

IAU Symposium

271

21–25 June 2010,  
Nice, France

IAU Symposium

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Nice, France

Proceedings of the International Astronomical Union

# Astrophysical Dynamics: From Stars to Galaxies

*Edited by*

Nicholas H. Brummell  
A. Sacha Brun  
Mark S. Miesch  
Yannick Ponty

**Astrophysical  
Dynamics:  
From Stars to  
Galaxies**

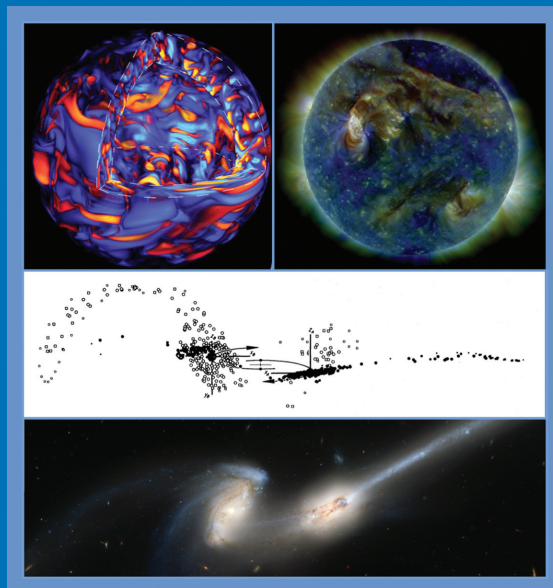
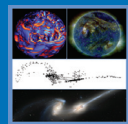
Brummell  
Brun  
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ASTROPHYSICAL DYNAMICS:  
FROM STARS TO GALAXIES

IAU SYMPOSIUM No. 271

*COVER ILLUSTRATION:*

The cover illustration of this book is a collage of four panels intending to illustrate the fundamental reasons for the existence of the conference. The symposium spanned a wide range of topics in astrophysical dynamics, from stars to galaxies, highlighting the common processes and common scientific approaches to understanding these phenomena. Hence both a star and a galaxy are pictured, both from observations and from simulations. The two simulations chosen are both from work that Prof. Juri Toomre has been involved in, since the symposium was dedicated to honouring his long, illustrious and varied career near the occasion of his 70<sup>th</sup> birthday.

*Upper left panel* Numerical simulations of dynamo action realized in a convective spherical envelope by the Toomre group using the ASH code (see e.g. Brun, Miesch & Toomre, 2004, *Astrophys. Jou.*, 614, 1073). Shown is the longitudinal component of the magnetic field with blue/red indicating negative/positive polarity.

*Upper right panel* Solar event on August 1, 2010 as viewed by the Solar Dynamics Observatory. This multi-wavelength (211, 193 & 171 Angstrom) extreme ultraviolet snapshot from the Solar Dynamics Observatory (SDO) shows the sun's northern hemisphere in mid flare-eruption. Different colors in the image represent different gas temperatures ranging from 1 to 2 million degrees K.  
Credit: NASA/SDO/AIA

*Lower left panel* Simulation of galaxy mergers by Toomre & Toomre 1972 (*Astrophys. Jou.*, 178, 623)

*Lower right panel* Mice galaxies. NGC 4676, or the Mice Galaxies, are two spiral galaxies in the constellation Coma Berenices, that are presently in the process of colliding and merging. Photographed in 2002 by the Hubble Space Telescope.  
Credit: <http://hubblesite.org/newscenter/archive/releases/2002/11/image/d>.

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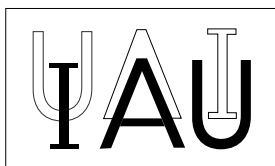
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INTERNATIONAL ASTRONOMICAL UNION  
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# ASTROPHYSICAL DYNAMICS: FROM STARS TO GALAXIES

PROCEEDINGS OF THE 271<sup>st</sup> SYMPOSIUM OF THE  
INTERNATIONAL ASTRONOMICAL UNION  
HELD IN NICE, FRANCE  
JUNE 21–25, 2010

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## Preface

The purpose of IAU symposium 271 was to enable interaction, discussion, study, and thereby to enhance our understanding, of some of the important nonlinear dynamical processes present in the Universe. The intention was to pay special attention to those that are ubiquitously present in a great variety of astronomical objects, from stars like our Sun to galaxies.

A wide range of temporal and spatial scales are present in many of the essential dynamical phenomena operating in most celestial bodies, and thus fluid and magnetic instabilities, highly nonlinear states and turbulence play a central role in these systems. Today, understanding the behaviour and evolution of such systems requires high-accuracy, multi-scale astronomical observations and thoughtful analysis of the data garnered, coupled with detailed theoretical study via models. Relatively recently, high-performance numerical simulations have become an essential and revealing tool for assessing the often subtle and surprising highly nonlinear regime of such models.

