

IAU Symposium

363

29 November - 3 December 2021

Virtual Meeting

Proceedings of the International Astronomical Union

# Neutron Star Astrophysics at the Crossroads: Magnetars and the Multimessenger Revolution

*Edited by*

Eleonora Troja  
Matthew G. Baring

ISSN 1743-9213

International Astronomical Union



**CAMBRIDGE**  
UNIVERSITY PRESS

NEUTRON STAR ASTROPHYSICS AT THE CROSSROADS: MAGNETARS  
AND THE MULTIMESSENGER REVOLUTION

IAU SYMPOSIUM 363

*COVER ILLUSTRATION:*

An artist's impression of a highly magnetized neutron star. Credit: ICRAR/  
University of Amsterdam

IAU SYMPOSIUM PROCEEDINGS SERIES

*Chief Editor*

JOSÉ MIGUEL RODRÍGUEZ ESPINOSA, General Secretariat

*Instituto de Astrofísica de Andalucía*

*Glorieta de la Astronomía s/n*

*18008 Granada*

*Spain*

[IAU-general.secretary@iap.fr](mailto:IAU-general.secretary@iap.fr)

*Editor*

DIANA WORRALL, Assistant General Secretary

*HH Wills Physics Laboratory*

*University of Bristol*

*Tyndall Avenue*

*Bristol*

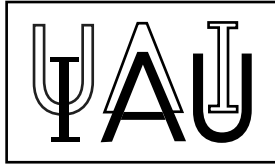
*BS8 1TL*

*UK*

[IAU-assistant.general.secretary@iap.fr](mailto:IAU-assistant.general.secretary@iap.fr)

INTERNATIONAL ASTRONOMICAL UNION  
UNION ASTRONOMIQUE INTERNATIONALE

International Astronomical Union



**NEUTRON STAR ASTROPHYSICS  
AT THE CROSSROADS:  
MAGNETARS AND THE  
MULTIMESSENGER  
REVOLUTION**

**PROCEEDINGS OF THE 363rd SYMPOSIUM OF  
THE INTERNATIONAL ASTRONOMICAL UNION  
VIRTUAL MEETING, ITALY  
29 NOVEMBER TO 3 DECEMBER, 2021**

Edited by

**ELEONORA TROJA**

*University of Rome Tor Vergata, Italy*

**MATTHEW G. BARING**

*Rice University, USA*



CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom  
1 Liberty Plaza, Floor 20, New York, NY 10006, USA  
10 Stamford Road, Oakleigh, Melbourne 3166, Australia

© International Astronomical Union 2023

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 2023

Printed in Great Britain by Henry Ling Limited, The Dorset Press, Dorchester, DT1 1HQ

Typeset in System L<sup>A</sup>T<sub>E</sub>X 2 $\epsilon$

*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<sup>TM</sup>-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](http://www.fsc.org) for information.

ISBN 9781108490757 hardback  
ISSN 1743-9213

## Table of Contents

Preface . . . . .	x
Editors . . . . .	xi
List of Participants . . . . .	xii
The search for Continuous Gravitational Waves: the journey to discovery . . . . . <i>Paola Leaci</i>	1
Neutron Star Equation of State Constraints from <i>NICER</i> and Multimessenger Gravitational Wave Observations . . . . . <i>Geert Raaijmakers</i>	10
Compact Remnant Constraints on the Core-Collapse Engine . . . . . <i>Chris L. Fryer</i>	19
Rates and environments of neutron star binaries . . . . . <i>Irina Dvorkin</i>	33
The environments and hosts of neutron star mergers and short GRBs . . . . . <i>Christina C. Thöne</i>	43
Exploring the neutron star zoo: An observational review . . . . . <i>Alice Borghese</i>	51
High magnetic field neutron stars and magnetars in binary systems . . . . . <i>Sergei B. Popov</i>	61
Fast Radio Bursts: neutron stars, magnetars or something else? . . . . . <i>Michael Kramer</i>	72
X-ray Polarization at the Crossroads . . . . . <i>Jeremy Heyl, Ilaria Caiazzo and Denis González-Caniulef</i>	80
Observations of Gravitational-wave Afterglows . . . . . <i>Alessandra Corsi</i>	92
GRB 170817A and the long-term aftermath of neutron star mergers . . . . . <i>Hendrik van Eerten</i>	105
Kilonovae and short GRBs observations in the multi-messenger era . . . . . <i>Paolo D'Avanzo</i>	117
Modeling kilonova emission from neutron star mergers . . . . . <i>Masaomi Tanaka, Daiji Kato, Gediminas Gaigalas, Kyohei Kawaguchi, Laima Radžiuūtė, Pavel Rynkun, Smaranika Banerjee and Nanae Domoto</i>	127
Multi-messenger science with Athena and Future Multi-messenger Observatories . . . . . <i>Luigi Piro</i>	135

