

IAU Symposium

305

25 November–5 December 2014
Punta Leona, Costa Rica

Proceedings of the International Astronomical Union

Polarimetry: From the Sun to Stars and Stellar Environments

Edited by

K.N. Nagendra
Stefano Bagnulo
Rebecca Centeno
Maria Jesus Martinez Gonzalez

ISSN 1743-921X
Volume 305



CAMBRIDGE
UNIVERSITY PRESS

INTERNATIONAL ASTRONOMICAL UNION
UNION ASTRONOMIQUE INTERNATIONALE

International Astronomical Union



POLARIMETRY: FROM THE SUN
TO STARS AND STELLAR
ENVIRONMENTS

PROCEEDINGS OF THE 305th SYMPOSIUM
OF THE INTERNATIONAL ASTRONOMICAL
UNION HELD IN PUNTA LEONA, COSTA RICA
NOVEMBER 30 – DECEMBER 5, 2014

Edited by

K. N. NAGENDRA
Indian Institute of Astrophysics, India

STEFANO BAGNULO
Armagh Observatory, UK

REBECCA CENTENO
High Altitude Observatory (NCAR), USA

and

MARÍA JESÚS MARTÍNEZ GONZÁLEZ
Instituto de Astrofísica de Canarias, Spain



CAMBRIDGE
UNIVERSITY PRESS

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 2015

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 2015

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

Typeset in System L^AT_EX 2_•

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

ISBN 9781107078550 hardback
ISSN 1743-9213

Table of Contents

Preface	x
The Organizing Committee	xiii
Conference Photograph	xiv
Participants	xxiv

Astronomical Polarization Tutorials

The Physics of Polarization	1
<i>E. Landi Degl'Innocenti</i>	

Session I. Solar and Stellar Surface Magnetic Fields

Chairs: S. Solanki, J. Trujillo Bueno, O. Kochukhov, J. Landstreet and R. Centeno

Two Centuries of Solar Polarimetry	2
<i>J. W. Harvey</i>	
Surface magnetic fields across the HR Diagram	12
<i>J. D. Landstreet</i>	
Do the quiet sun magnetic fields vary with the solar cycle?	22
<i>M. Faurobert, G. Ricort & B. Lites</i>	
Solar Surface Anisotropy effect on the Magnetic Field	28
<i>V. Bommier</i>	
The Persistence of Apparent Non-Magnetostatic Equilibrium in NOAA 11035 ..	35
<i>S. A. Jaeggli</i>	
Detection and characteristics of magnetic fields in evolved intermediate mass stars	42
<i>L. Sabin</i>	
Full Stokes <i>IQUV</i> spectropolarimetry of AGB and post-AGB stars: probing surface magnetism and atmospheric dynamics	47
<i>A. Lèbre, M. Aurière, N. Fabas, D. Gillet, E. Josselin, P. Mathias & P. Petit</i>	
Magnetic fields in early-type stars	53
<i>J. H. Grunhut & C. Neiner</i>	
The origin of magnetic fields in hot stars	61
<i>C. Neiner, S. Mathis, E. Alecian, C. Emeriau, J. Grunhut & the BinaMics and MiMeS collaborations</i>	
Ultra-weak magnetic fields in Am stars: β UMa and θ Leo	67
<i>A. Blazère, P. Petit, F. Lignières, M. Aurière, J. Ballot, T. Böhm, C. Folsom, A. López Ariste & G. A. Wade</i>	
Full Stokes observations in the He I 1083 nm spectral region covering an M3.2 flare	73
<i>C. Kuckein, M. Collados, R. Manso Sainz & A. Asensio Ramos</i>	

