Romania  
 Petre Popescu, Astronomical Institute of Romanian Academy, Romania  
 Gennadij Bisnovatyi-Kogan, Space Research Institute RAS, Russian Federation  
 Elena Gavryuseva, Institute for Nuclear Research, Russian Federation  
 Elena Glushkova, Sternberg Astronomical Institute, Russian Federation  
 Alexander Kholtygin, Astron. Inst. of Saint-Petersburg State Univ., Russian Federation  
 Vladimir Obridko, Izmiran, Russian Federation  
 Elena Pitjeva, Inst. Appl. Astron., Russian Academy of Sciences, Russian Federation  
 Maxim Pshirkov, PRAO ASC LPI, Russian Federation  
 Tatiana Ryabchikova, Institute of Astronomy RAS, Russian Federation  
 Sergey Samsonov, Yu. G. Shafer Inst. Cosmophys. & Aeronomy, Russian Federation  
 Dmitry Sokoloff, Moscow State University, Russian Federation  
 Vladislav Timofeev, Yu. G. Shafer Inst. Cosmophys. & Aeronomy, Russian Federation  
 Andrey Tlatov, The Central Astron. Observatory of RAS at Pulkovo, Russian Federation  
 Valeria Vasilyeva, The Central Astron. Observatory of RAS at Pulkovo, Russian Federation  
 Irina Voloshina, Stenberg Astronomical Institute, Russian Federation  
 Jan Budaj, Astronomical Institute, Slovak Academy of Sciences, Slovakia  
 Peter Martinez, South African Astronomical Observatory, South Africa  
 Daniel Christopher Opolot, University of the Western Cape, South Africa  
 Brian Warner, University of Cape Town, South Africa  
 Juan Fabregat, Universidad de Valencia, Spain  
 Alvaro Gimenez, Centro de Astrobiologia (INTA-CSIC), Spain  
 Alexis Klutsch, UCM, Spain  
 Valentin Martinez Pillet, Instituto de Astrofísica de Canarias, Spain  
 David Montes, UCM, Universidad Complutense de Madrid, Spain  
 Ignasi Ribas, Institut de Ciències de l'Espai (CSIC-IEEC), Spain  
 Jorge Sanz-Forcada, Center of Astrobiology-INTA/CSAI, Spain  
 Pilar de Teodoro, ESAC, Spain  
 Dainis Dravins, Lund Observatory, Sweden  
 Bengt Gustafsson, Uppsala University, Sweden  
 Oleg Kochukhov, Uppsala University, Sweden  
 Andres Carmona Gonzalez, Geneva University, Switzerland  
 Bruno Chazelas, Observatoire de Genève, Geneva University, Switzerland  
 Laurent Eyer, University of Geneva, Switzerland  
 Claudia Greco, Observatoire de Genève, Switzerland  
 Manuel Guedel, ETH Zurich, Switzerland  
 Jan Stenflo, ETH Zurich, Switzerland  
 Subhon Ibadov, Institute of Astrophysics, Tajik Academy of Sciences, Tajikistan  
 Boonruksar Soonthornthum, National Astronomical Research Institute of Thailand, Thailand  
 Solen Balman, Middle East Technical University, Turkey  
 Atila Ozguc, Bogazici University, Turkey  
 Alex Golovin, Main Astron. Obs. National Academy of Sciences of Ukraine, Ukraine  
 Nataliya Kovalenko, KYIV Planetarium, Ukraine  
 Yuri Tsap, Crimean Astrophysical Observatory, Ukraine  
 Nadine Afram, Imperial College London, UK  
 William Chaplin, University of Birmingham, UK  
 Giulio Del Zanna, University of Cambridge, UK  