Physics in Ultra-Strong Magnetic Fields . . . . .	149
<i>Alice K. Harding</i>	
Magnetic Field Evolution in the Crust of Neutron Stars: Crust Failure and Plastic Flow . . . . .	162
<i>Konstantinos N. Gourgouliatos</i>	
The non-trivial magnetic configuration in neutron stars . . . . .	173
<i>Daniele Viganò</i>	
Search for gravitational-wave transients associated with magnetar bursts during the third Advanced LIGO and Advanced Virgo observing run . . . . .	187
<i>Kara Merfeld</i>	
Inferring the dense nuclear matter equation of state with neutron star tides . . .	191
<i>Pantelis Pnigouras and Nils Andersson</i>	
Constraining three-nucleon forces with multimessenger data . . . . .	195
<i>Andrea Sabatucci</i>	
Modelling the deformability of magnetized neutron stars in the light of future continuous gravitational waves detection . . . . .	199
<i>Niccolò Bucciantini and Jacopo Soldateschi</i>	
Prospects for studying Galactic neutron stars in binaries with LISA . . . . .	203
<i>Valeriya Korol</i>	
Gravitational-wave EM Counterpart Korean Observatory (GECKO) . . . . .	207
<i>Myunghsin Im, Gregory S. H. Paek, Joonho Kim, Gu Lim and the GECKO Team</i>	
The neutron star neutron star merger GW170817: a multi-messenger study . . .	211
<i>Giulia Gianfagna, Luigi Piro, Eleonora Troja, Hendrik van Eerten, Geoffrey Ryan, Fulvio Ricci and Francesco Pannarale</i>	
The Off-Axis Afterglow of GW170817: Flux Prediction at Very High Energies . .	216
<i>Clément Pellouin and Frédéric Daigne</i>	
Radio afterglows of Very High Energy Gamma-ray Bursts . . . . .	220
<i>Lauren Rhodes, Alexander van der Horst and Rob Fender</i>	
Advancing Computational Methods to Understand the Dynamics of Ejection, Accretion, Winds, and Jets in Binary Neutron Star Mergers . . . . .	224
<i>Federico G. Lopez Armengol and Compact-Binaries Collaboration</i>	
HARM3D+NUC: GRMHD, nuclear tables and neutrino leakage . . . . .	228
<i>Ariadna Murguia-Berthier, Scott C. Noble, Luke F. Roberts and Enrico Ramirez-Ruiz</i>	
The simulations of early kilonova emission from neutron star mergers . . . . .	233
<i>Smaranika Banerjee, Masaomi Tanaka, Kyohei Kawaguchi, Daiji Kato and Gediminas Gaigalas</i>	
Signatures of <i>r</i> -process elements in kilonova spectra . . . . .	237
<i>Nanae Domoto, Masaomi Tanaka, Shinya Wanajo and Kyohei Kawaguchi</i>	