Flux emergence event underneath a filament	79
J. Palacios, Y. Cerrato, C. Cid, A. Guerrero & E. Saiz	
On the peculiarities of manifestation of kG magnetic elements in observations of the Sun with low spatial resolution	86
M. L. Demidov, R. M. Veretsky & A. V. Kiselev	
Solar Full-Disk Polarization Measurement with the Fe I 15648 Å Line	92
Y. Hanaoka, T. Sakurai & IRMag Group	
Magnetic field configuration in a flaring active region	97
J. Palacios, L. A. Balmaceda & L. E. Vieira	
Session II. Future Directions in Astrophysical Polarimetry	
<i>Chairs: R. Casini and B. W. Lites</i>	
Polarization calibration techniques and scheduling for the Daniel K. Inouye Solar Telescope	102
D. F. Elmore	
The Polarimetric and Helioseismic Imager for <i>Solar Orbiter</i> : SO/PHI	108
S. K. Solanki, J. C. del Toro Iniesta, J. Woch, A. Gandorfer, J. Hirzberger, W. Schmidt, T. Appourchaux, A. Alvarez-Herrero & the SO/PHI team	
SolpeX: the soft X-ray flare polarimeter-spectrometer for the ISS	114
J. Sylwester, S. Płocieniak, J. Bąkała, Ż. Szaforz, M. Stęślicki, D. Scisłowski, M. Kowaliński, P. Podgórski, J. Hernandez & S. Shestov	
Waves and Magnetism in the Solar Atmosphere (WAMIS)	121
L. Strachan, Y.-K. Ko, J. D. Moses, J. M. Laming, F. Auchere, R. Casini, S. Fineschi, S. Gibson, M. Knoelker, C. Korendyke, S. McIntosh, M. Romoli, J. Rybak, D. Socker, S. Tomczyk, A. Vourlidas & Q. Wu	
Session III. Physical Processes	
<i>Chair: P. Judge</i>	
Atomic Scattering Polarization. Observations, Modeling, Predictions	127
J. Trujillo Bueno, T. Del Pino Alemán & L. Belluzzi	
Coherence structure of D ₁ scattering	136
J. O. Stenflo	
Chromospheric diagnosis with forward scattering polarization	146
E. S. Carlin	
Paschen-Back effect involving atomic fine and hyperfine structure states	154
K. Sowmya, K. N. Nagendra, M. Sampoorna & J. O. Stenflo	
Session IV. Instrumentation for Astronomical Polarimetry	
<i>Chair: S. A. Jaeggli</i>	
New Optics for Astronomical Polarimetry	159
T. Baur	

Preliminary design of the full-Stokes UV and visible spectropolarimeter for UVMag/Arago	168
<i>M. Pertenaïs, C. Neiner, L. Parès, P. Petit, F. Snik & G. van Harten</i>	
Preliminary status of POLICAN: A near-infrared imaging polarimeter	175
<i>R. Devaraj, A. Luna, L. Carrasco & Y. D. Mayya</i>	
The importance of non-photon noise in astronomical spectropolarimetry	181
<i>S. Bagnulo, L. Fossati, J. D. Landstreet & O. Kochukhov</i>	
Design of a Full Stokes Polarimeter for Chromospheric Measurements with SOLIS/VSM	186
<i>S. Gosain & J. W. Harvey</i>	
The DAO Liquid Crystal Spectropolarimeter dimaPol	191
<i>D. Monin, D. Bohlender, T. Hardy & L. Saddlemeyer</i>	
Preliminary design of the INPE's Solar Vector Magnetograph	195
<i>L. E. A. Vieira, A. L. Clúa de Gonzalez, A. Dal Lago, C. Wrasse, E. Echer, F. L. Guarnieri, F. Reis Cardoso, G. Guerrero, J. Rezende Costa, J. Palacios, L. Balmaceda, L. Ribeiro Alves, L. da Silva, L. L. Costa, M. Sampaio, M. C. Rabello Soares, M. Barbosa, M. Domingues, N. Rigozo, O. Mendes Jr., P. Jauer, R. Dallaqua, R. H. Branco, T. Stekel, W. Gonzalez & W. Kabata</i>	
Commissioning Results of a New Polarimeter: Denver University Small Telescope Polarimeter (DUSTPol)	200
<i>T. M. Wolfe, R. Stencel & G. Cole</i>	

Session V. Data Analysis techniques for Polarization Observations

Chair: *J. C. del Toro Iniesta*

Pattern recognition techniques in Polarimetry	207
<i>A. Lopez Ariste</i>	
Multi-line techniques for inference of stellar magnetic fields	216
<i>O. Kochukhov</i>	
New generation Stokes inversion codes	225
<i>A. Asensio Ramos & J. de la Cruz Rodríguez</i>	
Study of resonance scattering polarization in O I 130 nm lines	234
<i>L. S. Anusha, K. N. Nagendra & Han Uitenbroek</i>	
Inhomogeneity and velocity fields effects on scattering polarization in solar prominences	238
<i>I. Milić & M. Faurobert</i>	
Data-model comparison using FORWARD and CoMP	245
<i>S. Gibson</i>	
Parallelization of the SIR code for the investigation of small-scale features in the solar photosphere	251
<i>S. Thonhofer, L. R. Bellot Rubio, D. Utz, A. Hanslmeier & J. Jurčák</i>	

