IAU Symposium
285
19-23 September 2011
Oxford, United Kingdom

IAU Symposium
285
19-23 September 2011
Oxford, United Kingdom

Proceedings of the International Astronomical Union

New Horizons in Time-Domain Astronomy

New Horizons
in Time-Domain
Astronomy

Edited by

R. Elizabeth Griffin
Robert J. Hanisch
Robert L. Seaman

Griffin
Hanisch
Seaman

ISSN 1743-9213

Proceedings of the International Astronomical Union

International Astronomical Union

CAMBRIDGE

CAMBRIDGE UNIVERSITY PRESS

https://doi.org/10.1017/S1743921311028512 Published online by Cambridge University Press

NEW HORIZONS IN TIME-DOMAIN ASTRONOMY

IAU SYMPOSIUM No. 285

COVER ILLUSTRATION by P. Marenfeld
National Optical Astronomy Observatory (Tucson, AZ, USA)

The IAU Symposium 285 Scientific Organizing Committee dedicates this volume to
Elizabeth Griffin in honour of her 70th birthday

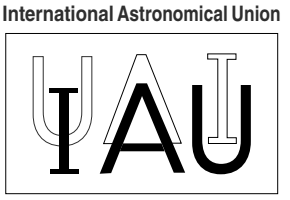
https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

IAU SYMPOSIUM PROCEEDINGS SERIES
2011 EDITORIAL BOARD

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

INTERNATIONAL ASTRONOMICAL UNION

UNION ASTRONOMIQUE INTERNATIONALE



NEW HORIZONS IN TIME-DOMAIN ASTRONOMY

PROCEEDINGS OF THE 285th SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HELD IN OXFORD, UNITED KINGDOM SEPTEMBER 19 – 23, 2011

Edited by

R. ELIZABETH GRIFFIN
Dominion Astrophysical Observatory, Canada

ROBERT J. HANISCH
Space Telescope Science Institute and Virtual Astronomical Observatory, USA

and

ROBERT L. SEAMAN
National Optical Astronomical Observatory, Tucson AZ USA

CAMBRIDGE UNIVERSITY PRESS

CAMBRIDGE UNIVERSITY PRESS
The Edinburgh Building, Cambridge CB2 2RU, UnitedKingdom
32 Avenue of the Americas, New York, NY 10013–2473, USA
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

First published 2012

Printed in the United Kingdom at the University Press, Cambridge

Typeset in System LaTeX 2ε

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

Library of Congress Cataloguing in Publication data

This journal 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 worlds forests. Please see www.fsc.org for information.

ISBN 9781107019850 hardback
ISSN 1743-9213

Table of Contents

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

Day 3: Things That Tick

Day 4: Irregular and Aperiodic Changes

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

Day 5: Preparing for the Future

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

Workshop Reports

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

Poster Papers

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

Introduction

Studies of variability constitute prolific and profitable sources of information about how objects in the cosmos form, exist, and evolve. Variability can be periodic, aperiodic, spasmodic, or secular; it can involve times-scales from a millisecond to a century and beyond, and it can embrace the whole electromagnetic spectrum or just one portion of it. Studies of radial-velocity variables require well-tried techniques and only need dedication and persistence to yield new information; stellar pulsations and exoplanets are tough to identify and demand special observing techniques, while previously unknown cases of variability require new data-mining techniques applied to large data collections. Progress and innovation thus depend on fully-supported, open, and coherent database management systems plus appropriate data extraction and analysis tools. Discoveries and observations of variability can drive theory (e.g., supernovæ light-echoes or binary-star mergers), while theory can inspire searches for phenomena that would otherwise pass undetected (e.g., in asteroseismology).

Whereas it was once believed that variable stars were exceptional, every celestial object actually varies to some degree. Our plate stores proved essential for studies of spectroscopic and astrometric variability, and the AAVSO (operational since 1911) has likewise been invaluable for studies of photometric variability; both sources of historic data are in fact growing in value as their respective time-bases increase. At the same time, the substantial developments in theory and in observational techniques have enabled studies of group similarities to graduate to the finer details suggested by their differences. That progress owes as much to rapid access to digital data, to database mining techniques, and to tools developed by the Virtual Observatory, as to the increased power of telescopes and systems, improved detector sensitivity, innovative technology, and phenomenology-focused research.

But while modern ingenuity and proficiency have opened up new fields of study such as transients, blazars, gamma-ray bursts, active galactic nuclei and quasars, the puzzles posed by more traditional longer-term variability have not been laid to rest. On the contrary, objects with substantially long variability characteristics are now returning to the scene; some even reveal stellar evolution itself. At the same time, networks of observers are nowadays "hotwired" to alerts of new events rather than relying on telegraph or mail. Studies of variability are thus burgeoning in all respects, and the principle of free, open-access data is a core factor throughout.

