

Dr. (HdR) ALLAN SACHA BRUN

Head of the Laboratory on Dynamics of Stars and their Environments

PI of the European (ERC) Grant STARS2

DSM/IRFU/Service d'Astrophysique & UMR AIM

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Education:

2005: Habilitation (HdR) (Honors) in Theoretical Physics, University of Paris VII-Denis Diderot, entitled: "Convection, Turbulence, Rotation and Magnetism in Stars"

1998: Ph.D. (Honors) in Astronomy, Theoretical Physics and Space Technology, Observatory of Paris, University of Paris VII-Denis Diderot, directed by Dr. S. Turck-Chièze and Prof. J.-P. Zahn, entitled: "Theoretical Study of the Internal Structure of the Sun: What do we learn from SOHO?", (date of defence: 02/12/1998)

1995: M.S. (Honors) in Astronomy, Theoretical Physics and Space Technology, Observatory of Paris, University of Paris VII-Denis Diderot

1993: B.Sc. (Honors) in Theoretical Physics, University of Paris VII-Denis Diderot.

Awards : Laureate of the Prix « La Recherche en Astrophysique » 2011

Research Positions Held:

01/10-present: Head of Research Laboratory (LDEE), CEA-Saclay, IRFU/SAp, France.

07/09-present: Permanent Senior Researcher, Service d'Astrophysique, CEA-Saclay, France.

01/03-06/09: Permanent Researcher, Service d'Astrophysique, CEA-Saclay, France.

01/03-present: associated Researcher, LESIA, Observatoire of Paris, France and JILA, University of Colorado, USA

01/02-01/03 Senior Research Associate, JILA & APS, University of Colorado, Boulder, USA.

01/99-01/02 Research Associate, JILA and APS, University of Colorado, Boulder, USA.

10/95-12/98 PhD Student, IRFU/SAp, CEA-Saclay & DASGAL, Observatory of Paris, France.

Teaching:

since 2010 : Lecturer Graduate School of Astrophysics d'Ile de France : Stellar dynamics

since 2007: Lecturer National Master on Fusion, module FCM3, Univ. St Jerome, Marseille

since 2006: Lecturer, graduate schools ENSTA, parallelism in astrophysics

since 2004: Lecturer, in master degree M2S, ENSTA, magnetism across the universe

2004-2008: Lecturer, ENST Brest, introduction to astronomy

08/00-08/01: Teaching Assistant, Physics Department, University of Colorado, USA

09/98-12/98: Teaching Assistant, Engineer School EFREI, Paris, France.

PhD Students and Postdoc Supervision:

- Jouve L., master and PhD thesis: study of the 22yr solar cycle and 3D numerical simulations of flux tube emergence in spherical convection zone (defence 12/12/08), Now Assisant Professor in University of Toulouse

- Aunai N., master thesis on nonlinear dynamo and the variability of the solar cycle

- A. Strugarek, master and PhD thesis on plasma physics in stars and tokamaks (defence 11/19/2012), Now postdoc in Montreal

- O. DoCao, PhD thesis on the dynamics of solar-like stars

- L. Alvan, PhD thesis on internal waves in stars

- N. Bessolaz, former STARS2 postdoc, working on young stars magnetism, Now in Exeter

- R. Pinto , former STARS2 postdoc, working on the coupling between the inner and outer Sun magnetism and solar wind, Now under CNES contract to work on SO/STIX between Lesia-SAp

- S. Matt, STARS2 senior postdoc on stellar magnetism and wind
- In collaboration with S. Turck-Chièze, PhD thesis of J. Ballot on convection and rotation law in Young Suns (defence 11/2004), V. Duez on stable magnetic field configurations in stars (defence 12/2009), A. Palacios CEA post-doc (18 months) on turbulent convection in low mass RGB stars, Now Assistant Astronomer in Montpellier
- In collaboration with Prof J. Toomre, PhD thesis of M. Browning (defence 09/2005) on A stars convection and dynamo, B. Brown on fastly rotating G stars (def 07/2009), N. Featherstone on massive stars (def 03/2011), K. Auguston on F & B stars and N. Nelson on flux emergence

Lectures in Summer Schools:

Ecole magnétisme stellaire de la Rochelle (Sept 07), Ecole de Bordeaux d'Astrophysique et de Fusion magnétique et inertielle (Sept 06), Ecole de Cargese en Dynamique des Fluides Astrophysiques (Mai 05), Ecole de structure interne d'Aussois no14 (Sept 04) et no20 (Sept 10)