Symposium 271 offered a unique opportunity for world experts with widely varying perspectives to share their knowledge and opinions on the latest advances in the study of the common underlying processes from the field of nonlinear astrophysical dynamics. In the end, more than 110 scientists attended from 35 countries ranging as far afield as China, India, Russia, Egypt, Japan, Australia, South Africa, USA, Columbia, etc.

This conference was particularly special in that it was a fitting occasion to celebrate the long and illustrious career of Professor Juri Toomre close to the date of his 70<sup>th</sup> birthday. The Symposium theme aptly befits Juri's widespread achievements in many realms of astrophysical dynamics. It was decided to have this meeting in Nice because Juri used to enjoy his visits to the Observatory here to visit Jean-Paul Zahn, who was Director there for some time. Juri's long career and many successes were remembered during the conference and were celebrated with a banquet in his honour.

*Nic Brummell, Sacha Brun, Mark Miesch and Yannick Ponty, Organisers  
December 2010*

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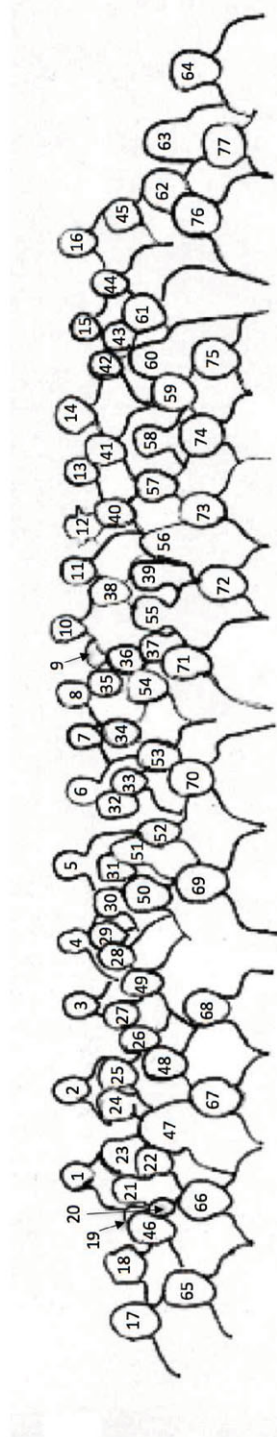
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CONFERENCE PHOTOGRAPH



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## Local organising committee: events

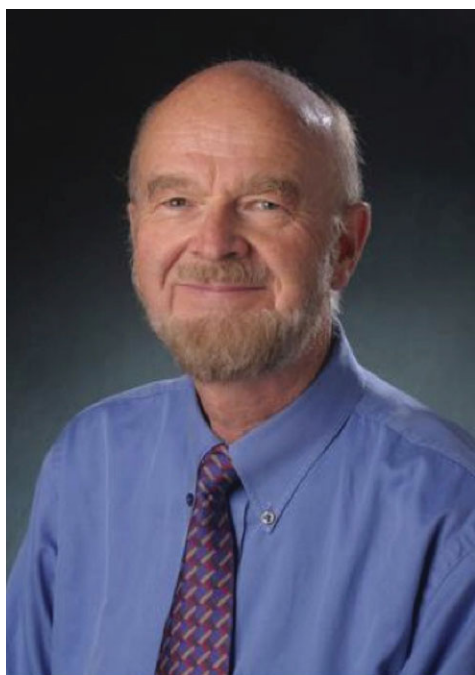
The local organising committee organised a very nice boat trip to Villefranche-sur-Mer and a wonderful dinner to honour Prof. Juri Toomre's 70th birthday in the middle of the conference.



## Address by the Organisers

Firstly, we would like to thank everyone for taking the time and effort to travel from far and wide to IAU Symposium 271. We had participants from all over the world, including most of Europe, the USA, Taiwan, Russia, South Africa, Australia, Egypt, Mexico, Japan, to name but a few of the 35 countries represented.

The aim of the conference was to encourage and enable scientific discussion on a broad range of topics, related to objects as varied as our Sun and other stars to galaxies. The emphasis was on the underlying processes that united these various objects, such as hydrodynamic and hydromagnetic turbulence, and complex nonlinear dynamics in general. A mixture of techniques including observations, basic theory and computation were discussed.



One of the reasons for the breadth of the topics discussed in the Symposium was that a large part of the motivation for the conference stemmed from a desire to recognise and honour the long and illustrious career of Professor Juri Toomre in the year of his 70<sup>th</sup> birthday.