On first detection all processes are mysterious, all objects unknown. As time-series data accumulate and archival cross-matching proceeds, empirical inferences emerge from the mist, and the first physical models are developed and debated. Available information on the plethora of variability types has now become overwhelming, to the point where whole symposia focus on just one type and its associated research community. But while specialist studies are undeniably important for refining theory, the significance of occurrences of similar phenomena in different objects may get overlooked, so key astrophysics can be missed.

This Symposium focused on the different manifestations of variability, and sought to shed light on new scientific insights which are not apparent when one type of object is studied in isolation. It therefore crossed previously recognized boundaries because the need is precisely to erase those boundaries, to think outside the box. Astrophysics transcends disciplines. Structures such as disks and jets, or processes such as pulsations and occultations, appear in different guises at different scales in different cosmic contexts.

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

The phenomenology of time-varying measurements that drives the empirical characterization of dramatically diverse astrophysical objects recurs time and again, but the cross-boundary links are less well aired. Phenomena of SNe, for example, were investigated for many years before it was realised that an apparently single class of object actually was composed of several very different celestial events. Recent digitizing of early plates of the Harvard collection has revealed objects that vary over periods of several tens of years with amplitudes of almost a magnitude. Can the cause(s) of those variations be linked to ones that manifest variations or pulsations of similar amplitudes but very much shorter period, and—if so—are there false constraints in current models? Similarly, can high-energy studies influence current concepts of stellar evolution and variability in the AGB zone? On the other hand, scientific progress in the phenomenology itself is still handicapped by very incomplete information regarding the frequency of events. How can observers make better use of tools, technologies and techniques in order to capture a greater percentage of transients, novæ, etc.?

The core question, "How can technology and collaboration be better harnessed to enhance the science requirements?" was fundamental to the Symposium's planning. The full potential of new observing opportunities and techniques, new capabilities to revisit historic data, and new interpretative tools will not be realized unless the user community acquires the necessary skills to manage relevant data in diverse forms. "Showing and telling" are a vital element of the learning process, but are insufficient if performed only generically or are deemed to be the province of the specialist. Summarising the principles of applying the tools is inadequate without real examples. "What" and "when" are vital complementary ingredients of the banquet offered by variability, but achieve little without the all-important recipes for "how". Neither database managers nor researchers can be maximally productive if working in isolation and without appropriate feedback. As well as highlighting what is actually new and what is promised, the Symposium included a strong didactic content in the form of topical workshops focusing on practical skills and knowledge.

The timing for a cross-discipline symposium in time-domain astronomy was highly favourable, and as at least one participant noted, this may be the last time that a Symposium of such broad scope will be feasible. Major new transient surveys are coming on-line as soon as the next year or two, and their data will drive the respective fields substantially forward at all wavelengths. On-line data from projects such as the Palomar Transient Factory, SkyMapper, Pan-STARRS, and LOFAR will revolutionize studies of (at least) supernovæ, novæ, AGNs (quasars/blazars), variable stars and pulsars. These projects (and many others) will lay the groundwork for even greater time-domain investigations over the next decade, including the truly massive Large Synoptic Survey. At the same time, high-speed digitizers to scan photographic plates are revealing the fascinating pervasiveness of even "more obvious" photometric and spectrum variability by harnessing the past to the present over long temporal baselines.

The Symposium was organized into daily themes:

- Monday: Can our data meet the challenges?
- Tuesday: Explosive or irreversible changes
- Wednesday: Things that tick
- Thursday: Irregular and aperiodic changes
- Friday: Preparing for the future

On each day we examined commonalities in the science as revealed by certain types of variability, crossing frequency and time-scale boundaries in the process, and including presentations from database experts on the present and projected status of analysis

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

tools. Talks from different sub-disciplines were intentionally interleaved in order to avoid specialist-level isolation, and speakers rose to the challenge and presented talks that were accessible to a broad audience. Some 110 poster papers were displayed in two multi-day sessions, leading to stimulating discussions over coffee and evening refreshments.

Afternoons were set aside for topical workshops, each organized by participants in the Symposium and structured as they saw fit for discussion of the challenges facing a particular subset of time-domain studies. Topics ran the gamut from Extreme Physics and Gravitational Waves to Stellar Variability, Astrotomography, Light Echoes, Historical Data, and Data Management.

An additional highlight of the Symposium was the Monday evening public lecture given by Professor Sir Martin Rees (Baron Rees of Ludlow), FRS and Astronomer Royal, entitled "From Microseconds to Æons—How Our Complex Cosmos Emerged." Held in the auditorium of the Oxford University Museum of Natural History, the talk attracted a full house and was followed by a lively question-and-answer session.

Some in the community were concerned that a Symposium of such breadth, and structured as a hybrid between presentations of new research results, visions of the future, and a practicum of research tools, would not succeed on any of these fronts. In fact, comments from participants after the meeting were unanimous in their acclaim. More than anything else, perhaps, the meeting opened up lines of communication and collaboration that had not existed before. On the first day of the meeting a common comment was "I barely know 20% of the people here," whereas by the end of the week people were saying "I've met at least three-quarters of the people, and have started new collaborations that would not have happened otherwise." The welcoming environment of St. Catherine's College, wherein nearly all participants of the conference were housed, encouraged many side discussions that often continued in the convivial pubs of Oxford.