Responsibilities in France and in International collaboration:

- Head of Laboratory on dynamics of Stars and their Environment, 15 group members
- PI of European Research Council Grant STARS2 (www.stars2.eu) for 5 yr on stellar dynamics and magnetism
- Co-I of ANR (French funding agency) Grant TOUPIES on rotational history of stars
- Co-I of IDEX Paris-Saclay VKSstar project on dynamo studies in VKS2 experiment and stars
- Member of Scientific Panel of INSU-PNST (National program on Sun, Earth & plasmas)
- Project scientist at CEA for European Space Agency satellite Solar Orbiter/STIX
- French PI of the French-American Memorandum Of Understanding (MOU) on Stellar dynamos, student supervision; definition of general strategy; co write papers common to the collaboration, development and maintenance of the ASH code
- Active member of the ISSI international research group "Solar cycles and data assimilation"
- Coordinator of the international 2-D solar dynamo benchmark initiative (Jouve, Brun et al. 2008, A&A in press, see also <http://www.nordita.dk/~brandenb/tmp/benchmark>)
- Co-leader of the 3-D MHD anelastic convection driven dynamo benchmark with Prof. C. Jones & G. Glatzmaier (Jones et al. 2011, Icarus).
- Organisation of SAp Colloquium and regular seminars since September 2003, invitation of speaker, planning in advance of colloquia program for each spring and fall semesters
- Member of the search committee for the position in computational astrophysics within SAp (Jun 07), and of the computing and of the science and technology commissions of SAp
- Chair of SOC+LOC of IAU Symposium 271: Astrophysical Dynamics: from stars to galaxies
- Covenor of ISSI international workshop on Helioseismology and solar interior dynamics in Bern
- Chair of SOC+LOC of Flux Emergence Workshop 2013 in France
- SOC member of : 5th Postdam Thinkshop Potsdam (2007), Workshop on solar magnetism (Oct 2008), Soho 24 (Aug 2010), data assimilation (Nordita - 2011), SF2A (french AAS) (Session 11 on dynamo Jun 2012), PNST (March 2012), Forum météo spatiale (Nov 2012), ISSI workshop on Helioseismology (Sept 2012), Conference Originalités de la Vie II (Oct 2012)

Conducted or Ongoing Research Projects:

- Computed 3--D high resolution (2000^3) nonlinear numerical simulations on massively parallel machine architectures of rotating compressible convection in spherical shells to model the solar convective and radiative zones, A-type star core convection, RGB stars, F stars, Young and fast rotating Suns, using the Anelastic Spherical Harmonic (ASH) code.
- Developed the MHD version of the ASH code. Computed 3--D nonlinear numerical simulations of rotating compressible magneto-convection using ASH to model key ingredients of the solar/stellar dynamo, such as dynamo in convective core or envelope, MHD instabilities in radiation zone and the solar tachocline.
- Interpretation of solar differential profile and meridional circulation as inferred by helioseismology in terms of transport of angular momentum, heat and thermal wind balance.

- Assessed the respective role of Reynolds, Maxwell stresses, meridional circulation or viscous effects. Extended analysis to other stars such A, F, K, T Tauri's or low mass RGB stars.
- Developed a 2--D finite element axisymmetric MHD code STELEM to study the solar and stellar magnetic cycles, butterfly diagrams and the influence of multi cellular meridional circulation or magnetic pumping on the activity cycles.
- Study nonlinear interactions between magnetized stars & wind, disk or planet using 2--D & 3--D PLUTO code
- Improved the physical contents (microscopic and macroscopic such as tachocline mixing) in the CESAM code to improve the computation of 1--D "standard" solar (or stellar) models and the agreement with photospheric abundances (Li7, Be9, He3), neutrino fluxes and helioseismology constraints (mode frequencies, sound speed & density profiles, He4).
- Extracted 1-D profiles from 3-D MHD run to help progressing in 1-D stellar evolution including large scale transport effects or in 2-D kinematic dynamo models

Key Invited Talks in International Conference:

