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## **Winds of stars and exoplanets**

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# Winds of Stars and Exoplanets

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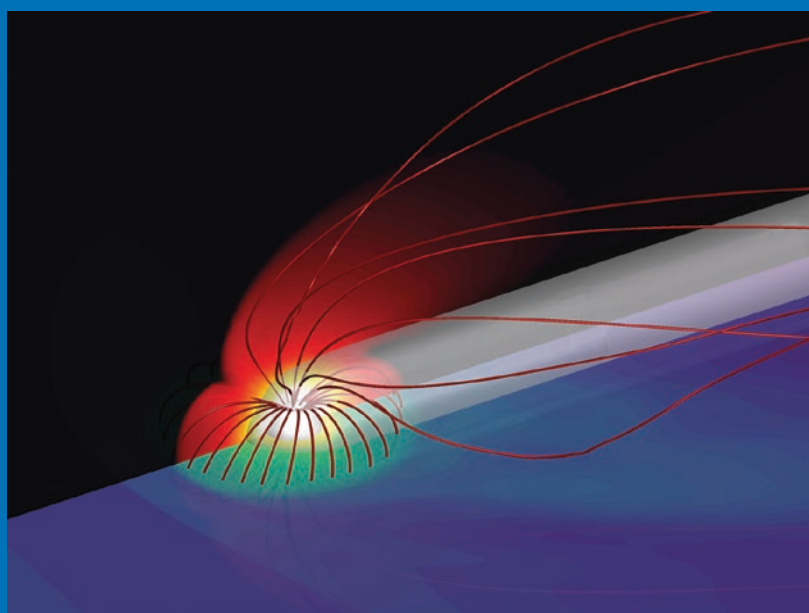
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# WINDS OF STARS AND EXOPLANETS

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### *COVER ILLUSTRATION:*

Three-dimensional simulation of the escaping atmosphere of a close-in exoplanet interacting with the wind of its host star. The red field lines represent the planetary magnetic field, while the contours represent the total density (horizontal plane) and the neutral hydrogen density (vertical plane). Figure from Carolan et al 2021.

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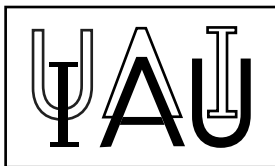
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# WINDS OF STARS AND EXOPLANETS

PROCEEDINGS OF THE 370th SYMPOSIUM OF  
THE INTERNATIONAL ASTRONOMICAL UNION  
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8–11 AUGUST 2022

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# Table of Contents

Preface . . . . .	ix
Editors . . . . .	xi
List of Contributors . . . . .	xii

## Part 1: Overview of Winds of stars and exoplanets

Winds and magnetospheres from stars and planets: similarities and differences . . . . .	3
<i>Stan Owocki</i>	

## Part 2: Observational evidence of winds

Observations of Winds and CMEs of Low-Mass Stars . . . . .	25
<i>Rachel A. Osten</i>	
Observations of outflows of massive stars . . . . .	37
<i>Andrea Mehner</i>	
Observations of planetary winds and outflows . . . . .	56
<i>Leonardo A. Dos Santos</i>	
The effect of winds in red supergiants: modeling for interferometry . . . . .	72
<i>Gemma González-Torà, Markus Wittkowski, Ben Davies and Bertrand Plez</i>	
The porous envelope and circumstellar wind matter of the closest carbon star, CW Leonis . . . . .	78
<i>Hyosun Kim, Ho-Gyu Lee, Youichi Ohyama, Ji Hoon Kim, Peter Scicluna, You-Hua Chu, Nicolas Mauron and Toshiya Ueta</i>	
Is the magnetospheric accretion active in the Herbig Ae/Be stars? . . . . .	84
<i>Giovanni Pinzón, Jesús Hernández and Javier Serna</i>	
Short-term variations of surface magnetism and prominences of the young sun-like star V530 Per . . . . .	89
<i>Cang Tianqi, Pascal Petit, Jean-François Donati and Colin Folsom</i>	
Water and silicon-monoxide masers monitored towards the “water fountain” sources . . . . .	91
<i>H. Imai, K. Amada, J. F. Gómez, L. Uscanga, D. Tafoya, K. Nakashima, K.-Y. Shum, Y. Hamae, R. Burns and G. Orosz</i>	
Weakening the wind with ULLYSES: Examining the Bi-Stability Jump . . . . .	94
<i>Olivier Verhamme and Jon Olof Sundqvist</i>	
Statistical properties of cold circumstellar envelopes observed in NESS–NRO . . . . .	97
<i>K. Amada, S. Fukaya, H. Imai, P. Scicluna, N. Hirano, A. Trejo-Cruz, S. Zeegers, F. Kemper, S. Srinivasan, S. Wallström, T. Dharmawardena and H. Shinnaga</i>	