While there may indeed not be another conference on time domain astronomy that casts such a broad net, this one certainly accomplished its goal of being integrative and enabling of cross-cutting research. The organizers thank the participants for their willingness to share their knowledge—and to appreciate the knowledge of others in different fields—as a means to understanding the many mysteries of the time domain.

Robert Hanisch
Space Telescope Science Institute and Virtual Astronomical Observatory, USA
Elizabeth Griffin
Dominion Astrophysical Observatory, Canada
December 2011

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press

Foreword

The divergences from convention which IAU S285 introduced affected not only the scheduling of each day's communications but also the layout of these Proceedings. In compiling them we have aimed to reflect the contents of the week's science in a manner that is both informative and useful as a research document. To that end, we laid emphasis on capturing not only the new but also the slightly speculative, welcoming opinions and ideas as well as journal-style research papers. Speakers were given the option of not submitting a full write-up if the content of a talk had been, or would be, published in its entirety elsewhere; 28% so chose, and for those we have reproduced here just an abstract, slightly modified into a summary.

The most severe divergence from a conventional schedule was the introduction of workshops (*a.k.a.* breakout sessions or focus discussions) on the three full afternoons. For each we have included here a report, written in whatever style its author(s) selected; some are statements condensed from the discussions which constituted the Workshop, some are brief scientific papers, while for just a few—those with a predominantly pedagogical element—we have reproduced instead the "paragraphs" which told visitors to our Wiki page what were a workshop's objectives and (possibly) an outline programme.

That daily schedule did not permit as many contributed talks as would have been the case in a more conventional programme—only 1 in 9 applicants could be thus accommodated; most of the rest prepared posters instead. We therefore offered all 110 poster presenters the opportunity to submit short write-ups of their posters. One-half accepted, while for the rest we have included their abstracts, once again modified into summaries.

While endeavouring to maintain fidelity between these Proceedings and what was communicated and discussed at IAU S285, we have tried hard to make the book *readable*. However, while the laurel of that achievement could be shared by the two closing papers of the Symposium (*q.v.*), we also recommend making time to heed the thought-provoking views in the after-dinner speech, which is reproduced intact on page 455. Without question, the pulse of change that is so clearly revealed by the perceptive and thought-provoking view of the younger generation will be incorporated into the way in which we conduct scientific research in the future.

As many remarked, ours was a star-studded cast, and—alas—the promised full-length write-up by the opening speaker of the first session could not be completed because its author was subsequently called to receive the Nobel Prize. The diversity of the topics which appeared to be touched by variability astonished even the organizers, and the capacity number of participants whom they attracted ran the whole gamut from senior academics and researchers to programmers and database experts and a blind graduate from an ethnic minority.

We thank the participants of IAU Symposium 285 for their contributions to this Proceedings, and for making the conference such a success.

Acknowledgements

It is a real pleasure to thank the colleagues and organizations whose assistance, co-operation and advice contributed vitally towards the overall success of the Symposium:

• Mark Sullivan and Aris Karastergiou (co-Chairs of the LOC), who undertook the lion's share of the Website and Wiki management, handled all the housekeeping duties such as Registration and funding administration, and organized many invisible details with perfection,

• the LOC team recruited from Oxford Astrophysics: Vanessa Ferraro-Wood (Departmental Secretary) and graduate students Sarah Blake, Tom Evans, Ian Heywood, Kate Maguire, Amy McQuillan, Yen-Chen Pan and Kimon Zagkouris. Between them they coped efficiently with all the back-stage duties and manifold preparations and tasks, both before and during the event,

• Amy McQuillan, for managing the "Variability" mug,

• Pete Marenfeld, whose design of the Symposium poster captured cryptically and exquisitely the breadth and diversity of the meeting,

• Sehar Tahir, for providing invaluable technical support with Latex,

• the IAU, for generously sponsoring S285 through travel grants to 28 participants,

• the Royal Astronomical Society, for a grant to run the public lecture—and of course to Professor Rees for giving it,

• St. Catherine's College—so near the centre of this historic and vibrant University city, yet far enough away as to not be inconvenienced by its bustle—for accommodating the Symposium when we wanted it, and for being amazingly co-operative and flexible. The impressive organizational skills of their dining-room staff in serving an excellent lunch each day speedily yet graciously was a practical lesson in parallel processing,

• Oxford Astrophysics, for financial sponsorship and for lending us personnel,

• Oxford University Press and Springer Scientific Publications, for books to display,

• the Lord Mayor of Oxford (Cllr. Elise Benjamin), for opening the Symposium, and the City Council for laying on a reception, and

• most importantly of all, the participants, for donating time, energy, enthusiasm, ideas and good-will.

Elizabeth and Bob
Co-Chairs, IAU S285

CONFERENCE PHOTOGRAPH

Symposium participants, in the grounds of St. Catherine's College, Oxford

https://doi.org/10.1017/S1743921312002499 Published online by Cambridge University Press