

Contents

Radio Pulsar Phenomenology	1
Simon Johnston and Aris Karastergiou	
1 Introduction	1
2 Observational Basics	2
3 Integrated profiles and polarization	4
3.1 Pulse width	5
3.2 Profile shape	5
3.3 Linear polarization	6
3.4 Position angle swing and orthogonal modes	7
3.5 Circular polarization	7
4 Rotating Vector Model	8
5 Problems and Perils of the RVM	10
6 Radius-to-Frequency mapping	11
7 Velocity - spin axis alignment	12
8 Beam models	12
8.1 Rankin et al.	12
8.2 Lyne & Manchester	13
8.3 Karastergiou & Johnston	14
9 Two Case Studies	14
9.1 The radio loud magnetars	14
9.2 Pulsars with notches	15
10 Summary	16
11 Future instruments and the Square Kilometre Array	17
References	18
Radio pulsar populations	21
Duncan R. Lorimer	
1 Selection effects in radio pulsar surveys	21
1.1 Flux–distance relationship	22
1.2 The radio sky background	22
1.3 Propagation effects in the interstellar medium	22

1.4	Finite size of the emission beam	23
1.5	Pulse nulling	24
1.6	Intermittency	24
2	Correcting the biases in the observed sample	24
3	Recent results	26
3.1	Pulsar space distribution	26
3.2	Pulsar velocities	28
3.3	Pulsar luminosities	28
3.4	Magnetic alignment	30
3.5	Magnetic field decay	31
4	Final thoughts and future prospects	32
4.1	Rotating radio transients	32
4.2	Millisecond pulsars	32
4.3	Pulsars in the Magellanic Clouds	33
4.4	Globular cluster pulsars	33
	References	34
	Pulsar Results with the <i>Fermi</i> Large Area Telescope	37
	Paul S. Ray and Pablo M. Saz Parkinson for the <i>Fermi</i> LAT Collaboration, the LAT Pulsar Timing Consortium, and the LAT Pulsar Search Consortium	
1	Introduction	37
1.1	Gamma-ray Pulsars in the Year 2000	37
1.2	<i>Fermi</i> and <i>AGILE</i>	38
2	The EGRET Pulsars in Exquisite Detail	39
3	Young Pulsars Found Using Radio Ephemerides	42
4	Millisecond Pulsars	42
4.1	Radio MSPs	43
4.2	Searches of LAT Unassociated Sources	44
4.3	Globular Cluster MSPs	45
5	Blind Periodicity Searches	46
6	Pulsar Timing with the LAT	48
7	Multiwavelength Connections	49
8	The LAT Pulsar Population	52
9	Future Expectations	54
	References	55
	<i>Fermi</i> view of the EGRET pulsars	57
	F. Gargano for the <i>Fermi</i> -LAT collaboration	
1	Introduction	57
2	Analysis results	58
3	Conclusion	61
	References	61

“Garden-variety” Gamma-ray Pulsars J0248+6021 & J2240+5832	63
David A. Smith for the <i>Fermi</i> LAT Collaboration	
1 Introduction	63
2 Two Not-So-Typical Pulsars	64
3 About those distances	64
4 Understanding the Beams	65
5 Conclusions	66
References	67
Extension studies of galactic sources with Fermi	69
Francesco Giordano on behalf of the Fermi-LAT Collaboration	
1 The simulated cases	69
2 Galactic extended SNRs: the W51C, the W44 and the IC443	72
3 Conclusions	73
References	73
Advances in understanding double features in radio pulsar profiles	75
Jarosław Dyks, Bronisław Rudak and Paul Demorest	
1 The Double Features	75
2 The interpretation	76
References	78
Emission from the Polar Cap and Slot Gap	79
Alice K. Harding and Isabelle A. Grenier	
1 Introduction	79
2 Polar cap and slot gap electrodynamics	80
2.1 Polar cap pair cascades	81
2.2 The slot gap	82
3 Geometry of high-energy radiation	84
4 Confronting the Fermi observations	85
4.1 Spectra	86
4.2 Population synthesis and light curve fitting	87
4.3 New insights from the increasing γ -ray MSP Population	94
5 Learning from Nature - Future pulsar modeling	96
References	97
Gamma-ray emission and pair creation of outer gap	99
K. S. Cheng	
1 Introduction	99
2 Two dimensional outergap model	100
2.1 Gap structure	101
2.2 Curvature radiation spectrum	103
2.3 Properties of curvature spectra with gap parameters	104
2.4 Fitting Results	105
3 Pair creation mechanisms	108
3.1 Photon-photon pair-creation process	108

