STAR CLUSTERS: BASIC GALACTIC BUILDING BLOCKS THROUGHOUT TIME AND SPACE

IAU SYMPOSIUM No. 266

COVER ILLUSTRATION: ORION AND THE TRAPEZIUM CLUSTER.

This composite *Spitzer* and *Hubble Space Telescope* image exemplifies the chaotic environment in the Orion Nebula, created by having caught the Galactic star-formation process in the act.

Swirls of green in *Hubble*'s ultraviolet and visible-light view reveal hydrogen and sulfur gas that have been heated and ionized by intense ultraviolet radiation from the massive stars in the Trapezium cluster, seen as the yellow stars in the centre of the image. Meanwhile, *Spitzer*'s infrared view exposes carbon-rich molecules (polycyclic aromatic hydrocarbons) in the cloud. These organic molecules have been illuminated by the Trapezium cluster's stars, and are shown in the composite as wisps of red and orange.

Stellar winds from clusters of newborn stars scattered throughout the cloud etched all of the well-defined ridges and cavities in Orion. The large cavity near the right of the image was most likely carved by winds from the Trapezium's stars.

This image is a false-colour composite where blue corresponds to light detected at wavelengths of 0.43, 0.50 and 0.53 μm and green to wavelengths of 0.6, 0.65, and 0.91 μm. Light emitted at 3.6 μm is orange and at 8.0 μm is red.

Image and paraphrased text courtesy of the *Spitzer* Science Center (NASA/JPL-Caltech/T. Megeath & M. Robberto).

https://doi.org/10.1017/S1743921309990755 Published online by Cambridge University Press

https://doi.org/10.1017/S1743921309990755 Published online by Cambridge University Press

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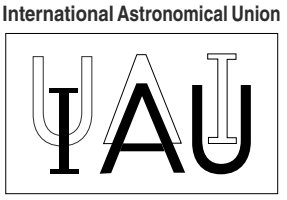

STAR CLUSTERS: BASIC GALACTIC BUILDING BLOCKS THROUGHOUT TIME AND SPACE

PROCEEDINGS OF THE 266th SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HELD IN RIO DE JANEIRO, BRAZIL 10–14 AUGUST 2009

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CAMBRIDGE UNIVERSITY PRESS

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

First published 2010

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 world's forests. Please see www.fsc.org for information

ISBN 9780521764995 hardback
ISSN 1743–9213

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https://doi.org/10.1017/S1743921309990755 Published online by Cambridge University Press

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Preface: Star clusters as basic galactic building blocks

It is widely accepted that stars do not form in isolation, but result from the fragmentation of molecular clouds, which in turn leads to star cluster formation. Over time, clusters dissolve or are destroyed by interactions with molecular clouds or tidal striping, and their members become part of the general field population. Star clusters are thus among the basic building blocks of galaxies.

In turn, star cluster populations, from young associations and open clusters to old globulars, are powerful tracers of the formation, assembly and evolutionary history of their parent galaxies. Although their importance (e.g., in mapping out the Milky Way) had been recognised for decades, major progress in this area has only become possible in recent years, both for Galactic and extragalactic cluster populations. This area has seen a major recent investment in time and effort, largely thanks to significant new resources in theory, simulations and observations, including breakthroughs in computational power, the advent of *Hubble Space Telescope*-driven science, deep and more precise data for large numbers of Galactic clusters, and an explosion of astrometric data (e.g., *Hipparcos*, UCAC2).

In the summer of 2009, several years had passed since a number of very successful IAU symposia were held on aspects related to the build-up of galaxies and their basic building blocks. IAU Symposium 254 on 'The Galactic Disk in Cosmological Context' (June 2008), IAU Symposium 241 on 'Stellar populations as basic building blocks of galaxies' (December 2006) and IAU Symposium 235 on 'Galaxy Evolution across the Hubble Time' (August 2006) addressed galaxy formation and evolution in a wider sense, while IAU Symposium 246 on 'Dynamical Evolution of Dense Stellar Systems' (September 2007) and IAU Symposium 207 on 'Extragalactic Star Clusters' (March 2001) focussed on star clusters in their own right.

