CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

THE EMISSION-LINE UNIVERSE

Emission lines provide a powerful tool for studying the physical properties and chemical compositions of astrophysical objects in the Universe, from the first stars to objects in our Galaxy. The analysis of emission lines allows us to estimate the star formation rate and initial mass function of ionizing stellar populations, and the properties of active galactic nuclei.

This book presents lectures from the eighteenth Winter School of the Canary Islands Astrophysics Institute (IAC). Written by prestigious researchers and experienced observers, it covers the formation of emission lines and the different sources that produce them. It shows how emission lines in different wavelengths, from ultraviolet to near infrared, can provide essential information on understanding the formation and evolution of astrophysical objects. It also includes practical tutorials for data reduction, making this a valuable reference for researchers and graduate students.

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

Canary Islands Winter School of Astrophysics

Volume XVIII

Editor in Chief
F. Sánchez, *Instituto de Astrofísica de Canarias*

Previous volumes in this series

I. Solar Physics
II. Physical and Observational Cosmology
III. Star Formation in Stellar Systems
IV. Infrared Astronomy
V. The Formation of Galaxies
VI. The Structure of the Sun
VII. Instrumentation for Large Telescopes: a Course for Astronomers
VIII. Stellar Astrophysics for the Local Group: a First Step to the Universe
IX. Astrophysics with Large Databases in the Internet Age
X. Globular Clusters
XI. Galaxies at High Redshift
XII. Astrophysical Spectropolarimetry
XIII. Cosmochemistry: the Melting Pot of Elements
XIV. Dark Matter and Dark Energy in the Universe
XV. Payload and Mission Definition in Space Sciences
XVI. Extrasolar Planets
XVII. 3D Spectroscopy in Astronomy

© Cambridge University Press www.cambridge.org

Participants of the XVIII Canary Islands Winter School.

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

THE EMISSION-LINE UNIVERSE

XVIII Canary Islands Winter School of Astrophysics

Edited by

JORDI CEPA

Instituto de Astrofísica de Canarias, Tenerife

CAMBRIDGE
UNIVERSITY PRESS

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo, Delhi

Cambridge University Press
The Edinburgh Building, Cambridge CB2 8RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521898867

© Cambridge University Press 2009

This publication is in copyright. Subject to statutory exception
and to the provisions of relevant collective licensing agreements,
no reproduction of any part may take place without
the written permission of Cambridge University Press.

First published 2009

Printed in the United Kingdom at the University Press, Cambridge

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

Library of Congress Cataloguing in Publication data
Canary Islands Winter School on Astrophysics (18th : 2006 : Instituto de Astrofmsica de Canarias)
The emission-line universe : XVIII Canary Islands Winter School of Astrophysics / edited by Jordi Cepa.
p. cm.
ISBN 978-0-521-89886-7 (hardback)
1. Emission-line galaxies – Congresses. 2. Active galactic nuclei – Congresses. I. Cepa, Jordi.
II. Title.
QB858.3.C365 2006
523.1′12 – dc22 2008026917

ISBN 978-0-521-89886-7 hardback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication, and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

Contents

List of contributors *page* viii

List of participants ix

Preface xi

Acknowledgements xii

1 What can emission lines tell us? 1
G. Stasińska

2 The observer's perspective: Emission-line surveys 41
M. Giavalisco

3 The astrophysics of early galaxy formation 66
P. Madau

4 Primeval galaxies 106
D. Schaerer

5 Active galactic nuclei 138
B. M. Peterson

6 Chemical evolution 183
F. Matteucci

7 Galactic sources of emission lines 222
S. S. Eikenberry

8 Narrow-band imaging 262
S. Pascual and B. Cedrés

9 Long-slit spectroscopy 274
M. Sánchez-Portal and A. Pérez-García

10 Basic principles of tunable filters 283
H. Castañeda and A. Bongiovanni

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

Contributors

Grażyna Stasińska, LUTH, Observatoire de Paris-Meudon, France

Mauro Giavalisco, Space Telescope Science Institute, USA

Piero Madau, Department of Astronomy and Astrophysics, University of California, Santa Cruz, California, USA