3.2	New gap closure mechanism	109
3.3	Predictions of new outer gap model	112
4	Summary	115
	References	115
What Pulsar High-Energy Emission Model Survives?		117
Kouichi Hirotani		
1	Introduction	117
2	Basic equations	120
2.1	Poisson Equation for Electrostatic Potential	120
2.2	Particle Boltzmann Equations	122
2.3	Radiative Transfer Equation	123
2.4	Boundary Conditions	124
3	Self-consistent OG solution: the case of the Crab pulsar	125
3.1	Gap geometry and acceleration electric field	125
3.2	Photon mapping result and radiation spectrum	125
4	Slot-gap model: the case of the Crab pulsar	126
4.1	Formation of a slot gap in the polar-cap region	127
4.2	Lower-altitude slot-gap solution	129
4.3	Higher-altitude slot-gap model	130
5	Discussion	133
	References	134
Current Models of Pulsar Magnetospheres		139
Anatoly Spitkovsky		
1	Introduction	139
2	Plasma supply and charge-separated models	140
3	Force-free models	142
4	Implications of the magnetospheric solutions	149
4.1	Consequences for spin down	149
4.2	High energy emission	150
4.3	Reconnection and time-dependence	153
4.4	Current structure and origin	154
4.5	Differential rotation	155
4.6	Conclusion	156
	References	156
Modeling of γ-ray Pulsar Light Curves from Force-Free Magnetosphere ..		159
Xue-Ning Bai & Anatoly Spitkovsky		
	References	163
A Tale of Two Current Sheets		165
Jonathan Arons		
1	Follow The Energy	165
2	Follow the Mass	176
	References	179

The high-energy emission from the pulsar striped wind 181

J  r  me P  tri

1	Introduction	181
2	The striped wind model	182
3	Application to γ -ray pulsars	183
	References	184

Gamma-rays from millisecond pulsars in Globular Clusters 185

W  dek Bednarek

1	Introduction	185
2	The stellar content of Globular Clusters	186
3	Compact objects within Globular Clusters	187
	3.1 Millisecond pulsars	187
	3.2 Cataclysmic Variables and LMXBs	188
	3.3 Intermediate mass black holes ?	188
4	Non-thermal emission from Globular Clusters	189
	4.1 Low energy radiation	189
	4.2 Gamma-rays	189
5	Models for gamma-ray emission	191
	5.1 Interpretation of the observed GeV γ -ray emission	192
	5.2 TeV γ -ray emission from MSP winds and shocks	193
	5.3 Constraints on the MSP population	197
6	Gamma-rays from electrons injected from other sources ?	200
7	Conclusions	202
	References	204

