

SaaS-Fee Advanced Course 48

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Tiziana Di Matteo · Andrew King ·
Neil J. Cornish

Black Hole Formation and Growth

Saas-Fee Advanced Course 48

Swiss Society for Astrophysics and Astronomy
Edited by Roland Walter, Philippe Jetzer,
Lucio Mayer and Nicolas Produit

 Springer

Authors

Tiziana Di Matteo
McWilliams Center for Cosmology
Carnegie Mellon University
Pittsburgh, USA

Andrew King
Department of Physics and Astronomy
University of Leicester
Leicester, UK

Neil J. Cornish
Department of Physics
Montana State University
Bozeman, USA

Volume Editors

Roland Walter
Department of Astronomy
University of Geneva
Geneva, Switzerland

Philippe Jetzer
Physik-Institut
University of Zurich
Zürich, Switzerland

Lucio Mayer
Institute for Computational Science
University of Zurich
Zürich, Switzerland

Nicolas Produit
Department of Astronomy
University of Geneva
Geneva, Switzerland

This Series is edited on behalf of the Swiss Society for Astrophysics and Astronomy: Société Suisse d'Astrophysique et d'Astronomie, Observatoire de Genève, ch. des Maillettes 51, CH-1290 Sauverny, Switzerland.

ISSN 1861-7980

ISSN 1861-8227 (electronic)

Saas-Fee Advanced Course

ISBN 978-3-662-59798-9

ISBN 978-3-662-59799-6 (eBook)

<https://doi.org/10.1007/978-3-662-59799-6>

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Cover illustration: Scientists have obtained the first image of a black hole, using Event Horizon Telescope observations of the center of the galaxy M87. The image shows a bright ring formed as light bends in the intense gravity around a black hole that is 6.5 billion times more massive than the Sun. Credit: Event Horizon Telescope Collaboration

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The registered company address is: Heidelberger Platz 3, 14197 Berlin, Germany

Preface

The 48th “Saas-Fee Advanced Course” of the Swiss Society for Astrophysics and Astronomy (SSAA) was held from 28 January to 3 February 2018 in Saas-Fee, in the Swiss Alps. It was very timely devoted to:

Black Hole Formation and Growth

and attended by 119 participants. The Saas-Fee courses are intended mainly for postgraduate, Ph.D. students, astronomers and physicists who wish to broaden their knowledge. The lectures were organised in the morning and late afternoon leaving free time for informal discussions, studies and outdoor activities in the afternoons.

This advanced course provided three comprehensive and up-to-date reviews covering the gravitational wave breakthrough, our understanding of accretion and feedback in supermassive black hole and the relevance of black hole to the Universe structure since the Big Bang. The lectures were given by three world experts in the field:

Prof. Tiziana Di Matteo (Carnegie Mellon University, USA)

Tiziana Di Matteo is a Professor in the McWilliams Center for Cosmology of the Physics Department at Carnegie Mellon University, USA. She received her Ph.D. in 1998 at Cambridge University, UK. She was a Chandra Fellow at Harvard and a junior faculty member at the Max Planck Institute for Astrophysics in Germany. She is a theorist with expertise in both high energy astrophysics and cosmology. Her interests focus on state-of-the-art cosmological simulations of galaxy formation with special emphasis on modelling the impact of black holes on structure formation in the Universe.

Prof. Andrew King (University of Leicester, UK)

Andrew King is Professor of Theoretical Astrophysics at the University of Leicester and holds visiting appointments at the Universities of Amsterdam and Leiden. During his career, he has been awarded a PPARC Senior Fellowship, the Gauss

Professorship at the University of Goettingen, a Royal Society Wolfson Merit Award, and the RAS Eddington Medal. He is an author and co-author of several books, including *Stars, a Very Short Introduction*, and *Accretion Power in Astrophysics*. His research interests include accretion disc structure, supermassive black hole growth and feedback, active galactic nuclei, compact binary evolution, and ultraluminous X-ray sources.

Prof. Neil J. Cornish (Montana State University, USA)

Neil J. Cornish is Regents Professor of Physics and Director of the eXtreme Gravity Institute at Montana State University. He completed his Ph.D. at the University of Toronto, followed by postdoctoral fellowships in Steven Hawking's group at the University of Cambridge and in David Spergel's group at Princeton University. He is a multiwavelength gravitational-wave astronomer, and he is a member of the Laser Interferometer Gravitational-Wave Observatory (LIGO) Scientific Collaboration, the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) Collaboration and the NASA Laser Interferometer Space Antenna (LISA) Science Study team.

Exactly 100 years before this Saas-Fee course, on 31 January 1918, Einstein submitted his paper entitled "Gravitational waves" to be presented at the Prussian Academy meeting held on 14 February. Actually, Einstein started to think on gravitational waves (at least as far it is documented) in 1913 when he was still Professor at ETH in Zürich. At the 85th Congress of the German Natural Scientists and Physicists (9 September 1913) in Vienna, Max Born asked Einstein about the speed of propagation of gravitation, in particular, whether it would be that of light. Einstein replied that it is extremely simple to write down the equations for the case in which the disturbance in the field is extremely small and this is what Einstein then did in his 1916 paper "Approximate Integration of the Field Equations of Gravitation", with some mistake, and in a more correct way in 1918.

It took a century from Einstein's papers to the actual detection of a gravitational wave (and the ultimate proof that black holes exist). A pretty important step, demonstrating that the content of this book is closer to reality than it would have been just a few years ago.

We are very grateful to the lecturers for their enthusiasm in communicating their deep knowledge, their brilliant lectures, as well as for writing the rich manuscripts composing this book. We extend our warmest thanks to the course secretaries, Martine Logossou and Marie-Claude Dunand, for their effective administration and organisational help during the course. We also would like to thank our students and collaborators helping in Saas-Fee and finalising the manuscripts, in particular, V. Sliusar, C. Panagiotou, M. Balbo, E. Lyard, T. Bernasconi and M. Kole.

Saas-Fee provided a very pleasant environment with two metres of fresh snow and an entirely sunny week. We enjoyed the first century birthday of gravitational wave on 31 January 2018, with a concert of the Swiss ethno-electronic music band "Vouipe", who composed the track "Black Hole in Saas-Fee"¹ based on the

¹Available at <http://vouipe.com/>.

space-time chirp of GW150914! We also enjoyed a concert from Moncef Genoud and Ernie Odoom. These were magical evenings, and we would like to thank again the outstanding performers for their delighting music.

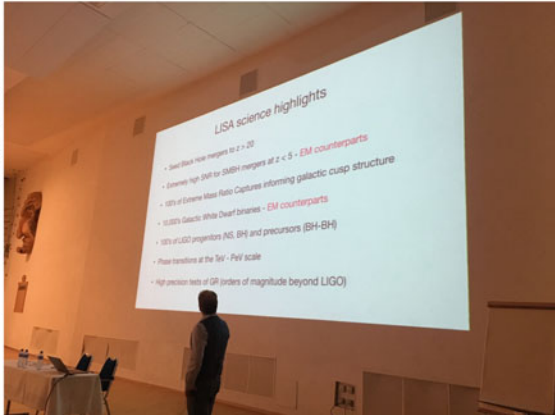
Finally, this course would not have been possible without the financial support of the Swiss Society for Astrophysics and Astronomy, the Société Académique de Genève and the Universities of Geneva and Zürich. We are very grateful to these organisations for their contributions, which allowed the participants to attend a very interesting and successful course.

The course organisers

Geneva, Switzerland
Zürich, Switzerland

Roland Walter, Nicolas Produit
Philippe Jetzer, Lucio Mayer





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