Daniel Schaerer, Observatoire de Genève, Université de Genève, Sauverny, Switzerland

Bradley M. Peterson, Department of Astronomy, The Ohio State University, Columbus, Ohio, USA

Francesca Matteucci, Dipartamento di Astronomia, Università di Trieste, Italy

Stephen S. Eikenberry, University of Florida, Florida, USA

Sergio Pascual, Departamento de Astrofísica, Facultad de Ciencias Físicas, Universidad Complutense de Madrid, Spain

Bernabé Cedrés, Instituto de Astrofísica de Canarias, Tenerife, Spain

Miguel Sánchez-Portal, European Space Astronomy Centre, Spain

Ana Pérez-García, Instituto de Astrofísica de Canarias, Tenerife, Spain

Héctor Castañeda, Instituto de Astrofísica de Canarias, Tenerife, Spain

Angel Bongiovanni, Instituto de Astrofísica de Canarias, Tenerife, Spain

© Cambridge University Press www.cambridge.org

Participants

Agüero, M[a]	Paz Universidad de Córdoba (Argentina)
Atek, Hakim	Institute d'Astrophysique de Paris (France)
Barro Calvo, Guillermo	Universidad Complutense de Madrid (Spain)
Barway, Sudhanshu	Inter-University Centre for Astronomy and Astrophysics (India)
Casebeer, Darrin A.	University of Oklahoma (USA)
Colavitti, Edoardo	Osservatorio Astronomico di Trieste (Italy)
Cottis, Christopher	University of Leicester (UK)
Delgado Inglada, Gloria	INAOE (Mexico)
Díaz Santos, Tanio	CSIC (Spain)
Fernández Lorenzo, Miriam	Instituto de Astrofísica de Canarias (Spain)
González Pérez, Violeta	IEEC/CSIC (Spain)
Hayes, Matthew	AlbaNova University Centre (Sweden)
Hernández Fernández, Jonathan David	Instituto de Astrofísica de Andalucía (Spain)
Hurley, Rossa	Chalmers University of Technology (Sweden)
Ilić, Dragana	University of Belgrade (Serbia)
Izquierdo Gómez, Jaime	Universidad Complutense de Madrid (Spain)
Köhler, Ralf	Max Planck Institute for Extraterrestrial Physics (Germany)
Kovačević, Jelena	University of Belgrade (Serbia)
Koziel, Dorota	Jagiellonian University (Poland)
Kusterer, Daniel-Jens	Universität Tübingen (Germany)
Lara López, Maritza	Instituto de Astrofísica de Canarias (Spain)
Lazarova, Mariana	University of California, Riverside (USA)
Lee, Janice	University of Arizona (USA)
Marcon Uchida, Monica Midori	Universidade de São Paulo (Brazil)
Mazzalay, Ximena	Córdoba Astronomical Observatory (Argentina)
Montero Dorta, Antonio David	Instituto de Astrofísica de Andalucía (Spain)
Muñoz Marín, Victor Manuel	Instituto de Astrofísica de Andalucía (Spain)
Nava Bencheikh, Aida H.	University of Oklahoma, Norman (USA)
Ovalasen, Jan-Erik	University of Oslo (Norway)
Padilla Torres, Carmen Pilar	Instituto de Astrofísica de Canarias (Spain)
Planelles Mira, Susana	Universidad de Valencia (Spain)
Pović, Mirjana	Instituto de Astrofísica de Canarias (Spain)
Prescott, Moire	University of Arizona (USA)
Raiter, Anna	Nicolaus Copernicus University (Poland)
Ramos Almeida, Cristina	Instituto de Astrofísica de Canarias (Spain)
Ruiz Fernández, Nieves	Instituto de Astrofísica de Andalucía (Spain)
Sampson, Leda	University of Cambridge (UK)
Sánchez, Juan Andrés	Universidad Central de Venezuela (Venezuela)
Simón Díaz, Sergio	Observatoire de Paris-Meudon (LUTH) (France)
Somero, Auni	University of Helsinki (Finland)
Stoklasová, Ivana	Charles University (Czech Republic)