Modelling the Growing Population of γ -ray Millisecond Pulsars 207

C. Venter, A. K. Harding, and T. J. Johnson

1	Introduction	207
2	Pulsar Models	208
3	Results	210
4	Discussion and Conclusions	210
	References	210

A Joint Radio Gamma-ray Variability Study of the Crab Pulsar 213

Glenn Jones and Ryan Shannon

1	Introduction	213
2	Radio Observations	214
	2.1 Signal Processing	214
3	Gamma-Ray Radio Correlation	215
	References	217

AGILE observations of PSR B1509-58	219
M. Pilia and A. Pellizzoni for the AGILE Team and Pulsar Working Group	
1 Introduction	219
2 AGILE Observations, Data Analysis and Results	220
3 Discussion	221
References	223
Understanding the fundamental parameters of millisecond pulsars	225
Benoit Pancrazi	
1 Introduction	225
2 Observations and data analysis	227
3 Discussion and conclusion	227
References	228
Pulsars as gravitational wave detectors	229
George Hobbs	
1 Introduction	229
2 Using pulsars to search for GWs	230
3 Current data sets	234
4 Potential sources of gravitational waves	236
4.1 Single sources	236
4.2 Burst sources	238
4.3 Stochastic background	239
5 Accessing pulsar data sets	241
6 The future	241
7 Conclusion	242
References	242
Magnetar outbursts: an observational review	247
Nanda Rea & Paolo Esposito	
1 Author's preface	247
2 A bit of history	248
3 General observational characteristics	250
4 Multiband view of magnetars	250
4.1 Radio emission of magnetars	251
4.2 Optical and infrared emission of magnetars	253
4.3 Soft X-ray emission of magnetars	253
4.4 Hard X-ray emission of magnetars	254
5 Magnetars' Outbursts	254
5.1 XTE J1810-197	255
5.2 1E 1547-5408	256
5.3 AX J1844-0258	258
5.4 1E 2259+586	258
5.5 1E 1048.1-5937	259
5.6 CXOU J1647-4552	260
5.7 4U 0142+614	260

5.8	SGR 1806–20	261
5.9	SGR 1627–41	262
5.10	SGR 0501+4516	263
5.11	SGR 0418+5729	263
5.12	SGR 1833–0832	264
6	Conclusions	264
	References	265
Wide-band X-ray Studies of Magnetars with Suzaku		275
T. Enoto, K. Makishima, N. Rea, Y. E. Nakagawa, K. Nakazawa, and T. Sakamoto		
1	Suzaku Observations of Magnetars	275
2	Spectral Evolution of Magnetars	277
	References	278
Bursts and Flares from Highly Magnetic Pulsars		279
GianLuca Israel and Simone Dall’Osso		
1	MAGnetic NEutron sTARS	280
2	SGRs Giant Flares and their magnetic fields	282
2.1	The Cavallo-Fabian-Rees Variability Limit	284
3	SGRs Intermediate Flares in the Swift era	285
3.1	The March 2006 Burst Storm of SGR 1900+14	287
3.2	Further Observations: the case of SGR 0501+4516 and 1E 1547.0-5408	293
	References	297
Activated Magnetospheres of Magnetars		299
Andrei M. Beloborodov		
1	Introduction	299
2	Electrodynamics of untwisting	301
2.1	Evolution equation for axisymmetric twist	301
2.2	j-bundle	303
3	Transient magnetars	306
3.1	Magnetospheric activity or deep crustal heating?	306
3.2	Individual objects	307
4	Pair creation	311
5	Plasma circulation in the magnetosphere	313
6	Magnetospheric emission	317
7	Conclusions	320
	References	320

Suzaku Detection of Hard X-ray Emission in SGR 0501+4516 Short Burst Spectrum	323
Yujin E. Nakagawa, Teruaki Enoto, Kazuo Makishima, Atsumasa Yoshida, Kazutaka Yamaoka, Takanori Sakamoto, Nanda Rea, Kevin Hurley, Suzaku SGR 0501+4516 Team and HETE-2 Team	
1 Introduction	324
2 Hard X-ray Emission in Burst Spectra	324
3 Discussion	325
References	326
The magnetar emission in the IR band: the role of magnetospheric currents	329
Silvia Zane, Luciano Nobili and Roberto Turolla	
1 Introduction	329
2 Pair production in the inner magnetosphere	330
3 IR/Optical emission	332
4 Discussion and Conclusion	333
References	334
Double features in mean pulsar profiles and the nature of their radio emission	337
George I. Melikidze and Janusz Gil	
1 Frequency dependence of the bifurcation angle	337
2 Energy considerations	339
References	340
Can the magnetic field of long-period X-ray pulsars be supercritical?	341
N.R. Iksanov and N.G. Beskrovnaya	
1 Magnetar hypothesis	341
2 Feedback hypothesis	343
References	344
X-ray emission from isolated neutron stars	345
Sandro Mereghetti	
1 Introduction	345
2 Origin of the X-ray emission in isolated neutron stars	347
3 The X-ray Dim Isolated Neutron Stars	348
4 Central Compact Objects in Supernova Remnants	351
5 The Magnetar candidates: Anomalous X-ray Pulsars and Soft Gamma-ray Repeaters	352
6 Rotating Radio Transients	356
7 Rotation-powered pulsars with high magnetic field	357
8 Conclusions	358
References	359

