

IAU Symposium

312

25-29 August 2014  
Beijing, China

Proceedings of the International Astronomical Union

# Star Clusters and Black Holes in Galaxies across Cosmic Time

*Edited by*

Yohai Meiron

Shuo Li

Fukun Liu

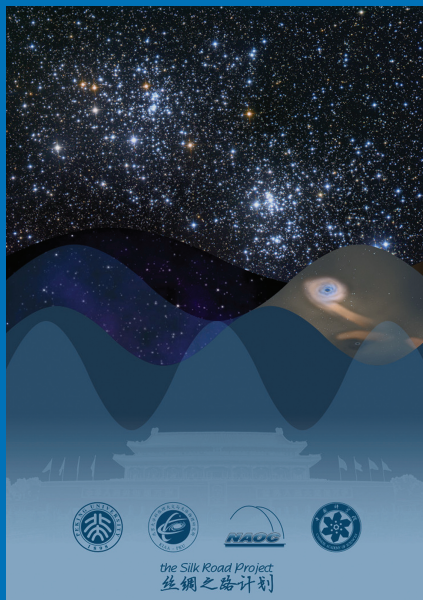
Rainer Spurzem

ISSN 1743-9213

International Astronomical Union



**CAMBRIDGE**  
UNIVERSITY PRESS



STAR CLUSTERS AND BLACK HOLES  
IN GALAXIES ACROSS COSMIC TIME

IAU SYMPOSIUM 312

*COVER ILLUSTRATION:*

The background for the symposium poster is comprised of several images relating to the event. From bottom to top, the logos of the Silk Road Project, which is funded by the Chinese Government's Thousand Talent (Qiān Rén) Programme, and contributed many person-hours to the organisation of the conference, of the two hosting institutions, the Kavli Institute for Astronomy and Astrophysics and the National Astronomical Observatories of China, as well as their parent institutions of Peking University and the Chinese Academy of Sciences. Further up is a silhouette of the Gate of Heavenly Peace (Tiān'ān Mén) in central Beijing. The sinusoidal patterns in the middle of the picture represent gravitational waves while the image on the right is an artist's impression of tidal disruption of a star around the supermassive black hole binary in the galaxy SDSS J120136.02+300305.5, discovered by Fukun Liu, Shuo Li, and Stefanie Komossa. Finally, at the top, NGC 869 and NGC 884 in the Perseus Constellation, also known as the Double Cluster and Caldwell 14. This pair of open clusters lies approximately two kiloparsecs from the Earth and is visible to the naked eye under some conditions (rarely in Beijing) or with small binoculars.

IAU SYMPOSIUM PROCEEDINGS SERIES

*Chief Editor*

THIERRY MONTMERLE, IAU General Secretary  
*Institut d'Astrophysique de Paris,*  
*98bis, Bd Arago, 75014 Paris, France*  
*montmerle@iap.fr*

*Editor*

PIERO BENVENUTI, IAU Assistant General Secretary  
*University of Padua, Dept of Physics and Astronomy,*  
*Vicolo dell'Osservatorio, 3, 35122 Padova, Italy*  
*piero.benvenuti@unipd.it*

INTERNATIONAL ASTRONOMICAL UNION  
UNION ASTRONOMIQUE INTERNATIONALE

International Astronomical Union



**STAR CLUSTERS AND BLACK  
HOLES IN GALAXIES ACROSS  
COSMIC TIME**

**PROCEEDINGS OF THE 312th SYMPOSIUM  
OF THE INTERNATIONAL ASTRONOMICAL  
UNION HELD IN BEIJING, CHINA  
AUGUST 25–29, 2014**

Edited by

**YOHAI MEIRON**

*Kavli Institute for Astronomy and Astrophysics at Peking University*

**SHUO LI**

*National Astronomical Observatories, Chinese Academy of Sciences*

**FUKUN LIU**

*Department of Astronomy, Peking University*

and

**RAINER SPURZEM**

*National Astronomical Observatories, Chinese Academy of Sciences*



CAMBRIDGE UNIVERSITY PRESS  
University Printing House, Cambridge CB2 8BS, United Kingdom  
40 West 20th Street, New York, NY 10011-4211, USA  
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© International Astronomical Union 2016

This book 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 the International Astronomical Union.