Let there be light: Illuminating kilonovae with the radiative transfer code POSSIS . . . . .	241
<i>Mattia Bulla</i>	
Consequences of Jet-Ejecta Interaction in Neutron Star Mergers . . . . .	245
<i>Lorenzo Nativi, Stephan Rosswog, Mattia Bulla, Christoffer Lundman, Gavin P. Lamb and Grzegorz Kowal</i>	
Recoil Velocity of Binary Neutron Star Merger Remnants . . . . .	250
<i>Sumeet Kulkarni, Surendra Padamata and Anuradha Gupta</i>	
Equation-of-State effects on Gravitational Waves in Core-Collapse Supernovae . . . . .	255
<i>Oliver Eggenberger Andersen, Shuai Zha, André da Silva Schneider, Aurore Betranhandy, Sean M. Couch and Evan P. O'Connor</i>	
INTEGRAL contributions to magnetars and multimessenger astrophysics . . . . .	259
<i>Sandro Mereghetti</i>	
PULXs as Accreting Magnetars: Observational Manifestations . . . . .	263
<i>Nabil Brice, Silvia Zane, Roberto Taverna, Roberto Turolla and Kinwah Wu</i>	
Novel Clues to the Physics of Magnetars as Probed with Detailed Pulse-Timing Studies . . . . .	267
<i>Kazuo Makishima</i>	
Probing magnetar formation channels with high-precision astrometry: The progress of VLBA astrometry of the fastest-spinning magnetar Swift J1818.0–1607 . . . . .	271
<i>Hao Ding, Adam Deller, Marcus Lower and Ryan Shannon</i>	
Polarized emission from strongly magnetized sources . . . . .	276
<i>Roberto Taverna, Roberto Turolla, Silvia Zane, Valery Suleimanov and Alexander Y. Potekhin</i>	
Modelling Magnetar Behaviour with 3D Magnetothermal Simulations . . . . .	280
<i>Davide De Grandis, Roberto Turolla, Roberto Taverna, Toby S. Wood and Silvia Zane</i>	
Identification of a Local Sample of Gamma-Ray Bursts Consistent with a Magnetar Giant Flare Origin . . . . .	284
<i>Michela Negro and Eric Burns</i>	
Deep eROSITA observations of the <i>magnificent seven</i> isolated neutron stars . . . . .	288
<i>Adriana Mancini Pires, Axel Schwöpe and Jan Kurpas</i>	
The new magnetar SGR J1830–0645 in outburst . . . . .	293
<i>Francesco Coti Zelati</i>	
Polarized Radiation Signals from Highly Magnetized Neutron Star Surfaces . . . . .	297
<i>Kun Hu, Matthew G. Baring, Joseph A. Barchas and George Younes</i>	
Observability of isolated neutron stars at SRG/eROSITA . . . . .	301
<i>Alena D. Khokhriakova, Anton V. Biryukov and Sergei B. Popov</i>	



Heating from Electron Captures by Nuclei in Magnetar Crusts . . . . .	305
<i>Nicolas Chamel, Anthea Francesca Fantina, Lami Suleiman, Julian-Leszek Zdunik and Pawel Haensel</i>	
Magnetorotational core-collapse supernovae: the impact of the magnetic field's structure . . . . .	309
<i>Matteo Bugli, Jérôme Guilet and Martin Obergaulinger</i>	
IXPE Simulations for magnetars . . . . .	314
<i>Denis González-Caniulef, Ilaria Caiazzo and Jeremy Heyl</i>	
Probing Magnetars Using Spectral Lines with Future Telescopes . . . . .	318
<i>Demet Kirmızıbayrak and Jeremy Heyl</i>	
The Magnetar Connection . . . . .	322
<i>Tanmay Tushar Chowhan, Sushan Konar and Sarmistha Banik</i>	
Astrophysical entomology: dissecting the black widow population through multi-band light curve modelling . . . . .	324
<i>Daniel Mata Sánchez, Mark R. Kennedy, Colin J. Clark, Rene P. Breton and Vikhram S. Dhillon</i>	
Importance of electron-positron pairs on the maximum possible luminosity of the accretion columns in ULXs . . . . .	327
<i>Valery F. Suleimanov, Alexander Mushtukov, Igor Ognev, Victor A. Doroshenko and Klaus Werner</i>	
NS parameters from IXPE data of AMPs . . . . .	329
<i>Alessandro Di Marco, Alessandro Papitto, Maura Pilia, Juri Poutanen and Tuomo Salmi</i>	
A broad-band perspective on circular polarization in radio pulsar observations . .	332
<i>Lucy S. Oswald</i>	
Probing accretion flow structure of the HMXB Centaurus X-3 through X-ray spectral variability . . . . .	335
<i>Tsubasa Tamba, Hirokazu Odaka, Aya Bamba, Atsushi Tanimoto, Satoshi Takashima and Hiromasa Suzuki</i>	
Force-free and twisted, relativistic neutron star magnetosphere . . . . .	338
<i>Dimitris Ntotsikas and Konstantinos N. Gourgouliatos</i>	
A new model for nulling and moding in radio pulsars . . . . .	340
<i>Jaroslav Dyks</i>	
Silicon K-edge Dust Properties of Neutron Star Low-mass X-ray Binaries . . . . .	342
<i>A. Danekkar</i>	
X-ray dim isolated neutron star candidates from the eROSITA All-Sky Survey . .	345
<i>J. Kurpas, A. Schwope, A. M. Pires and F. Haberl</i>	
Magnetic field dissipation in nucleonic neutron star cores . . . . .	347
<i>Dmitry D. Ofengeim, Mikhail E. Gusakov and Alexander Y. Potekhin</i>	