 Christoffer Karoff, School of Physics and Astronomy, UK  
 John Landstreet, Armagh Observatory, UK  
 Urmila Mitra-Kraev, University of Cambridge, UK  
 Danail Obreschkow, University of Oxford, UK  
 Alan Pickwick, EAAE & MGS, UK  
 Christophe Pinte, University of Exeter, UK  
 Vinothini Sangaralingam, University of Birmingham, UK  
 Helen Walker, STFC Rutherford Appleton Laboratory, UK  
 Lidia van Driel-Gesztelyi, University College London, UK  
 Douglas Arion, Carthage College, USA  
 Thomas Ayres, University of Colorado, USA  
 Peter Beiersdorfer, Lawrence Livermore National Laboratory, USA  
 Alexander Brown, University of Colorado, USA  
 Joseph Burns, Cornell University, USA  
 Manfred Cuntz, University of Texas at Arlington, USA  
 Edward Devinney, Villanova University, USA  
 Pamela L Gay, Southern Illinois University Edwardsville, USA  
 Ciriaco Goddi, Harvard-Smithsonian Center for Astrophysics, USA  
 Richard Gray, Appalachian State University, USA  
 Daniel Green, Harvard-Smithsonian Center for Astrophysics, USA  
 Erika Grundstrom, Vanderbilt University, USA  
 Javiera Guedes, University of California, Santa Cruz, USA  
 Edward Guinan, Villanova University, USA  
 Margit Haberreiter, University of Colorado, USA  
 Thomas Hartlep, Stanford University, USA  
 Donald Hassler, Southwest Research Institute, USA  
 Frank Hill, National Solar Observatory, USA  
 Kenneth Hinkle, NOAO, USA  
 Jon Todd Hoeksema, Stanford University, USA  
 Christopher Johns-Krull, Rice University, USA  
 George Kaplan, -, USA  
 Irina Kitiashvili, Stanford University, USA  
 Alexander Kosovichev, Stanford University, USA  
 Chryssa Kouveliotou, NASA, USA  
 John Leibacher, National Solar Observatory, USA  
 Steven Majewski, University of Virginia, USA  
 Rocco Mancinelli, SETI Institute, USA  
 Bruce McCollum, California Institute of Technology, USA  
 Alexei Pevtsov, National Solar Observatory, USA  
 Peter Plavchan, Caltech / IPAC / NExSci, USA  
 Louise Riofrio, Oceanering Space Systems, USA  
 Rachel Roettenbacher, Lehigh University, USA  
 Ronald G. Samec, Bob Jones University, USA  
 Ashit Sanyal, Capitol College, USA  
 gmaris@geodin.ro  
 petre@aira.astro.ro  
 gkogan@iki.rssi.ru  
 elena.gavryuseva@gmail.com  
 elena@sai.msu.ru  
 afkholtygin@gmail.com  
 obridko@izmiran.ru  
 evp@ipa.nw.ru  
 pshirkov@gmail.com  
 ryabchik@inasan.ru  
 s.samsonov@ikfia.ysn.ru  
 sokoloff@dds.srcc.msu.su  
 vetimofeev@ikfia.ysn.ru  
 tlatov@mail.ru  
 xyzlera@rambler.ru  
 vib@sai.msu.ru  
 budaj@ta3.sk  
 peter@sao.ac.za  
 opodanchris@yahoo.ca  
 warner@physci.uct.ac.za  
 juan.fabregat@uv.es  
 gimenez@inta.es  
 klutsch@astrax.fis.ucm.es  
 vmp@iac.es  
 dmg@astrax.fis.ucm.es  
 ribas@ice.csis.es  
 jsanz@laeff.inta.es  
 pilar.teodoro@esa.int  
 dainis@astro.lu.se  
 bg@astro.uu.se  
 oleg.kochukhov@fysast.uu.se  
 andres.carmona@unige.ch  