First published 2016

Printed in the UK by Bell & Bain, Glasgow, UK

Typeset in System L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>

*A catalogue record for this book is available from the British Library Library of Congress  
Cataloguing in Publication data*

ISBN 9781107078727 hardback  
ISSN 1743-9213

## Table of Contents

Preface .....	xi
The organizing committees .....	xiii
Conference photo .....	xiv
Participants .....	xv

### PART ONE

## Black Holes in Galactic Nuclei

### Session 1: Galaxy Mergers, AGN Feedback, Binary Black Holes, Tidal Disruption

Radio evidence for AGN activity: relativistic jets as tracers of SMBHs .....	3
<i>K. I. Kellermann</i>	
Compact object mergers: observations of supermassive binary black holes and stellar tidal disruption events .....	13
<i>S. Komossa &amp; J. A. Zensus</i>	
Radio evidence for binary super massive black holes .....	26
<i>R. D. Ekers</i>	
Investigating the AGN activity and black hole masses in low surface brightness galaxies .....	31
<i>S. Subramanian, R. Sethuram, M. Das, K. George, S. Thirupathi &amp; T. P. Prabhu</i>	
Disentangling AGN and starburst activities in NGC 6240 from an X-ray perspective	36
<i>J. Wang</i>	
Relativistic FeK $\alpha$ line and ensemble spins of black holes in narrow-line Seyfert 1 galaxies .....	39
<i>W. Yuan, Z. Liu, Y. Lu &amp; X.-L. Zhou</i>	
Tidal disruption as a probe for supermassive black hole binaries .....	43
<i>S. Li, F. Liu, P. Berczik &amp; R. Spurzem</i>	
Formation of discs around super-massive black hole binaries .....	48
<i>F. G. Goicovic, J. Cuadra &amp; A. Sesana</i>	
Coronal accretion: the power of X-ray emission in AGN .....	52
<i>B.-F. Liu, R. E. Taam, E. Qiao &amp; W. Yuan</i>	
The Megamaser Cosmology Project: precise black hole mass measurement and the implication for the $M_{\text{BH}}-\sigma_*$ relation. ....	56
<i>C.-Y. Kuo, J. A. Braatz, J. J. Condon, C. M. V. Impellizzeri, K.-Y. Lo, I. Zaw, C. Henkel, M. J. Reid, J. E. Greene, F. Gao &amp; W. Zhao</i>	

Multi-wavelength observations of the narrow-line Seyfert 1 galaxy RX J2314.9+2243 . . . . .	61
<i>S. Komossa, I. Myserlis, L. Fuhrmann, D. Xu, D. Grupe, Z. Fan, S. Yao, E. Angelakis, V. Karamanavis, J. A. Zensus &amp; W. Yuan</i>	
Radio-loud narrow-line Seyfert 1 galaxies with high-velocity outflows . . . . .	63
<i>S. Komossa, D. Xu &amp; J. A. Zensus</i>	
<i>Swift</i> monitoring and <i>Suzaku</i> spectroscopy of the $\gamma$ -ray detected narrow-line Seyfert 1 galaxy 1H 0323+342 . . . . .	66
<i>S. Yao, W. Yuan, S. Komossa, D. Grupe, L. Fuhrmann &amp; B. Liu</i>	
Detecting tidal disruption events of massive black holes in normal galaxies with the Einstein Probe . . . . .	68
<i>W. Yuan, S. Komossa, C. Zhang, H. Feng, Z.-X. Ling, D. H. Zhao, S.-N. Zhang, J. P. Osborne, P. O'Brien, R. Willingale, J. Lapington &amp; the Einstein Probe team</i>	
May PKS 1155+251 be the habitat of a binary black hole? . . . . .	71
<i>X. Yang &amp; X. Liu</i>	
On the relationship between black hole mass and X-ray variability amplitude in the low-mass regime of active galactic nuclei . . . . .	73
<i>H. Pan, W. Yuan, X.-L. Zhou, X. Dong &amp; B. Liu</i>	
A search of new samples of active galactic nuclei with low-mass black holes from SDSS . . . . .	75
<i>H. Liu, W. Yuan, H. Zhou &amp; X.-B. Dong</i>	
How to detect supermassive binary black holes at parsec scales . . . . .	77
<i>X. Liu</i>	
Simulation of disc-bulge-halo galaxies using parallel GPU based codes . . . . .	79
<i>O. Veles, P. Berczik &amp; A. Just</i>	
Merging of unequal mass binary black holes in non-axisymmetric galactic nuclei . . . . .	82
<i>P. Berczik, L. Wang, K. Nitadori &amp; R. Spurzem</i>	
Photometric and spectroscopic study of cD galaxies . . . . .	86
<i>S. N. Kemp, E. Pérez-Hernández &amp; V. H. Ramírez-Siordia</i>	
The effect of binary stars on photometric redshift for galaxies at $z \sim 2.0$ . . . . .	89
<i>Y. Zhang &amp; J. Liu</i>	
 <b>Session 2: Dynamics of Stars and Gas around Black Hole</b>	
Evolution of binary supermassive black holes and the final-parsec problem . . . . .	92
<i>E. Vasiliev</i>	
Resonant motions of supermassive black hole triples . . . . .	101
<i>W. Hao, R. Spurzem, T. Naab, L. Wang, M. B. N. Kouwenhoven, P. Amaro-Seoane &amp; R. A. Mardling</i>	