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

Toloba, Elisa	Universidad Complutense de Madrid (Spain)
Vale Asari, Natalia	Universidade Federal de Santa Catarina (Brazil)
Vavilkin, Tatiana	Stony Brook University (USA)
Villar, Victor	Universidad Complutense de Madrid (Spain)
Wehres, Nadine	Leiden Observatory/Universiteit Groningen (The Netherlands)
Yan, Huirong	Canadian Institute of Theoretical Astrophysics (Canada)

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

Preface

Emission lines are powerful means to detect faint objects and to study their composition and physical properties. Detecting and studying objects ranging from galactic sources to the most distant galaxies is made possible by using these lines. The aim of the XVIII Winter School is to give a thorough introduction to this emission-line Universe from both theoretical and observational points of view. For this reason, the Winter School contents include not only classical lectures, but also tutorials on data reduction and analysis. This structure enables young researchers to participate actively in current and future research projects, while serving also as a reference book for experienced researchers.

The subject of this School was motivated by the upcoming advent of a new generation of wide-field instruments for large telescopes, specifically optimized for observing emission-line objects in two dimensions. These instruments will boost the study of these kinds of objects by providing large amounts of data, whose digestion will require a theoretical basis as well as specific data-reduction techniques. These powerful facilities will enable the study of very faint emission lines of nearby objects, or conspicuous lines of very distant targets. The former will provide finer details on the chemical composition and characteristics of the gas, while the latter will furnish insight on structure formation and its evolution via scanning of large proper volumes of Universe.

Most cosmological surveys have been based on the continuum emission of the objects of the Universe via broadband imaging and their spectroscopic follow-up. Although only a fraction of the targets will shine in emission, this "emission-line" Universe, which has thus far remained relatively unexplored, will provide information about both the bright and the faint ends of the luminosity function, nicely providing essential pieces of scientific information and complementing the results obtained from classical continuum-based surveys.

The XVIII Winter School includes an introduction to the insight that UV, optical and near-infrared lines can provide on emission-line objects considering physical emission mechanisms, line diagnostics and codes, and then focuses on various types of emission-line galactic objects, identification techniques and applications. A review of characteristics, advantages and disadvantages of emission-line surveys at various wavelengths, both wide and deep, will serve as a starting point to study active galactic nuclei, QSOs, primaeval galaxies, extragalactic star formation and the evolution of the metal content of galaxies. All these topics are tackled considering their cosmic evolution and astrophysical implications. Finally, this Winter School includes hands-on tutorials presenting practical examples of data reduction and analysis of a variety of emission-line objects using diverse observational techniques.

Jordi Cepa
Instituto de Astrofísica de Canarias

© Cambridge University Press www.cambridge.org

CAMBRIDGE

Cambridge University Press
978-0-521-89886-7 - The Emission-Line Universe: XVIII Canary Islands Winter School of Astrophysics
Edited by Jordi Cepa
Frontmatter
More information

Acknowledgements

I want to express my warmest gratitude to the lecturers for their efforts in preparing their lectures and the manuscripts, making them pedagogical and challenging. I also wish to thank our efficient secretaries Nieves Villoslada and Lourdes González for their care in the preparation and organization of the School. Their experience and support have been essential for its success. Also, I am indebted to Ramón Castro for the design and production of the poster, to the technicians of the Servicios Informáticos Comunes for the installation and maintenance of the hardware and communications network, to Carmen del Puerto for her lively Winter School electronic bulletin, to Terry Mahoney for sorting out the subtleties of manuscript production and to Jesús Burgos for his efforts at trying to raise funds from the Ministry of Education (however, I do not thank the Ministry since they gave us nothing at all). I acknowledge Anna Fagan for preparing the final version of this book for Cambridge University Press.

I also wish to thank the Cabildo of the island of Tenerife and the personnel of the Salón de Congresos del Parque Taoro (I am afraid I cannot recall all their names) for their generous support and help.

Finally I wish to thank all participants for the excellent atmosphere of collaboration, enjoyment and learning that they created throughout the School. I will always remember the gift of excellent local wines from the students: not *ora et labora* but *bibere et discere*.

Açúcar!

© Cambridge University Press www.cambridge.org