In AGU-SPD (USA, Jun01), 3D stellar evolution workshop (USA, Jul 02), Workshop of solar and stellar magnetism (France, Sept 02), GONG04-SOHO14 (USA, Jul 04), MSI prg (UK, Nov 04), SPM11 (Belgium, Sep 05), Festival Theory & European Fusion Theory (France, Jul & Oct 05), USTTF (USA, Apr 06), IAU-GA JD17 (Rep. Tech, Jul 06), Potsdam (Ger, Jun 07), ISSI-Bern (Swi, Jan 08), Evershed Meeting (India, Dec 08), IAU Symp 264 (Bra, Aug 09), FEW09 (Spain, Nov 09), Hinode 3rd (Jap, Dec09), Solar-C (Japan, Mar 10), IAU Symp 271 (Jun 10), MREP60 (Sept 10), Diff. Rot in Stars (Princeton, May 11), SF2A (Paris, Jun 11), FEW11 (Berkeley, Aug 11), IAU 286 (Arg, Oct 11), Cool Star 17 (June 12), IAU-GA JD 3, Spsc 10 (Aug 12), ISSI workshop (Sept 12)

Main Publications (citations 2366, h-factor 26, 58 refereed papers, 112 proceedings):

- Brun, A.S., Turck-Chièze, S. and Zahn, J.-P. 1999, "Standard solar models in the light of new helioseismic constraints: II mixing below the convection zone", *ApJ*, 525, 1032-1041
- Brun, A. S. and Toomre, J. 2002, "Turbulent Convection under the Influence of Rotation: Sustaining a strong differential rotation", *ApJ*, 570, 865--885.
- Brun, A. S., Miesch, M.S. and Toomre, J. 2004, "Global-Scale Turbulent Convection and Magnetic Dynamo Action in the Solar Envelope", *ApJ*, 614, 1073-1098
- Brun, A.S., Browning, M. and Toomre, J. 2005, "Simulations of Core Convection in Rotating A-type Stars: Dynamo Action", *ApJ*, 629, 461-481
- Brun, A.S., Zahn, J.P. 2006, "Magnetic Confinement of the Solar Tachocline", *A&A*, 457,665
- Zahn, J.-P., Brun, A.S., Mathis, S. 2007, "On magnetic instabilities and dynamo action in stellar radiation zones", *A&A*, 474, 145
- Miesch, M.S., Brun, A.S., Derosa, M. , Toomre, J. 2008, "Structure and evolution of giant cells in global models of solar convection", *ApJ*, 673, 557
- Brun, A.S. & Palacios, A. 2009, "3-D simulations of Red Giant Stars", *ApJ*, 702, 1078
- Jouve, L and Brun, A.S., 2009, "3-D Nonlinear evolution of a magnetic flux tube in a spherical shell: influence of turbulent convection and associated mean flows", *ApJ*, 701, 1300
- Brown, B. P., Browning, M.K., Brun, A.S., Miesch, M.S., Toomre, J. 2010, "Persistent Magnetic Wreaths in a Rapidly Rotating Sun", *ApJ*, 711, 424
- Brun, A. S., Miesch, M.S. and Toomre, J. 2011, "Modeling the Dynamical Coupling of Solar Convection with the Radiative Interior", *ApJ*, 742, 79
- Derosa, M., Brun, A.S. and Hoeksema, T. 2012, "Solar magnetic field reversal and the role of dynamo families", *ApJ*, 757, 96

Refereeing in Major Scientific Journals:

Science, Astronomy & Astrophysics, Astrophysical Journal & Letters, Solar Physics. Geophysical & Astrophysical Fluid Dynamics, MNRAS, Journal of Computational Physics

Public Outreach:

- Talks in La Cité des Science in Paris and in Libraries or ``Bar des Sciences`` or ``Fête de la Science`` in Paris and many cities in France, many interviews on France Inter radio (Tête au carré, téléphone sonne) or Ciel & Espace (e.g. french sky & telescope magazine) podcast
- Numerous articles in general public magazines or letters of supercomputer centres, such as National Geographic special issue on the Sun (2004), La Recherche (01/2006, 05/2007, 11/2011), Lettre de l'IDRIS dec 2004 no 7, Clefs CEA no 49 & 58 , USA NPACI Newsletter Envision no17, DEISA-DECI NewsLetter, vol 1, 2007, Science & Vie (Dec 2010), Ciel et Espace (Mai, Juin, Juillet, Octobre 2011), L'Astronomie (Juillet 2011), La Recherche Oct2011, LaRecherche Feb 2013

Computing Skills:

Languages: Fortran 77/90, C, C++, HTML, PERL, MPI (parallel programming)

Scientific numerical library : LAPACK, BLAS, FFTW, DXML, ESSL, MKL, IDL, Matlab