Large scale direct galaxy collision simulations with central supermassive binary black holes. . . . .	105
<i>M. Sobolenko, P. Berczik &amp; R. Spurzem</i>	
Star accretion onto supermassive black holes in axisymmetric galactic nuclei . . .	109
<i>S. Zhong, P. Berczik &amp; R. Spurzem</i>	
The effect of gaseous accretion disk on dynamics of the stellar cluster in AGN. . .	113
<i>B. Shukirgaliyev</i>	
The interaction between supermassive black holes and globular clusters . . . . .	118
<i>M. Spera, M. Arca-Sedda &amp; R. Capuzzo-Dolcetta</i>	
Formation and evolution of nuclear star clusters. . . . .	122
<i>A. Mastrobuono-Battisti &amp; H. B. Perets</i>	
Sculpting the central parsec of our Galaxy . . . . .	126
<i>X. Chen</i>	
Orientation of galactic bulge planetary nebulae toward the Galactic center. . . . .	128
<i>A. Danehkar &amp; Q. A. Parker</i>	
<b>Session 3: Accretion Disks around Supermassive Black Holes</b>	
Eddington capture sphere around luminous relativistic stars. . . . .	131
<i>M. Wielgus</i>	
Shadow of a Kerr-like black hole. . . . .	135
<i>F. Atamurotov</i>	
The <i>Fermi</i> bubbles inflated by winds from the accretion flow in Sgr A* . . . . .	137
<i>G. Mou</i>	
Radiative efficiency of hot accretion flow and the radio/X-ray correlation in X-ray binaries . . . . .	139
<i>F.-G. Xie</i>	
P-mode oscillation on slim discs . . . . .	141
<i>L. Xue &amp; J.-F. Lu</i>	
The black hole spins of quasars. . . . .	143
<i>B. You &amp; X. Cao</i>	

## PART TWO

# Galactic and Extragalactic Globular Clusters

### Session 1: Extragalactic Globular Cluster Systems

Are globular clusters the natural outcome of regular high-redshift star formation?	147
<i>J. M. D. Kruijssen</i>	
Preliminary results from simulations on the sub-galactic structure formation . . .	155
<i>K. Chun &amp; J. Shin</i>	



**Session 2: Globular Star Clusters in the Local Group**

Globular clusters in the Local Group . . . . .	157
<i>E. K. Grebel</i>	
Exotic populations in globular clusters: blue stragglers as tracers of the internal dynamical evolution of stellar systems . . . . .	171
<i>F. R. Ferraro</i>	
Intermediate-mass black holes in globular clusters: observations and simulations . . . . .	181
<i>N. Lützgendorf, M. Kissler-Patig, K. Gebhardt, H. Baumgardt, D. Kruijssen, E. Noyola, N. Neumayer, T. de Zeeuw, A. Feldmeier, E. van der Helm, I. Pelupessy &amp; S. Portegies Zwart</i>	
Searching for IMBHs in Galactic globular clusters through radial velocities of individual stars . . . . .	189
<i>B. Lanzoni</i>	
On the uniqueness of kinematical signatures of intermediate-mass black holes in globular clusters . . . . .	197
<i>A. Zocchi, M. Gieles &amp; V. Hénault-Brunet</i>	
Spectroscopic study of formation, evolution and interaction of M31 and M33 with star clusters. . . . .	201
<i>Z. Fan &amp; Y. Yang</i>	

**Session 3: Galactic Globular Clusters**

Evolution of binaries with compact objects in globular clusters . . . . .	203
<i>N. Ivanova</i>	
Monte Carlo modeling of globular star clusters: many primordial binaries and IMBH formation. . . . .	213
<i>M. Giersz, N. Leigh, M. Marks, A. Hypki &amp; A. Askar</i>	
Searching for intermediate mass black holes: understanding the data first . . . . .	223
<i>P. Bianchini, M. Norris, G. van de Ven &amp; E. Schinnerer</i>	
Expansion techniques for collisionless stellar dynamical simulations. . . . .	227
<i>Y. Meiron</i>	
The role of three-body stability in tidally interacting globular clusters . . . . .	231
<i>G. F. Kennedy</i>	
Planetary systems in star clusters . . . . .	235
<i>M. X. Cai, R. Spurzem &amp; M. B. N. Kouwenhoven</i>	
Dynamics of primordial binary stars in multiple-population globular clusters . . . . .	237
<i>J. Hong, E. Vesperini, A. Sollima, S. McMillan, F. D'Antona &amp; A. D'Ercole</i>	
Evolutionary models of rotating dense stellar systems: challenges in software and hardware . . . . .	239
<i>J. Fiestas</i>	
Dynamical modeling of the Arches cluster using Fokker-Planck calculations . . . . .	241
<i>J. Lee &amp; J. Shin</i>	