Are hypermassive neutron stars stable against a prompt collapse? . . . . . 350  
*Paweł Szewczyk, Dorota Gondek-Rosińska, Kamil Kolasa and Parita Mehta*

Improving agnostic searches of Gravitational Waves from Neutron Star  
 instabilities using image filtering . . . . . 352  
*Lorenzo Pierini*

Toward an efficient modeling of neutrino-driven winds in binary neutron  
 star mergers . . . . . 354  
*Davide Gizzi, Stephan Rosswog, Evan O'Connor, Albino Perego and  
 Christoffer Lundman*

GECKO: Network of Telescopes and Follow-up Observation of GW190425 . . . . . 356  
*Gregory S.H. Paek, Myungshin Im, Joonho Kim and Gu Lim*

A search for optical and near-infrared counterparts of the compact binary  
 merger GW190814 . . . . . 358  
*Aishwarya Limesh Thakur on behalf of a larger collaboration*

Magnetic fields in galactic binaries and gravitational waves . . . . . 361  
*A. Bourgoïn, C. Le Poncin-Lafitte, S. Mathis and M.-C. Angonin*

Exploring Populations of Low Mass Merging Compact Binary Systems with  
 Single Einstein Telescope . . . . . 363  
*Neha Singh and Tomasz Bulik*

RNO-G detection perspectives of binary neutron star mergers . . . . . 365  
*Maddalena Cataldo for the RNO-G Collaboration*

Author Index . . . . . 369

## Preface

This special volume includes contributions from the IAUS 363 Symposium, *Neutron Star Astrophysics at the Crossroads: Magnetars and the Multimessenger Revolution*. It was intended to hold the symposium in Italy in June 2020, at the end of the third LIGO and Virgo observing run. Unfortunately, due to the Covid-19 global pandemic, the symposium was postponed to December 2021 and conducted virtually.

The main goal of this symposium was to address the astrophysical implications of gravitational wave and electromagnetic observations of neutron stars. At its core are offerings on the state of the art understanding of mergers of binary neutron stars producing short gamma-ray bursts, and the most extremely magnetic varieties of neutron stars, magnetars. The papers discuss the status, perspectives and challenges in the blossoming era of multi-messenger astronomy, which is accelerating the path towards a more complete physical picture of neutron stars. The book encapsulates both observations and modeling, addressing extreme transient events including kilonovae, afterglows, magnetar giant flares, and fast radio bursts. By exploring the intersection of studies of isolated neutron stars and binary system synthesis and merging, the ensemble of papers sets the scene for interpreting exciting results pertaining to powerful X-ray, gamma-ray, and gravitational wave transients to be acquired in the next decade and beyond.

The symposium was organized around a morning plenary session followed by two parallel sessions in the afternoon. This format was selected to encourage synergy and cross-fertilization among different communities and, at the same time, to identify and address the most pressing open questions within each field of research. Plenary sessions gave a broad and interdisciplinary overview of neutron stars, their gravitational waves and electromagnetic emission. There were five plenary sessions with the following themes and articles from each are included in these proceedings:

- 1) Neutron star population and environment
- 2) Neutron stars and magnetars as sources of gravitational waves
- 3) Neutron star and magnetar emission processes
- 4) Neutron star and gamma-ray burst connection
- 5) Neutron star astrophysics with future observatories

Parallel sessions instead provided a deeper insight into specific questions on the physics of magnetar on one side, and neutron stars as sources of gravitational waves, gamma-ray bursts, and kilonovae on the other. The symposium's program included the following parallel sessions: neutron stars through gravitational wave observations: modeling, search and implications for fundamental physics and astrophysics; neutron star population synthesis and links among diverse neutron star classes; binary neutron star mergers, kilonovae and gamma-ray bursts; magnetars: from their formation to present multiwavelength observations; binary neutron star population and environment through gravitational wave observations and host galaxy studies; magnetars in binary systems; neutron star physics and cosmology with the new generation multi-messenger instruments; neutron star magnetic fields and magnetar magnetospheres.