X-ray thermal radiation from hot polar cap in pulsars 365

Janusz Gil and George I. Melikidze

1	Introduction	365
2	Surface magnetic field	366
3	Drifting subpulses	367
	References	368

Radio polarization of RRAT J1819-1458 369

A. Karastergiou

1	Introduction	369
2	Polarization characteristics	370
3	Discussion and conclusions	372
	References	372

Multiwavelength Observations of Pulsar Wind Nebulae 373

Patrick Slane

1	Introduction	373
2	Dynamical Evolution of PWNe	374
3	Spectral Evolution of PWNe	377
4	Case Studies	379
4.1	3C 58	379
4.2	Vela X	382
4.3	G327.1-1.1	384
4.4	HESS J1640-465	387
5	Summary	390
	References	390

Multi-wavelength Observations of Composite Supernova Remnants 393

Tea Temim

1	Introduction	393
2	G54.1+0.3: Expansion into SN Ejecta	394
3	G327.1-1.1: Interaction with the Reverse Shock	395
4	Conclusions	396
	References	396

***Fermi*-LAT Results on Pulsar Wind Nebulae after 1.5 year of Observations 399**M.-H. Grondin & M. Lemoine-Goumard for the *Fermi*-LAT Collaboration and the Pulsar Timing Consortium

1	Introduction	399
2	The Crab Nebula	400
3	The Vela-X PWN	402
4	The PWN in MSH 15-52	404
5	PSR J1907+0602 and its TeV PWN	404
6	The PWN HESS J1640-465	405

7	A plausible pulsar wind nebula candidate powered by PSR J1023-5746	407
8	Conclusion.....	408
	References	410
Pulsar Wind Nebulae: The GeV to TeV Connection		413
O. C. de Jager		
1	Introduction	413
2	The Crab Nebula in γ -rays	414
2.1	The acceleration limit for electrons in the Crab Nebula ..	414
2.2	The inverse Compton spectrum of the Crab Nebula - towards the spectral tail	416
3	Accelerated PWN Spectra: Observations of the Cooling Effect ...	417
4	A Single Spectral Component for the GeV to TeV Emission from the PWN of PSR B1509-58	419
5	Calorimetric GeV emission from PWN	421
6	Discontinuous GeV and TeV Emission from Two-Component PWN.....	422
6.1	Two-Component Extended Emission from the Vela X PWN	422
6.2	Radio and X-Ray Torii of Vela X near the Termination Shock: Discontinuous Spectra	422
7	HESS J1640-465: Another Two-Component Candidate?	424
8	Conclusions	426
	References	428
Extended hard X-ray emission from Vela X		431
Fabio Mattana, Régis Terrier, Diego Götz, Gabriele Ponti, Laurent Bouchet, Maurizio Falanga, Matthieu Renaud, Stephane Schanne		
1	Introduction	431
2	<i>INTEGRAL</i> identification of extended hard X-ray emission	432
3	Combined IBIS/ISGRI and <i>Suzaku</i> /XIS spectral analysis	434
4	Conclusions	434
	References	434
Cherenkov Telescopes Results on Pulsar Wind Nebulae and Pulsars		435
Emma de Oña Wilhelmi		
1	Introduction	435
2	IACT Technique	439
3	Observations of pulsars with IACTs	440
4	Observations of PWNe with Cherenkov telescopes	441
4.1	Young/Composite Pulsar Wind Nebula	444
4.2	"Relic" Pulsar Wind Nebula	447
4.3	Other PWNe candidates	449
5	Concluding Remarks	451
	References	451