Session VI. Polarization Diagnostics of Atmospheres & Circumstellar Environments

Chairs: J. Vink, S. Gibson and F. Menard

Circumstellar Polarimetry	257
<i>A. M. Magalhães, A. C. Carciofi & D. B. Seriacopi</i>	
Polarimetry as a window into supernova explosions and progenitors	269
<i>J. L. Hoffman</i>	
Polarimetric measurements in prominences and “tornadoes” observed by THEMIS ..	275
<i>B. Schmieder, A. Lopez Ariste, P. Levens, N. Labrosse & K. Dalmasse</i>	
The Coronal Structure of the Sun-Like Exoplanet-Host GJ 3021	282
<i>J. D. Alvarado-Gómez, O. Cohen, G. A. J. Hussain, J. Grunhut, C. Garraffo & J. Drake</i>	
Emission line spectropolarimetry and circumstellar structures	288
<i>J. S. Vink</i>	
Probing disk inhomogeneities using spectropolarimetry in the extreme binary epsilon Aurigae.....	293
<i>K. Geise & R. Stencel</i>	
Atmospheres, magnetism, mass loss of red supergiant stars.....	299
<i>E. Josselin, J. Lambert, M. Aurière, P. Petit & N. Ryde</i>	
High-velocity Wind from IRS 1 in the NGC 2071IR.....	301
<i>M. A. Trinidad</i>	

Session VII. Polarimetry as a Tool for Discovery Science

Chairs: M. Mishchenko and S. Bagnulo

Bio-signatures of Planet Earth from Spectropolarimetry	305
<i>M. F. Sterzik, S. Bagnulo & C. Emde</i>	
Polarimetry: a primary tool for the physical characterization of asteroids	313
<i>A. Cellino & S. Bagnulo</i>	
Linear spectropolarimetry: a new tool for the physical characterization of asteroids	319
<i>S. Bagnulo, A. Cellino & M. F. Sterzik,</i>	
Polarimetry as a tool to find and characterise habitable planets orbiting white dwarfs	325
<i>L. Fossati, S. Bagnulo, C. A. Haswell, M. R. Patel, R. Busuttil, P. M. Kowalski, D. V. Shukyak, M. F. Sterzik & G. Valyavin</i>	
Stellar magnetic activity and their influence on the habitability of exoplanets ..	333
<i>T. Lüftinger, M. Güdel & C. Johnstone</i>	
Line Profile Variations of Solar Analog Stars: Chromospheric Indexes vs. Li Abundance. The Host Star Search.	340
<i>E. M. Amazo-Gómez, G. Harutyunyan, J. D. Alvarado-Gómez, K. G. Strassmeier, M. Weber & T. A. Carroll.</i>	
Towards polarimetry as a tool for the detection of extra-terrestrial life	346
<i>S. Bagnulo, M. F. Sterzik & A. Cellino</i>	

Session VIII. Numerical Modeling of Polarized Emission

Chair: M. Faurobert

On the importance of partial frequency redistribution in modeling the scattering polarization.....	351
K. N. Nagendra	
Three-dimensional simulations of scattering polarization and the Hanle effect in MHD chromospheric models	360
J. Štěpán	
The impact of surface dynamo magnetic fields on the chemical abundance determination	368
N. G. Shchukina, A. V. Sukhorukov & J. Trujillo Bueno	
A revisit to model the Cr I triplet at 5204-5208 Å and the Ba II D ₂ line at 4554 Å in the Second Solar Spectrum	372
H. N. Smitha, K. N. Nagendra, J. O. Stenflo, M. Bianda, M. Sampoorna & R. Ramelli	
Radiative transfer simulations of multiphase AGN tori: thermal emission and polarisation	377
M. Baes, M. Stalevski, P. Camps, J. Fritz & L. Č. Popović	
Modeling the center-to-limb variation of the Ca I 4227 Å line using FCHHT models	381
H. D. Supriya, H. N. Smitha, K. N. Nagendra, J. O. Stenflo, M. Bianda, B. Ravindra, R. Ramelli & L. S. Anusha	
Partial Redistribution Effects on Polarized Lines Formed in Moving Media in the Presence of a Weak Magnetic Field	387
M. Sampoorna & K. N. Nagendra	
Polarized Continuum Radiation from Stellar Atmospheres	395
J. P. Harrington	
Formation of polarized spectral lines in atmospheres with horizontal inhomogeneities	401
A. Tichý, J. Štěpán, J. Trujillo Bueno & J. Kubát	
Author Index	407