We wish to extend our gratitude to our organizing institutions and sponsors for supporting the symposium.

Eleonora Troja and Matthew G. Baring

## **Editors**

Eleonora Troja  
University of Rome Tor Vergata, Italy

Matthew G. Baring  
Rice University, USA

## ***Organizing Committee***

### **Scientific Organising Committee**

Marica Branchesi (Co-Chair), GSSI, Italy  
Gian Luca Israel (Co-Chair), INAF – OA Roma, Italy  
Eleonora Troja (Co-Chair), University of Rome Tor Vergata, Italy  
Roberto Turolla (Co-Chair), University of Padova, Italy  
Matthew G. Baring, Rice University, USA  
Laura Cadonati, Georgia Tech, USA  
Bala Iyer, ICTS-TIFR, India  
Nobuyuki Kawai, Tokyo Institute of Technology, Japan  
Tara Murphy, University of Sidney, Australia  
Rosalba Perna, Stonybrook University, USA  
Nanda Rea, Instituto de Ciencia de l'Espacio, Spain  
Stephan Rosswog, Stockholm University, Sweden  
Samar Safi-Harb, University of Manitoba, Canada  
Dmitry Yakovlev, Ioffe Institute, Russia  
Silvia Zane, University College London – Mullard Space Science Laboratory, United Kingdom

### **Local Organising Committee Online**

Marica Branchesi, GSSI, Italy  
Eliana Di Giovanni, GSSI, Italy  
Marco Drago, Sapienza University, Italy  
Gian Luca Israel, INAF – OA Roma, Italy  
Andrea Maselli, GSSI, Italy  
Gor Oganessian, GSSI, Italy  
Eleonora Troja, University of Rome Tor Vergata, Italy  
Roberto Turolla, University of Padova, Italy  
Silvia Zane, University College London – Mullard Space Science Laboratory, United Kingdom

## List of Participants

Abdelmaguid, M.  
Aharonian, F.  
Ahumada, T.  
Amati, L.  
Andreoni, I.  
Arca Sedda, M.  
Artale, M. C.  
Ascenzi, S.  
Astone, P.  
Ayache, E.  
Bachetti, M.  
Ball, M.  
Banerjee, B.  
Banerjee, S.  
Baring, M. G.  
Barrère, P.  
Becerra-Gonzalez, J.  
Becerra, R.  
Becerra Bayona, L.  
Berge, D.  
Betranhandy, A.  
Borghese, A.  
Bourgoin, A.  
Branchesi, M.  
Brice, N.  
Brown, D.  
Bruni, G.  
Bucciantini, N.  
Buehler, R.  
Bugli, M.  
Bulla, M.  
Burns, E.  
Caiazzo, I.  
Camilletti, A.  
Castillo, F.  
Cataldo, M.  
Celora, T.  
Chakraborty, A.  
Chamel, N.  
Chandra, P.  
Chen, T.  
Chenevez, J.  
Chinonso, J.  
Choudhury, D.  
Chowhan, T.  
Chrimes, A.  
Colombo, A.  
Cooper, A.  
Corsi, A.  
Coti Zelati, F.  
Crosato Menegazzi, L.  
Daigne, F.  
Danekhar, A.  
Dash, L.  
D'Avanzo, P.  
De Grandis, D.  
Dehman, C.  
Di Marco, A.  
Dichiara, S.  
Diez, C.  
Dimitropoulos, I.  
Ding, H.  
Domoto, N.  
Donnarumma, I.  
Dupletsa, U.  
Dvorkin, I.  
Dyks, J.  
Eggenberger Andersen, O.  
Esposito, P.  
Finstad, D.  
Frey, R.  
Fryer, C.  
Fujibayashi, S.  
Gautam, A.  
Ghadimi, A.  
Gianfagna, G.  
Gittins, F.  
Gizzi, D.  
Gnarini, A.  
Gogus, E.  
Gonzalez-Caniulef, D.  
Gottlieb, A.  
Gourgouliatos, K.  
Graber, V.  
Greco, E.  
Guilet, J.  
Hajela, A.  
Hanlon, L.  
Harding, A.  
Hare, J.  
Hazra, N.  
Heyl, J.  
Hirschmann, E.  
Hope, J.  
Hu, K.  
Hurley-walker, N.