Lepton Acceleration in Pulsar Wind Nebulae 453

Matthew G. Baring

1	Introduction	453
2	Lepton Acceleration at Relativistic Shocks	455
2.1	The Monte Carlo Method	457
2.2	Results for Relativistic Shock Acceleration	458
3	The Quasi-Perpendicular Pulsar Wind Termination Shock	464
4	Connecting to PWN Observations	466
5	Conclusions	470
	References	470

MHD models of Pulsar Wind Nebulae 473

Niccolò Bucciantini

1	Introduction	473
2	Jet-Torus structure and Inner flow properties	475
2.1	Time variability	480
2.2	Gamma rays	481
3	Evolution of PWNe	482
4	Conclusion	486
	References	488

TeV Gamma Ray Survey on the Direction of *Fermi*-LAT Pulsars with the Tibet Air Shower Array 491

M. Amenomori, X. J. Bi, D. Chen, S. W. Cui, Danzengluobu, L. K. Ding, X. H. Ding, C. Fan, C. F. Feng, Zhaoyang Feng, Z. Y. Feng, X. Y. Gao, Q. X. Geng, Q. B. Gou, H. W. Guo, H. H. He, M. He, K. Hibino, N. Hotta, Haibing Hu, H. B. Hu, J. Huang, Q. Huang, H. Y. Jia, L. Jiang, F. Kajino, K. Kasahara, Y. Katayose, C. Kato, K. Kawata, Labaciren, G. M. Le, A. F. Li, H. C. Li, J. Y. Li, C. Liu, Y.-Q. Lou, H. Lu, X. R. Meng, K. Mizutani, J. Mu, K. Munakata, H. Nanjo, M. Nishizawa, M. Ohnishi, I. Ohta, S. Ozawa, T. Saito, T. Y. Saito, M. Sakata, T. K. Sako, M. Shibata, A. Shiomi, T. Shirai, H. Sugimoto, M. Takita, Y. H. Tan, N. Tateyama, S. Torii, H. Tsuchiya, S. Udo, B. Wang, H. Wang, Y. Wang, Y. G. Wang, H. R. Wu, L. Xue, Y. Yamamoto, C. T. Yan, X. C. Yang, S. Yasue, Z. H. Ye, G. C. Yu, A. F. Yuan, T. Yuda, H. M. Zhang, J. L. Zhang, N. J. Zhang, X. Y. Zhang, Y. Zhang, Yi Zhang, Ying Zhang, Zhaxisangzhu, and X. X. Zhou (The Tibet ASy Collaboration)

1	Introduction	493
2	Results & Discussion	493
	References	494

Fermi results on γ -ray binaries 497Adam B. Hill, Richard Dubois, and Diego F Torres for the *Fermi*-LAT collaboration

1	Introduction	498
2	LS I +61 303	498

2.1	The original discovery, and further TeV observations: flux, spectrum, periodicity	498
2.2	TeV and X-ray simultaneous observations	499
2.3	The <i>Fermi</i> results on LS I +61°303	500
3	LS 5039	502
3.1	The original discovery, and further TeV observations: flux, spectrum, periodicity	502
3.2	The <i>Fermi</i> results on LS 5039	503
4	Cygnus X-3	503
4.1	Historical observations at high energies	503
4.2	The <i>Fermi</i> results on Cygnus X-3	504
5	Cygnus X-1	507
5.1	Reports of high energy and very high energy emission ...	508
6	Conclusion	509
	References	510
	Cherenkov Telescope results on gamma-ray binaries	513
	Juan Cortina	
1	Introduction	513
2	Detected in VHE: PSR B1259-63, LS 5039 and LS I+61°303	514
2.1	PSR B1259-63/SS2833	514
2.2	LS 5039	515
2.3	LS I+61°303	517
3	Uncertain VHE binaries: Cyg X-1 and HESS J0632+057	519
3.1	Cyg X-1	519
3.2	HESS J0632+057	521
4	Searches for other VHE binaries	522
4.1	Cyg X-3	523
5	Conclusions	526
	References	527
	γ-ray binaries as non-accreting pulsar systems	531
	Diego F. Torres	
1	Prologue	531
2	Why is a non-accreting pulsar system a tenable alternative?	532
3	Caveats in the search for X-ray spectral lines	538
4	Caveats in the search for pulsations	540
5	Notes on the theoretical models based on pulsar systems	542
5.1	A perspective on the GeV cutoffs of LS I +61°303 and LS 5039	543
6	Epilogue	547
	References	548