**Part 3: Physical ingredients of winds**

The origin of planetary winds . . . . .	103
<i>Daria Kubyshkina</i>	
Stellar wind from low-mass main-sequence stars: an overview of theoretical models . . . . .	122
<i>Munehito Shoda</i>	
The Driving of Hot Star Winds . . . . .	130
<i>Andreas A.C. Sander</i>	
Slingshot Prominences, Formation, Ejection and Cycle Frequency in Cool Stars . . . . .	144
<i>S. Daley-Yates and M. M. Jardine</i>	
Effect of stellar flares and coronal mass ejections on the atmospheric escape from hot Jupiters . . . . .	148
<i>Gopal Hazra, Aline A. Vidotto, Stephen Carolan, Carolina Villarreal D'Angelo and Ward Manchester</i>	
Physics of the atmospheric escape driven by EUV photoionization heating: Classification of the hydrodynamic escape in close-in planets . . . . .	155
<i>Hiroto Mitani, Riouhei Nakatani and Naoki Yoshida</i>	
Discrete Absorption Components from 3-D spot models of hot star winds . . . .	161
<i>F. A. Driessen and N. D. Kee</i>	
Hydrodynamic disk solutions for Be stars using HDUST . . . . .	168
<i>C. Arcos, M. Curé, I. Araya, A. Rubio and A. Carciofi</i>	
Role of Longitudinal Waves in Alfvén-wave-driven Solar/Stellar Wind . . . . .	174
<i>Kimihiko Shimizu, Munehito Shoda and Takeru K. Suzuki</i>	
ISOSCELES: Grid of stellar atmosphere and hydrodynamic models of massive stars. The first results . . . . .	180
<i>Ignacio Araya, Michel Curé, Natalia Machuca and Catalina Arcos</i>	
Quantification of the environment of cool stars using numerical simulations . . .	185
<i>J. J. Chebly, Julián D. Alvarado-Gómez and Katja Poppenhaeger</i>	
Hydrodynamic solutions of radiation driven wind from hot stars . . . . .	191
<i>M. Curé, I. Araya, C. Arcos, N. Machuca and A. Rodriguez</i>	
Gap opening by planets in discs with magnetised winds . . . . .	194
<i>Vardan Elbakyan, Yinhao Wu, Sergei Nayakshin and Giovanni Rosotti</i>	
Solar Wind and Hydrologic Cycle . . . . .	196
<i>Xuguang Leng</i>	
Magnetic confinement in the wind of low mass stars . . . . .	198
<i>Rose F. P. Waugh and Moira M. Jardine</i>	



Clumping and X-rays in cool B Supergiants . . . . .	200
<i>Matheus Bernini-Peron, W. L. F. Marcolino and A. A. C. Sander</i>	
<b>Part 4: Flow-flow interactions</b>	
Interaction between massive star winds and the interstellar medium . . . . .	205
<i>Jonathan Mackey</i>	
Numerical Modeling of Galactic Superwinds with Time-evolving Stellar Feedback . . . . .	217
<i>A. Danekkar, M. S. Oey and W. J. Gray</i>	
Winds of OB stars: impact of metallicity, rotation and binary interaction . . . . .	223
<i>Varsha Ramachandran</i>	
X-ray view of colliding winds in WR 25 . . . . .	230
<i>Bharti Arora, Jeewan C. Pandey and Michaël De Becker</i>	
Double tail structure in escaping atmospheres of magnetised close-in planets . . . . .	232
<i>A. A. Vidotto, S. Carolan, G. Hazra, C. Villarreal D'Angelo and D. Kubyskhina</i>	
Shock breakout in winds of red supergiants: Type IIP supernovae . . . . .	235
<i>Alak Ray, Harita Palani Balaji, Adarsh Raghu and Gururaj Wagle</i>	
On the making of a PN: the interaction of a multiple stellar wind with the ISM . . . . .	238
<i>Arturo Manchado, Eva Villaver, G. García-Segura and Luciana Bianchi</i>	
<b>Part 5: Relevance of winds on stellar/planetary evolution</b>	
Role of planetary winds in planet evolution and population . . . . .	243
<i>D. Modirrousta-Galian</i>	
Size Evolution and Orbital Architecture of KEPLER Small Planets through Giant Impacts and Photoevaporation . . . . .	251
<i>Gu Pin-Gao, Matsumoto Yuji, Kokubo Eiichiro and Kurosaki Kenji</i>	
Spin-down and reduced mass loss in early-type stars with large-scale magnetic fields . . . . .	257
<i>Z. Keszthelyi, A. de Koter, Y. Götzberg, G. Meynet, S.A. Brands, V. Petit, M. Carrington, A. David-Uraz, S.T. Geen, C. Georgy, R. Hirschi, J. Puls, K.J. Ramalatswa, M.E. Shultz and A. ud-Doula</i>	
Mass loss implementation and temperature evolution of very massive stars . . . . .	263
<i>Gautham N. Sabharwal, Jorick S. Vink, Erin R. Higgins and Andreas A.C. Sander</i>	
The Evolution of Atmospheric Escape of Highly Irradiated Gassy Exoplanets . . . . .	269
<i>Andrew P. Allan, Aline A. Vidotto and Leonardo A. Dos Santos</i>	