 bruno.chazelas@unige.ch  
 laurent.eyer@unige.ch  
 claudia.greco@unige.ch  
 guedel@astro.phys.ethz.ch  
 stenflo@astro.phys.ethz.ch  
 ibadovsu@yandex.ru  
 boonruksar@narit.or.th  
 solen@metu.edu.tr  
 ozguc@boun.edu.tr  
 golovin.alex@gmail.com  
 kievplanet@ukr.net  
 yur\_crao@mail.ru  
 n.afram@ic.ac.uk  
 w.j.chaplin@bham.ac.uk  
 g.del-zanna@damtp.cam.ac.uk  
 karoff@bison.ph.bham.ac.uk  
 jlandstr@astro.uwo.ca  
 u.mitra-kraev@damtp.cam.ac.uk  
 dobresch@astro.ox.ac.uk  
 alan\_c\_pickwick@btinternet.com  
 pinte@astro.ex.ac.uk  
 vs@star.sr.bham.ac.uk  
 helen.walker@stfc.ac.uk  
 lidia.vandriel@obspm.fr  
 darion@carthage.edu  
 thomas.ayres@colorado.edu  
 beiersdorfer@llnl.gov  
 alexander.brown@colorado.edu  
 jab16@cornell.edu  
 cuntz@uta.edu  
 edward.devinney@villanova.edu  
 pgay@siue.edu  
 cgoddi@cfa.harvard.edu  
 grayro@appstate.edu  
 green@cfa.harvard.edu  
 erika.grundstrom@vanderbilt.edu  
 javiera@ucolick.org  
 edward.guinan@villanova.edu  
 haberreiter@lasp.colorado.edu  
 thartlep@stanford.edu  
 hassler@boulder.swri.edu  
 fhill@noao.edu  
 hinkle@noao.edu  
 jthoeksema@spd.aas.org  
 cmj@rice.edu  
 gkaplan@zoominternet.net  
 irinasun@stanford.edu  
 sasha@sun.stanford.edu  
 chryssa.kouveliotou@nasa.gov  
 jleibacher@nso.edu  
 srm4n@virginia.edu  
 rmancinelli@seti.org  
 mcollum@ipac.caltech.edu  
 apevtsov@nso.edu  
 plavchan@ipac.caltech.edu  
 l.m.riofrio@nasa.gov  
 rmr207@lehigh.edu  
 rsamec@bju.edu  
 asanyal@comcast.net

Ethan J. Schreier, Associated Universities Inc., USA	ejs@aui.edu
Ryan Shannon, Cornell University, USA	rms72@cornell.edu
David Soderblom, Space Telescope Science Institute, USA	drs@stsci.edu
John Stauffer, California Institute of Technology, USA	stauffer@ipac.caltech.edu
David Tholen, University of Hawaii, USA	tholen@ifa.hawaii.edu
Guillermo Torres, Harvard-Smithsonian Center for Astrophysics, USA	gtorres@cfa.harvard.edu
Wesley Traub, Jet Propulsion Laboratory, USA	wtraub@jpl.nasa.gov
Jeff Valenti, Space Telescope Science Institute, USA	valenti@stsci.edu
Steven Vogt, UCO/Lick Observatory, USA	vogt@ucolick.org
Lucianne Walkowicz, University of California Berkeley, USA	walkowicz@berkeley.edu
David Webb, Boston College, USA	david.webb@hanscom.af.mil
Junwei Zhao, Stanford University, USA	junwei@sun.stanford.edu
Xuepu Zhao, Stanford University, USA	xuepu@sun.stanford.edu
Tabare Gallardo, Facultad de Ciencias, Uruguay	gallardo@fisica.edu.uy
Andrea Maciel, Facultad de Ciencias, Uruguay	amaciel@fisica.edu.uy
Andrea Sanchez Saldias, Facultad de Ciencias, Uruguay	andrea@fisica.edu.uy
Gonzalo Tancredi, Facultad de Ciencias, Uruguay	gonzalo@fisica.edu.uy
Alisher S Hojaev, Nat. Univ. Uzbekistan & UBAl/Uzbek Academy of Sciences, Uzbekistan	ash@astrin.uzsci.net
Nguyen Lan, Hanoi National University of Education, Viet Nam	nquynhlan@hnue.edu.vn
Prosperity C Simpemba, Copperbelt University, Zambia	pcsimpemba@yahoo.com