The grey extinction curve in NGC 3603 . . . . .	243
<i>X. Pang, A. Pasquali &amp; E. K. Grebel</i>	
Evolution of a globular cluster with a two-component BH mass spectrum . . . . .	245
<i>D. Park, C. Kim, H. M. Lee &amp; Y.-B. Bae</i>	
The coupling of a disk corona and a jet for the radio/X-ray correlation in black hole X-ray binaries . . . . .	247
<i>E. Qiao</i>	
The X-ray spectral evolution and radio–X-ray correlation in radiatively efficient black-hole sources . . . . .	249
<i>A.-J. Dong, Q. Wu &amp; X.-F. Cao</i>	
GraviDy: a modular, GPU-based, direct-summation $N$ -body code . . . . .	252
<i>C. Maureira-Fredes &amp; P. Amaro-Seoane</i>	
Performance evaluation of the Hermite scheme on many-core accelerators . . . . .	254
<i>N. Nakasato</i>	
GalevNB: GALEV for $N$ -body simulations . . . . .	258
<i>X. Pang, C. Olczak &amp; R. Spurzem</i>	
Acceleration of hybrid MPI parallel NBODY6++ for large $N$ -body globular cluster simulations . . . . .	260
<i>L. Wang, R. Spurzem, S. Aarseth, K. Nitadori, P. Berczik, M. B. N. Kouwenhoven &amp; T. Naab</i>	
MOCCA code for star cluster simulation: comparison with optical observations using COCOA . . . . .	262
<i>A. Askar, M. Giersz, W. Pych, A. Olech &amp; A. Hypki</i>	

#### Session 4: Dwarf Galaxies, Nuclear Star Clusters

Origin of ultra-compact dwarfs: a dynamical perspective . . . . .	264
<i>H.-X. Zhang, E. W. Peng, P. Côté, C. Liu, L. Ferrarese, J.-C. Cuillandre, N. Caldwell, S. D. J. Gwyn, A. Jordán, A. Lançon, B. Li, R. P. Muñoz, T. H. Puzia, K. Bekki, J. Blakeslee, A. Boselli, M. J. Drinkwater, P.-A. Duc, P. Durrell, E. Emsellem, P. Firth &amp; R. Sánchez-Janssen</i>	

#### Session 5: Nuclear Star Clusters

Black hole and nuclear cluster scaling relations: $M_{\text{bh}} \propto M_{\text{nc}}^{2.7 \pm 0.7}$ . . . . .	269
<i>A. W. Graham</i>	
The Milky Way's nuclear star cluster and massive black hole . . . . .	274
<i>R. Schödel</i>	
Star-formation in nuclear clusters and the origin of the Galactic center apparent core distribution . . . . .	282
<i>D. Aharon &amp; H. B. Perets</i>	

## PART THREE

Gravitational wave emission, observations, and the link  
to astrophysics**Session 1: Gravitational Wave Emission, Space Instruments,  
Black Holes in Galaxies**

White dwarf binaries and the gravitational wave foreground . . . . .	289
<i>M. Benacquista</i>	
The gravitational wave signal from close galaxy pairs . . . . .	296
<i>J. Liu &amp; Y. Zhang</i>	
Author index . . . . .	298

## Preface

Star clusters and black holes are moving into the focus of high resolution astrophysics, computationally as well as observationally. For the first time, Observations in many regions of the electromagnetic spectrum are converging with theoretical modelling and computer simulations. These cosmological and galaxy formation models reach down to the supermassive black hole level and follow their formation and growth in the centres of galaxies, by gas and star accretion. High star formation activity in the early universe leads to the formation of dense and very compact clusters of stars around these black holes, where stars can diffuse into the depth of the potential well and finally get disrupted by tidal forces of the central black hole, or by direct stellar collisions. Gas which settles in nuclear discs around supermassive black holes feeds the central engine of active galactic nuclei, where relativistic dynamics of stars and gas is coupled to the larger galactic scales through energy and momentum feedback.

IAU Symposium (IAUS) 312 brought together experts on high resolution observations as well as theoretical modelling and computational simulations, who presented their research on star clusters, black holes and their interrelation. IAUS 312 continues a tradition of former IAU symposia on stellar dynamics and related fields, beginning with IAUS 69 in Besançon, France (1969; *Dynamics of Stellar Systems*) and IAUS 113 in Princeton, New Jersey, United States (1984; *Dynamics of Star Clusters*), continued by IAUS 174 in Tokyo, Japan (1995; *Dynamical Evolution of Star Clusters – Confrontation of Theory and Observations*), and IAUS 246 in Capri, Italy (2007; *Dynamical Evolution of Dense Stellar Systems*). The interested reader could nicely follow the evolution of the field and its main scientific actors by browsing through these historic volumes. One may also realise how modern astrophysical techniques (computational as well as observational) have widened the field, even though one can still find methods and physical concepts today, active and well used in science, which were introduced as early as *e.g.* in IAUS 69.