The future of Jupiter-like planets around Sun-like stars: first steps . . . . .	275
<i>T. Konings, R. Baeyens and L. Decin</i>	
Rapid orbital precession of the eclipsing binary HS Hydrae . . . . .	278
<i>A. M. Matekov and A. S. Hojaev</i>	
To the dynamics of the two-body problem with variable masses in the presence of reactive forces . . . . .	281
<i>A.T. Ibraimova and M.Zh Minglibayev</i>	
Evolution equations of the multi-planetary problem with variable masses . . . .	283
<i>A.B. Kosherbayeva and M.Zh Minglibayev</i>	
Planet migration in accretion discs in binary systems . . . . .	285
<i>A.D. Nekrasov, S.B. Popov and V.V. Zhuravlev</i>	
Signatures of wind formation in optical spectra of precursors of planetary nebulae . . . . .	287
<i>Kārlis Puķītis and Laimons Začs</i>	
Author Index . . . . .	289

## Preface

Winds form an integral part of astronomy – from regulating rotation of stars through enriching galaxies with fresh materials, outflowing winds persist during the entire lives of stars and play a key role in shaping the observed exoplanet demographics. In the case of massive stars, their winds are a vital ingredient of their evolution, from the main sequence to the pre-supernova stage, determining black hole masses as measured from gravitational waves. In the case of low-mass stars, their winds dictate rotational evolution, which affect angular momentum distribution within the stellar interior and thus affect generation of magnetic fields. Finally, in the case of planets, winds take the form of atmospheric escape, which can strongly affect their atmospheric evolution. Strong escape of highly irradiated exoplanets have now been observed in several close-in exoplanets during transits and are indirectly detected in the observed exoplanet radius distribution.

Although the only astrophysical wind that we are able to directly probe is that of the Sun, the past decades have seen great progress in observing winds of other astrophysical objects. In particular, in recent years, several observing programmes and space missions have focused on studying winds from our Sun, other stars and exoplanets.

On the solar side, two new space missions, Parker Solar Probe and Solar Orbiter, are dedicated to studying the physics of the solar wind. By traveling much closer to the Sun than any other spacecraft has ever been, these new missions allow direct measurements of the solar wind at an unprecedented close distance. Data from these missions might provide interesting implications for the variability of the plasma environment at the orbits of close-in exoplanets.

On the stellar side, winds of low-mass stars are magnetically driven, and magnetism has been either directly (through Zeeman effects) or indirectly (through activity proxies) observed in these stars. Recently, many new magnetospheres were detected around massive stars as well. In spite of similarities, there is a major difference between winds of low- and high-mass stars: their mass-loss rates are orders of magnitude different, due to different physical processes driving their winds. Even with substantially lower mass loss rates, winds of low mass-stars play a fundamental role in removing angular momentum, and thus, shaping the rotational evolution of these stars.

On the planetary side, missions like Kepler, TESS and Plato (will) provide the statistics for planet population studies and hence infer the indirect presence of outflowing planetary winds in shaping the distribution of sizes of close-in exoplanets. HST has been fundamental in detecting strong atmospheric escape of close-in giant planets through ultraviolet transmission spectroscopy. Recent observations have also opened the possibility to detect escaping planetary winds from the ground.

In order to gain insight in the physics and the modelling tools used by different communities, and to foster communication between communities that do not usually interact with each other, we brought together researchers working on winds of close-in exoplanets (atmospheric escape), winds of low- and high-mass stars and the solar wind in a symposium dedicated to “winds”. The IAU Symposium “S370: Winds of stars and exoplanets”, that took place in Busan, Republic of Korea, from 8 to 11 August 2022.

In this book, you will find contributions from most of the symposium presenters. The first Part presents an overview of winds of stars and planets, introducing its similarities and differences. The remaining parts contain the four main themes discussed in the symposium

- Observational evidence of winds
- Physical ingredients of winds

- Flow-flow interactions
- Relevance of winds on stellar/planetary evolution

The IAU Symposium 370 took place during the XXXI General Assembly meeting in Busan, in the midst of the Covid-19 global pandemic. We wish to thank the Local Organisation of the General Assembly meeting for their substantial efforts to make it possible that we all could meet in person again. We also warmly thank all the participants of the meeting for their cooperation and understanding during these difficult times.

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