Ibrahim, A.	Mutafchieva, Y.
Igoshev, A.	Nagele, C.
ILHE, S.	Nakama, Y.
Im, M.	Nathanail, A.
Iosif, P.	Nativi, L.
Israel, G.	Nazari, E.
Itoh, Y.	Negro, M.
Kalinani, J.	Nissanke, S.
Khanal, A.	Nomoto, K.
Khatiwada, K.	Ntotsikas, D.
Khokhriakova, A.	O'Brien, P.
Kim, S.	O'Connor, B.
Kirmizibayrak, D.	O'Connor, E.
Klingler, N.	Ofengeim, D.
Kojima, Y.	Oganesyan, G.
Kolesova, H.	Olivares E., F.
Korol, V.	Omand, C.
Kouveliotou, C.	Orellana, M.
Kramer, M.	Oswald, L.
Kravtsov, I.	Owen, B.
Kulkarni, S.	Pacilio, C.
Kuroda, T.	Paek, G.
Kurpas, J.	Palomba, C.
Laha, S.	Papitto, A.
Lander, S.	Park, S.
Leaci, P.	Patel, M.
Leung, J.	Patricelli, B.
Li, X.	Paul, K.
Li, K.	Pellouin, C.
Li, X.	Penacchioni, A.
Lin, L.	Pereyra Talamantes, E.
Linares, M.	Pérez Torres, M.
Liu, K.	Perna, R.
Loffredo, E.	Piccinni, O.
Lopez Armengol, F.	Pierini, L.
Lyman, J.	Piro, L.
Lyutikov, M.	Pittori, C.
Macquet, A.	Pnigouras, P.
Makishima, K.	Popov, S.
Mancini Pires, A.	Posselt, B.
Maselli, A.	Possenti, A.
Masnou, J.	Raaijmakers, G.
Mata Sanchez, D.	Rajwade, K.
Mei, A.	Raman, G.
Mereghetti, S.	Raynaud, R.
Merfeld, K.	Rea, N.
Miani, A.	Reboul-salze, A.
Miller, J.	Reisenegger, A.
Moraga, N.	Rhodes, L.
Murguia-Berthier, A.	Ricci, R.
Murphy, T.	Rigoselli, M.

Ripoche, P.  
Ronchi, M.  
Ronchini, S.  
Rosinska, D.  
Rossi, A.  
Sabatucci, A.  
Safi-Harb, S.  
Sakamoto, T.  
Salafia, O.  
Salmi, T.  
Sarin, N.  
Sathyaprakash, B.  
Schmidt, P.  
Schwope, A.  
Scragg, T.  
Shawhan, P.  
Shen, H.  
Shibata, M.  
Siellez, K.  
Singh, N.  
Slane, P.  
Slavko, B.  
Słowikowska, A.  
Song, Y.  
Stappers, B.  
Stefanou, P.  
Stewart, R.  
Stiele, H.  
Stoyanov, Z.  
Stratta, G.  
Suleimanov, V.  
Suresh, A.  
Szewczyk, P.  
Szigeti, B.  
Taani, A.  
Tamba, T.  
Tanaka, M.  
Taverna, R.  
Thakur, A.  
Thielemann, F.  
Thoene, C.  
Tohuvavohu, A.  
Tonetto, L.  
Topinka, M.  
Trevor, M.  
Trudu, M.  
Turolla, R.  
Urrutia, G.  
Van Eerten, H.  
Viganò, D.  
Vinciguerra, S.  
Wadiasingh, Z.  
Wallis, M.  
Wang, Z.  
Wang, Y.  
Wen, L.  
Witte, S.  
Yakovlev, D.  
Yang, H.  
Ye, C.  
Yim, G.  
Zakharenko, V.  
Zane, S.  
Zepeda, F.  
Zhang, J.  
Zhang, B.