IAUS 312 was divided into three main parts:

- (a) black holes in galactic nuclei
- (b) galactic and extragalactic star clusters
- (c) gravitational waves and multi-messenger astrophysics

Compared to the past symposia mentioned above, the connection with gravitational wave astrophysics was new and could prepare the ground for future collaborations between astrophysicists, instrument developers and data processing experts for ground and space based gravitational wave instruments. Just like the modelling of star cluster dynamics was inspired many decades ago by optical star counts and observations of stars using electromagnetic waves, we may see in the coming decades scientific inspirations coming from gravitational wave signals originating from compact objects (*e.g.* black holes) in star clusters. Certainly, the immense progress in astronomy in the optical, as well as in other regions of the electromagnetic spectrum, is and will be a main driver in the field in the near future.

During IAU Symposium 312, about 130 astronomers from 22 countries in all continents (except Antarctica) assembled to exchange their new results on black holes, star clusters, and gravitational wave research. This was the first IAU Symposium in the field to take place in China, and while many domestic researchers and students attended, it also attracted a large number of high level international scientists to the country, some of them for the first time.

The chairs and members of the scientific and local organising committees and the editors would like to cordially thank all colleagues, administrative staff and students

who have contributed to make this conference a success, for their help and support. We thank the International Astronomical Union for supporting the proposal for this Symposium and also for providing significant support for young scientists. We also thank the National Astronomical Observatories of Chinese Academy of Sciences, the Thousand Talent Programme of the Government of China, and the National Science Foundation of China for significant support.

*Yohai Meiron, Shuo Li,  
Fukun Liu & Rainer Spurzem  
Beijing, China, February 9, 2015*

## THE ORGANIZING COMMITTEE

### Scientific

Rainer Spurzem (China; co-chair)  
 Fukun Liu (China; co-chair)  
 Joss Bland-Hawthorn (Australia)  
 Joan Centrella (USA)  
 Ron Ekers (Australia)  
 Martin Gaskell (USA)  
 Douglas Heggie (UK)

Stefanie Komossa (Germany/China)  
 Hyung-Mok Lee (Korea)  
 Jufu Lu (China)  
 Steve McMillan (USA)  
 Giampaolo Piotto (Italy)  
 Alison Sills (Canada)  
 Kim Venn (Canada)

### Local

Rainer Spurzem (NAOC<sup>1</sup>/KIAA<sup>2</sup>; co-chair)  
 Fukun Liu (DoA<sup>3</sup>/KIAA; co-chair)  
 Peter Anders (NAOC)  
 Peter Berczik (NAOC)  
 Licai Deng (NAOC)  
 Jose Fiestas (NAOC)  
 Lijun Gou (NAOC)  
 Gareth Kennedy (NAOC)  
 Thijs Kouwenhoven (KIAA)

Lixin Li (KIAA)  
 Shuo Li (NAOC)  
 Jifeng Liu (NAOC)  
 Youjun Lu (NAOC)  
 Yohai Meiron (KIAA)  
 Eric Peng (KIAA/DoA)  
 Maxwell Xu Tsai (NAOC/KIAA)  
 Qingjuan Yu (KIAA)

<sup>1</sup>National Astronomical Observatories, Chinese Academy of Sciences

<sup>2</sup>Kavli Institute for Astronomy and Astrophysics at Peking University

<sup>3</sup>Department of Astronomy, Peking University

### Acknowledgements

The symposium was sponsored and supported by the coordinating IAU division H (Interstellar Matter and Local Universe), and further supported by the IAU divisions D (High Energy Phenomena and Fundamental Physics), G (Stars and Stellar Physics), and J (Galaxies and Cosmology); and by the IAU Commissions No. 28 (Galaxies), 33 (Structure and Dynamics of the Galactic System), 37 (Star Clusters and Associations), 44 (Space and High Energy Astrophysics), and 47 (Cosmology).

Funding by the International Astronomical Union, Thousand Talent (Qiān Rén) Programme of the Government of China, National Astronomical Observatories of Chinese Academy of Sciences and its Silk Road Project, National Natural Science Foundation of China (NSFC grant No. 11410301047), Sugon, National Science Library of Chinese Academy of Sciences, is gratefully acknowledged.