Juri was born in Estonia in 1940 but immigrated to the USA with his family in 1949. He received both a Bachelors and a Masters degree from Massachusetts Institute of Technology (MIT) by 1963 and then went to Trinity College, Cambridge, England as a Marshall scholar to work with Prof. H. Keith Moffatt in the Department of Applied Mathematics and Theoretical Physics. Juri obtained a Ph.D. in 1967 with a thesis on “Hydromagnetic Jets”.

Juri then returned to the USA to work as a postdoctoral scholar at the Department of Mathematics, New York university and the Goddard Institute for Space Studies, New York. During this time, Juri worked with his brother, Alar, a professor of Mathematics at MIT, on models of close encounters of galaxies, and the “tails” and “bridges” that can be formed in their tidal interaction, resulting in a famous paper, Toomre & Toomre, 1972 (*Astrophys. Jou.*, 178, 623). Juri also cemented a strong relationship with a group of peers at this time, which resulted in long-standing collaborative projects that bore fruition in a long series of papers with various combinations of the group members Douglas Gough, Jean Latour, Ed Spiegel, Juri and Jean-Paul Zahn. This group become affectionately known as “the Convective Collective” since the body of work addressed stellar convection theory (see page 339).

In 1975, Juri became a Professor in the (now) Astrophysics and Planetary Science Department and a Fellow of the (then) Joint Institute for Laboratory Astrophysics (now JILA) at the University of Colorado, Boulder, a position that he retains to this today.

Juri's work with the Convective Collective continued into the early '80s, and has expanded along these lines towards more complex anelastic and compressible systems with magnetic fields and in various geometries, with a series of students and postdoctoral scholars ever since. Indeed, Juri became a veritable clearing house for any up and coming person with an interest in stellar fluid dynamics, either spawning students (e.g. David Hathaway, Neal Hurlburt, Anil Deane, Phil Jones, Xin Xie, Mark Rast, Mark Miesch, Matt Browning, Ben Brown) or grooming postdocs (e.g. David Hughes, Fausto Cattaneo, Nic Brummell, Keith Julien, Tom Clune, Sacha Brun), lists that read like a "Who's Who" of mathematical stellar fluid dynamics today. One of Juri's distinct successes was to recognise the potential of high performance computing, and to champion its use in the study of the highly nonlinear systems that are relevant to stellar situations. Juri's stellar convection and MHD group is a major user of the nation's supercomputing facilities, and, indeed, has evolved into a new version of the Convective Collective known (also affectionately) as "the ASH Mob" (after the main Anelastic Spherical Harmonic computational code that they use as their main tool).

On a parallel work strand, in the mid-1980s, through his close collaboration with Douglas Gough (Cambridge, England), Juri also became an early pioneer in the subject of helioseismology, the inversion of sound data to infer information about the interior of the Sun. Juri again became the benevolent father and incubator for a series of students and postdocs associated with this breakthrough line of work (e.g. Deborah Haber, Frank Hill, Brad Hindman).

Along the way, Juri has been a major contributor to both service in the academic field and teaching in the University. Juri has been vice-chair of the Solar Observatories Council of Association of Universities for Research in Astronomy (AURA) with oversight for the National Solar Observatory, served several terms on the Observatories Council dealing with National Optical Astronomy Observatory (NOAO), and has been member and chairman of the Space Telescope Institute Council (STIC) which has oversight for the Space Telescope Science Institute (STScI). Juri is currently chair of the scientific advisory committee to the Global Oscillations Network Group (GONG, the major ground-based project in helioseismology), was a Co-I on the Solar Oscillations Investigation (SOI) Michelson Doppler Interferometer (MDI) helioseismology experiment on the Solar and Heliospheric Observatory (SOHO), and is now Co-I on the Helioseismic Magnetic Imager (HMI) experiment on the newly launched Solar Dynamics Observatory (SDO). Juri also recently served on the Astro2010 Astronomy & Astrophysics Decadal Survey central committee. Juri also received the 2010 University of Colorado Hazel Barnes prize, the highest accolade for research and teaching at the university.

Overall, Juri's scientific nose for a good problem, acute awareness of the cutting edge, skill with a turn of phrase, keen eye for a strong selling point, and nurturing nature have made for a deservedly long and extremely successful career. He has established himself as a long term server of the scientific goal and a leader and mentor to others with the same ideals. We therefore dedicated this meeting to honouring Juri's personal achievements and his devotion to these goals.

*Nic Brummell, Sacha Brun, Mark Miesch and Yannick Ponty*