While most of these past Symposia addressed individual aspects of galaxy formation and evolution, we felt the need for a new Symposium encompassing many of the individual aspects in a more general approach, and in particular focussing on star clusters (including the full range from very young associations and open clusters to young massive star clusters and old globulars), and star cluster populations in the wider context of their parent galaxies. Putting these results and new developments related to star clusters as individual entities into the broader context of galaxy evolution is the next logical step, which requires the combined efforts of theorists, observers and modellers working on a large variety of spatial scales, and spanning a very wide range of expertise. We are now reaching the stage that we are within reach of answering a number of fundamental questions that will have a significant impact on our understanding of numerous related issues as well, ranging from the formation, assembly and evolution of galaxies, to the details of the process of star formation itself. These two issues are the backbone of research in modern astrophysics. Thus, we proposed to focus on the role of star clusters, of any size and age, and their stellar populations in the overall context of galaxy evolution, across space (from local to high redshift) and time (from currently forming to fossil remnants).

Star clusters are the observational foundation for stellar astrophysics and evolution, provide essential tracers of galactic structure, and are unique stellar dynamical

https://doi.org/10.1017/S1743921309990755 Published online by Cambridge University Press

environments. Star formation, stellar structure and stellar evolution continue to benefit and improve tremendously from the study of these systems. Additionally, fundamental quantities such as the initial mass function can be successfully derived from modelling either the Hertzsprung–Russell diagrams or the integrated velocity structures (i.e., for massive clusters, the velocity dispersions, leading to dynamical mass estimates, and combined with integrated luminosities and independent age estimates) of, respectively, resolved and unresolved clusters and cluster populations. Star cluster studies thus span the fields of Galactic and extragalactic astrophysics, while heavily affecting our detailed understanding of the process of star formation in dense environments.

Globular clusters are regarded as fossil records of the earliest epochs of galaxy formation, including that of our own Milky Way. At the same time, the young massive star clusters currently being formed in the most violent starburst environments may be viable proto-globular clusters. Thus, star clusters form an ideal testbed for stellar evolution theories and are in fact among the best tools to study extreme stellar populations, such as X-ray binaries or 'blue stragglers', both of which are likely products of dynamical interactions within clusters. However, dynamical modelling of clusters and entire cluster systems, at any age, still poses a considerable challenge for both theory and computational requirements.

Recent advances in instrumentation are driving a renaissance in the study of Galactic clusters, while extragalactic cluster studies are significantly aided by the development of new instrumentation supporting ever wider fields of view. New wide-field imaging cameras on several 4–8m telescopes offer the unique opportunity to study entire cluster populations to very faint magnitudes in a single pointing, both in the optical and near-infrared (e.g., *VISTA*). Complementing these photometric capabilities are a new generation of multi-object spectrographs and multiplexed integral-field units on 8–10m telescopes. In addition, from *Chandra/XMM* and *GALEX* at short wavelengths to the *Spitzer Space Telescope* in the mid- and far-infrared, our observational window in which to study both the star clusters and their stellar populations are unsurpassed in terms of wavelength coverage and spatial resolution at the present time. With major efforts being expended on the planning for possible 30–42m 'extremely large telescopes', now is the opportune time to look forward to future progress in mapping a representative slice of the local Universe at the highest possible resolution and thus in the greatest detail ever achieved. Combining the emerging, unprecedented understanding of local stellar populations with observations of galaxies ('composite' stellar populations) at ever higher redshifts, we now have a fighting chance to constrain the evolution of the basic galactic building blocks throughout space and time.

With all of these exciting efforts ongoing at the present time, we believed that it was an opportune time to organise a Symposium on 'Star Clusters as Basic Galactic Building Bocks Throughout Time and Space' at the XXVII$^{\rm th}$ General Assembly of the IAU in the summer of 2009. Looking back at a very successful meeting, we are strengthened in our resolve to make this meeting happen and would like to thank all participants for a hugely rewarding and thought-provoking week in Rio de Janeiro.

Richard de Grijs and Jacques Lépine
November 2009

https://doi.org/10.1017/S1743921309990755 Published online by Cambridge University Press

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Acknowledgements

The Symposium was sponsored and supported by IAU Divisions VII (Galactic System), VIII (Galaxies) and X (Radio Astronomy); and by IAU Commissions No. 28 (Galaxies), No. 33 (Structure and Dynamics of the Galactic System), No. 34 (Interstellar Matter), No. 37 (Star Clusters and Associations), No. 40 (Radio Astronomy) and No. 55 (Communicating Astronomy with the Public).

Financial support was provided by the International Astronomical Union in the form of travel grants for 21 participants, selected from the invited and contributing speakers, PhD students and scientists from less-favoured countries. The Local Organising Committee consisted of the Local Organising Committee of the IAU's XXVII$^{\text{th}}$ General Assembly, to whom we are grateful for structural and logistical support.

The editors of these proceedings are grateful to Joana Oliveira and Jacco van Loon for their indispensable assistance with the technical aspects of putting this volume together.