# CONFERENCE PHOTOGRAPH



## Participants

Marek **Abramowicz**, Copernicus Center  
 Danor **Aharon**, Technion – Israel Institute of Technology  
 Karla **Alamo-Martínez**, Peking University  
 Tal **Alexander**, Weizmann Institute of Science  
 Pau **Amaro Seoane**, Albert Einstein Institute  
 Peter **Anders**, National Astronomical Observatories, Chinese Academy of Sciences  
 Farruh **Atamurotov**, Institute of Nuclear Physics  
 Giacomo **Beccari**, ESO  
 Matthew **Benacquista**, University of Texas at Brownsville  
 Peter **Berczik**, National Astronomical Observatories of China, Chinese Academy of Sciences  
 Paolo **Bianchini**, Max-Planck Institute for Astronomy  
 Omer **Blaes**, University of California, Santa Barbara  
 Patrick **Brem**, Albert-Einstein-Institute  
 Maxwell Xu **Cai**, National Astronomical Observatories, Chinese Academy of Sciences  
 Raymond **Carlberg**, University of Toronto  
 Joan **Centrella**, Astrophysics Science Division  
 Xian **Chen**, Max-Planck Institute for Gravitational Physics  
 Yuguang **Chen**, Peking University  
 Zihan **Chen**, National Astronomical Observatories, Chinese Academy of Sciences  
 Huaqing **Cheng**, National Astronomical Observatories, Chinese Academy of Sciences  
 Kyungwon **Chun**, School of Space Research, Kyung Hee University  
 Jorge **Cuadra**, PUC  
 Lixin **Dai**, University of Maryland / Yale University / University of Chile  
 Ashkbiz **Danehkar**, Macquarie University  
 Richard de **Grijs**, Kavli Institute for Astronomy and Astrophysics, Peking University  
 Bililign T. **Dullo**, Swinburne University  
 Ron **Ekers**, CSIRO  
 Zhou **Fan**, National Astronomical Observatories, Chinese Academy of Sciences  
 Francesco R. **Ferraro**, Dipartimento di Fisica e astronomia  
 Jose **Fiestas**, National Astronomical Observatories, Chinese Academy of Sciences  
 Zhaoming **Gan**, Shanghai Astronomical Observatory  
 Qing **Gao**, National Astronomical Observatories, Chinese Academy of Sciences  
 Felipe **Garrido**, Instituto de Astrofísica, Universidad Católica de Chile  
 Mirek **Giersz**, Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences  
 Xuefei **Gong**, Academy of Mathematics and Systems Science, Chinese Academy of Sciences  
 Hang **Gong**, National Astronomical Observatories, Chinese Academy of Sciences  
 Rosa A. **González-Lópezlira**, UNAM  
 Lijun **Gou**, National Astronomical Observatories, Chinese Academy of Sciences  
 Alister **Graham**, Swinburne University of Technology  
 Eva **Grebel**, Heidelberg University  
 Difeng **Guo**, University of Heidelberg  
 Wei **Hao**, Max Planck Institute for Astrophysics  
 Luis **Ho**, Kavli Institute for Astronomy and Astrophysics (KIAA)  
 Jongsuk **Hong**, Indiana University  
 Siyi **Huang**, National Astronomical Observatories of China, Chinese Academy of Sciences  