Relativistic motion and beamed radiation in gamma-ray binaries	551
Benoît Cerutti, Guillaume Dubus, and Gilles Henri	
1 Introduction	551
2 Observational backdrop	552
3 Doppler-boosted emission in LS 5039 and LS I +61 303	552
4 Conclusion	554
References	554
A leptonic One-Zone model of the X-Ray/VHE correlated emission in LS I +61 303	555
V. Zabalza, J.M. Paredes and V. Bosch-Ramon	
1 Introduction	555
2 Model description and results	556
3 Discussion	557
References	558
New Optical Results on γ-ray Binaries	559
J. Casares, J.M. Corral-Santana, A. Herrero, J.C. Morales, T. Muñoz-Darias, I. Negueruela, J.M. Paredes, I. Ribas, M. Ribó, D. Steeghs, L. van Spaandonk and F. Vilardell	
1 Introduction	559
2 Revised Orbital Solution in LS 5039	560
3 Probing Binarity in MWC 148	561
References	562
The International X-ray Observatory and other X-ray missions, expectations for pulsar physics	563
Yukikatsu Terada and Tadayasu Dotani	
1 Introduction	563
2 Future X-ray Missions	565
2.1 Overview of X-ray Missions	565
2.2 The Small Satellite Missions in 2010s	566
2.3 The <i>ASTRO-H</i> Mission	568
2.4 The International X-ray Observatory	569
3 Pulsar Sciences with Future X-ray Missions	570
3.1 General relativity under strong gravity	570
3.2 Equation of State in neutron stars	572
3.3 Plasma physics under a strong magnetic field	573
3.4 Emission mechanism from Magnetars	575
3.5 Diversity of Pulsar systems: white dwarf pulsars	577
4 Synergy with other wavelength observatories	580
References	581

X-ray Polarimeters	585
Marco Feroci and Paolo Soffitta	
1 Neutron Stars Science with X-ray Polarimetry	585
2 Fundamental Parameters of X-ray Polarimetry	587
3 Classical Techniques and Observational Status	588
3.1 Bragg Polarimeters	588
3.2 Thompson/Compton Polarimeters	591
3.3 Observational results	594
4 A jump in sensitivity: the focal plane photoelectric polarimeters for soft X-rays	595
4.1 The Gas Pixel Detector (GPD) solution	597
4.2 The Time Projection Chamber (TPC) polarimeter solution.	598
5 Observational Prospects	600
5.1 Gravity and Extreme Magnetism SMEX (GEMS)	600
5.2 New Hard X-ray Mission (NHXM)	601
5.3 International X-ray Observatory (IXO)	604
6 Conclusions	607
References	607
 New results on high energy cosmic ray electrons observed with Fermi LAT	611
Alexander Moiseev, on behalf of the Fermi LAT Collaboration	
1 Introduction	611
2 Detection of electrons by LAT	612
3 Result and Discussion	617
4 Conclusion	620
5 Acknowledgements	620
References	620
 Positrons from pulsar winds	623
Pasquale Blasi and Elena Amato	
1 Introduction	624
2 A pulsar wind inside a supernova remnant	626
3 A pulsar wind escaping the parent supernova remnant: bow shock nebulae	629
4 The positron flux from pulsars	631
5 Discussion	637
References	640

High-Energy Emission from Pulsars and their Systems
Proceedings of the First Session of the Sant Cugat
Forum on Astrophysics

Rea, N.; Torres, D.F. (Eds.)

2011, XXXVI, 644 p., Hardcover

ISBN: 978-3-642-17250-2