 Jarrod **Hurley**, Swinburne University of Technology  
 Natalia **Ivanova**, University of Alberta  
 Siyao **Jia**, Peking University  
 Dongming **Jin**, University of Texas at Brownsville  
 Kenneth **Kellermann**, NRAO  
 Simon **Kemp**, Instituto de Astronomía, Universidad de Guadalajara  
 Gareth **Kennedy**, National Astronomical Observatories, Chinese Academy of Sciences  
 Stefanie **Komossa**, Max-Planck-Institut fuer Radioastronomie  
 M.B.N. (Thijs) **Kouwenhoven**, Kavli Institute for Astronomy and Astrophysics, Peking University  
 Pavel **Kroupa**, University of Bonn / Helmholtz-Institut fuer Strahlen- und Kernphysik  
 Diederik **Kruijssen**, Max-Planck Institut für Astrophysik  
 Cheng-Yu **Kuo**, ASIAA  
 Kazuki **Kuroda**, ICRR, UTokyo  
 Barbara **Lanzoni**, Department of Physics and Astronomy, University of Bologna  
 Yun-Kau **Lau**, Institute of Appl. Maths, Chinese Academy of Sciences  
 Joowon **Lee**, Kyung Hee University  
 Kejia **Lee**, Peking University  
 Shuo **Li**, National Astronomical Observatories, Chinese Academy of Sciences  
 Biao **Li**, Kavli Institute for Astronomy and Astrophysics at Peking University  
 Jinzhong **Liu**, Xinjiang astronomical Observatory  
 Chengze **Liu**, Shanghai Jiao Tong University  
 marek.abramowicz@physics.gu.se  
 danor@tx.technion.ac.il  
 k.alamo@crya.unam.mx  
 tal.alexander@weizmann.ac.il  
 Pau.Amaro-Seoane@aei.mpg.de  
 anders@bao.ac.cn  
 farruh@astrin.uz  
 gbeccari@eso.org  
 benacquista@phys.utb.edu  
 berczik@nao.cas.cn  
 bianchini@mpia.de  
 blaes@physics.ucsb.edu  
 pbrem@aei.mpg.de  
 maxwell@nao.cas.cn  
 raymond.carlberg@utoronto.ca  
 Joan.Centrella@nasa.gov  
 xian.chen@aei.mpg.de  
 yuguang.chen.1@gmail.com  
 zhchen@nao.cas.cn  
 hqcheng@nao.cas.cn  
 kwchun@khu.ac.kr  
 jcuadra@astro.puc.cl  
 phycosimo@gmail.com  
 ashkbiz.danehkar@students.mq.edu.au  
 grijs@pku.edu.cn  
 bdullo@astro.swin.edu.au  
 ron.ekers@csiro.au  
 zfan@bao.ac.cn  
 francesco.ferraro3@unibo.it  
 fiestas@nao.cas.cn  
 zmgan@shao.ac.cn  
 gaoqing10@mails.gucas.ac.cn  
 fagarri1@uc.cl  
 mig@camk.edu.pl  
 xfgong@amss.ac.cn  
 ghang.nao@gmail.com  
 r.gonzalez@crya.unam.mx  
 lgou@nao.cas.cn  
 agramham@astro.swin.edu.au  
 grebel@ari.uni-heidelberg.de  
 difengguo@gmail.com  
 elvis@mpa-garching.mpg.de  
 lho.pku@gmail.com  
 hongjong@indiana.edu  
 huang41@nao.cas.cn  
 jhurley@swin.edu.au  
 nata.ivanova@ualberta.ca  
 luckyjy@126.com  
 domi.kingdom@gmail.com  
 kkellerm@nrao.edu  
 snk@astro.iam.udg.mx  
 gareth.f.kennedy@gmail.com  
 skomossa@mpifr.de  
 thijskouwenhoven@gmail.com  
 pavel@astro.uni-bonn.de  
 kruijssen@mpa-garching.mpg.de  
 cykuo@asiaa.sinica.edu.tw  
 kuroda@icrr.u-tokyo.ac.jp  
 barbara.lanzoni3@unibo.it  
 lau@amss.ac.cn  
 jwlee9033@khu.ac.kr  
 kjlee@pku.edu.cn  
 lishuo@nao.cas.cn  
 hslibiao@163.com  
 liujinzh@xao.ac.cn  
 czliu@sjtu.edu.cn



Fukun <b>Liu</b> , Peking University	fkliu@pku.edu.cn
Bifang <b>Liu</b> , National Astronomical Observatories, Chinese Academy of Sciences	bfliu@nao.cas.cn
Heyang <b>Liu</b> , National Astronomical Observatories, Chinese Academy of Sciences	liuheyang@nao.cas.cn
Yiqing <b>Liu</b> , Peking University	yiqing.liu@pku.edu.cn
Xiang <b>Liu</b> , Xinjiang Astronomical Observatory, Chinese Academy of Sciences	liux@xao.ac.cn
Luis-Fernando <b>Lomeli-Nuñez</b> , Universidad Nacional Autónoma de México,	l.lomeli@crya.unam.mx
Centro de Radioastronomía y Astrofísica	
Nora <b>Lützgendorf</b> , European Space Agency (ESA/ESTEC)	nluetzge@cosmos.esa.int
Alessandra <b>Mastrobuono Battisti</b> , Technion – Israel Institute of Technology	amastrobuono@ph.technion.ac.il
Cristián <b>Maureira</b> , Albert-Einstein-Institute	cristian.maureira.fredes@aei.mpg.de
Yohai <b>Meiron</b> , Kavli Institute for Astronomy and Astrophysics at Peking University	sahmes@gmail.com
Chris <b>Messenger</b> , University of Glasgow	christopher.messenger@glasgow.ac.uk
Amin <b>Mosallanezhad</b> , Shanghai Astronomical Observatory (SHAO)	amin@shao.ac.cn
Guobin <b>Mou</b> , Shanghai Astronomical Observatory, Chinese Academy of Sciences	gbmou@shao.ac.cn
Naohito <b>Nakasato</b> , University of Aizu	nakasato@u-aizu.ac.jp
Sakurako <b>Okamoto</b> , Shanghai Astronomical Observatory	sakurako.okamoto@gmail.com
Haiwu <b>Pan</b> , National Astronomical Observatories, Chinese Academy of Sciences	panhaiwu@bao.ac.cn
Xiaoying <b>Pang</b> , Shanghai Institute of Technology	xypang@bao.ac.cn
Dawoo <b>Park</b> , Seoul National University	dawoo@astro.snu.ac.kr
Eric <b>Peng</b> , Peking University	peng@pku.edu.cn
Giampaolo <b>Piotto</b> , Università di Padova	giampaolo.piotto@unipd.it
Erbin <b>Qiao</b> , National Astronomical Observatories, Chinese Academy of Sciences	qiaoel@nao.cas.cn
Yanli <b>Qiu</b> , National Astronomical Observatories, Chinese Academy of Sciences	ylqiu@bao.ac.cn
Zara <b>Randriamanakoto</b> , South African Astronomical Observatory	zara@sao.ac.za
Carl <b>Rodriguez</b> , Northwestern University	carllouisrodriguez@gmail.com
Rainer <b>Schödel</b> , IAA (CSIC)	rainer@iaa.es
Nathan <b>Secrest</b> , George Mason University	nathansecrest@msn.com
Alberto <b>Sesana</b> , Albert Einstein Institute	alberto.sesana@aei.mpg.de
Jinyi <b>Shangguan</b> , Department of astronomy, Peking University	shangguan@pku.edu.cn
Jihye <b>Shin</b> , Kavli Institute for Astronomy and Astrophysics	jhshin.jhshin@gmail.com
Bekdaulet <b>Shukirgaliyev</b> , Fesenkov Astrophysical Institute	bekdaulet.s@gmail.com
Margarita <b>Sobolenko</b> , Main Astronomical Observatory NAS of Ukraine	sobolenko@mao.kiev.ua
Roberto <b>Soria</b> , Curtin Institute of Radio Astronomy	roberto.soria@curtin.edu.au
Mario <b>Spera</b> , INAF – Astronomical Observatory of Padova	mario.spera@oapd.inaf.it
Rainer <b>Spurzem</b> , National Astronomical Observatories, Chinese Academy of Sciences	spurzem@nao.cas.cn
Smitha <b>Subramanian</b> , Indian Institute of Astrophysics	smitha@iiap.res.in
Edwin <b>van der Helm</b> , Leiden observatory	vdhelm@strw.leidenuniv.nl
Eugene <b>Vasiliev</b> , Lebedev Physical Institute	eugvas@lpi.ru
Oleksandr <b>Veles</b> , Astronomisches Rechen-Institut	veles@ari.uni-heidelberg.de
Enrico <b>Vesperini</b> , Indiana University	evesperi@indiana.edu
Jingbo <b>Wang</b> , Xinjiang Astronomical Observatory, Chinese Academy of Sciences	wangjingbo@xao.ac.cn
Long <b>Wang</b> , Department of Astronomy at Peking University	longwang.astro@gmail.com
Song <b>Wang</b> , National Astronomical Observatories, Chinese Academy of Sciences	songw@bao.ac.cn
Junfeng <b>Wang</b> , Xiamen University	jfwang@xmu.edu.cn
Maciej <b>Wielgus</b> , Nicolaus Copernicus Astronomical Center	maciej.wielgus@gmail.com
Qingwen <b>Wu</b> , Huazhong University of Science and Technology	qw@mail.hust.edu.cn
Fu-Guo <b>Xie</b> , Shanghai Astronomical Observatory, China	fgxie@shao.ac.cn
Dawei <b>Xu</b> , National Astronomical Observatories, Chinese Academy of Sciences	dxu@nao.cas.cn
Weiwei <b>Xu</b> , National Astronomical Observatories, Chinese Academy of Sciences	weiweixu@bao.ac.cn
Li <b>Xue</b> , Department of Astronomy, Xiamen University	lixue@xmu.edu.cn
Changshuo <b>Yan</b> , NAOC	yancs@nao.cas.cn
Xiaolong <b>Yang</b> , Xinjiang Astronomical Observatory, Chinese Academy of Sciences	yangxiaolong@xao.ac.cn
Su <b>Yao</b> , National Astronomical Observatories, Chinese Academy of Sciences	yaosu@nao.cas.cn
Bei <b>You</b> , Shanghai Astronomical Observatory	youbeyib@gmail.com
Feng <b>Yuan</b> , Shanghai Astronomical Observatory	fyuan@shao.ac.cn
Weimin <b>Yuan</b> , National Astronomical Observatories, Chinese Academy of Sciences	wmy@nao.cas.cn
Yu <b>Zhang</b> , Xinjiang Observatory	zhy@xao.ac.cn
Hongxin <b>Zhang</b> , Peking University	hongxin@pku.edu.cn
Shiyan <b>Zhong</b> , National Astronomical Observatories, Chinese Academy of Sciences	zhongshiyang09@mails.gucas.ac.cn
Zhiqin <b>Zhou</b> , Astronomy Department, Peking University	zhiqinzhou@qq.com
Alice <b>Zocchi</b> , University of Surrey	a.zocchi@surrey.ac.uk