

# “IAUS 370: Winds of stars and exoplanets”

## Scientific highlights (1 page)

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. To foster communication between communities that do not usually interact with each other, we organised the IAU Symposium “S370: Winds of stars and exoplanets”, during the XXXI General Assembly meeting in Busan, Republic of Korea, from 8 to 11 August 2022.

The symposium covered three main themes: (A) winds of low-mass stars; (B) winds of massive stars and (C) atmospheric escape in exoplanets. To set the stage, the symposium started with a Plenary Lecture (Owocki), which presented the fundamental physics involved in the driving of stellar and planetary outflows, their common ingredients and their main differences. This lecture provided a common ground introduction to the topic of “Winds”.

Following the Plenary lecture on Day 1, we then moved on to address the “Observational evidence of winds” on Day 2. We had four invited talks during this day: Osten reviewing “Observations of winds and CMEs of low-mass stars”; Mehner reviewing “Observations of outflows of massive stars”; Dos Santos presenting “A review on the observations of planetary winds and outflows”; and Parenti presenting “Updates on recent findings from the solar wind with major facilities”. During this day, we had 10 contributed talks representing the three main themes (A,B,C) of the symposium.

On Day 3, we focused on the theoretical aspect of winds, when we had 3 invited speakers: Kubyshkina reviewing “The origin of planetary winds”; Shoda presenting “Stellar wind from low-mass main-sequence stars: an overview of theoretical models”; and Sander introducing “The driving of hot star winds”. During this day, we additionally had 12 contributed talks representing the three main themes (A,B,C) of the symposium.

On the last day of the conference, we shifted the focus to “Flow-flow interactions”, with two invited talks “Interaction between massive star winds and the interstellar medium” by Mackey and “Interaction of exoplanetary and stellar winds and its observational manifestations” by Shaikhislamov. Finally, the “Relevance of winds on stellar/planetary evolution” was discussed at the end of the meeting, with two invited talks: Modirrousta Galian presented the “Role of Planetary Winds in Planet Evolution and Population” and Sung-Chul Yoon introduced the “Effects of rotation on the evolution of early-type stars”. During this day, we additionally had 8 contributed talks representing the three main themes (A,B,C) of the symposium.

# “IAUS 370: Winds of stars and exoplanets”

## Executive Summary

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 will allow direct measurements of the solar wind at an unprecedented close distance, giving us more information of the acceleration mechanism that drives the solar wind. 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, the HST director has committed 1,000 Hubble orbits on ULLYSES, the “Ultraviolet Legacy Library of Young Stars as Essential Standards”, providing the key motivator to understanding the winds of massive OB stars and low-mass stars at the same time. Massive stars ubiquitously show discrete absorption components in their ultraviolet spectra, the origin of which is still an open question. One of the possible candidates for these absorption lines are hot spots from magnetic fields originating from the sub-surface convection zone that has more recently been revealed. To make theoretical progress in this area, physical insight from the low-mass stars community is particularly welcome.

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, circular spectropolarimetry surveys (MiMeS and BOB) detected many new magnetospheres around massive stars, similarly to what has been seen in low-mass counterparts. 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. Monitoring surveys, like Kepler and TESS, have measured rotation rates of low-mass stars and are thus key for constraining their wind evolution. GAIA is currently revolutionising the field by providing the largest dataset of stellar rotational periods, which will inform stellar wind models.

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, and NASA is funding CUTE, a CubeSat mission fully dedicated to study the intense mass loss of exoplanets. Recent observations have also opened the possibility to detect escaping planetary winds from the ground, for example, using the Helium infrared triplet at 10830A.

One critical open question is the theoretical differences of fully (stellar winds) and partly ionised (exoplanet) winds and radiative transfer (with metal lines) in the planetary wind acceleration region. Ionised and partly/mostly neutral flows do not behave in the same way, and the neutral fraction depends critically on the planetary system. In terms of radiative transfer, on the other hand, we have recently started to realise that particularly ultra-hot Jupiters can be much more complicated than simple hydrogen models. Exchange of ideas between the exoplanetary community and the low-mass stars and high-mass stars (radiative transfer) communities can lead to possibly fruitful insights.

With all the synergy between these different communities and in order to gain insight in the physics and modelling tools used by these communities, we brought together researchers on the three main areas: (A) winds of low-mass stars; (B) winds of massive stars and (C) atmospheric escape in exoplanets.

The symposium took place during the XXXI General Assembly meeting in Busan, Republic of Korea, from 8 to 11 August 2022. The symposium started with a Plenary Lecture on Monday (Day 1) covering the three main areas of our symposium. Following the Plenary Lecture, we divided the contributions into 4 Sessions of talks, with the following themes:

1. Observational evidence of winds (Day 2, Tuesday)
2. Physical ingredients of winds (Day 3, Wednesday)
3. Flow-flow interactions (Day 4, Thursday)
4. Relevance of winds on stellar/planetary evolution (Day 4, Thursday)

Each session started with one invited talk (sessions had multiple invited speakers to cover the three main themes), followed by contributed talks and further invited talks. One of the main goals of the meeting was to maximise exchange between the three main areas of the symposium. Thus, each session had a mix of contributions from the three main areas of the symposium. We had 88 contributions, of which 32 were selected as contributed talks, 11 invited talks and 1 plenary talk.

*Scientific Organising Committee:*

Low-mass stars:

- Aline Vidotto (Netherlands, F) - **Chair**
- Moira Jardine (UK, F)
- Takeru Suzuki (Japan, M)
- Steve Cranmer (US, M)

Massive stars:

- Jorick Vink (UK, M) - **Co-Chair**
- Shazrene Mohamed (South Africa/US, F)
- Richard Ignace (US, M)

Atmospheric escape in close-in exoplanets:

- Luca Fossati (Austria, M) - **Co-chair**
- Tommi Koskinen (US, M)
- Kristina Kislyakova (Austria, F)

*Coordinating Division:* G (Stars)

*Other divisions:*

- E (Sun)
- F (Planets)
- H (ISM)

*Editors of proceedings:*

- Aline Vidotto, Luca Fossati & Jorick Vink

## Daily Schedule IAUS370 Winds of Stars and Exoplanets

last update: 5 August 2022

Date	8th Aug	Monday			Type of Participation
Time (KST, GMT+9)	Category	Speakers			
		Name	Abs_no.	Title	
08:15-09:45	Plenary	Stanley Owocki	2488	Winds and magnetospheres from stars and planets: similarities and differences	Remote Talk

Date	9th Aug	Tuesday			Type of Participation
Time (KST, GMT+9)	Category	Speakers			
		Name	Abs_no.	Title	
				See main IAU GA programme	
Coffee Break & e-poster					
10:30-11:00	Invited	Rachel Osten	2751	Observations of winds and CMEs of low-mass stars	In-person Talk
11:00-11:15	Contributed	Grace Telford	1806	FUV Constraints on the Winds and Rotation of Main-Sequence O Stars at Extremely Low Metallicity	In-person Talk
11:15-11:30	Contributed	Allan Sacha Brun	1719	Advanced models of the solar wind, inner corona and heliosphere	In-person Talk
11:30-11:45	Contributed	Calum Hawcroft	2864	New empirical mass-loss rates and wind properties of massive stars at low metallicity	In-person Talk
11:45-12:00	Contributed	Gemma González-Torà	283	The effect of winds in Red Supergiants I. 1D Modelling for interferometric observations	In-person Talk
Lunch					
13:30-14:00	Invited	Andrea Mehner	1053	Observations of outflows of massive stars	In-person Talk
14:00-14:15	Contributed	Atefeh Javadi	2775	Mass-loss rates of cool evolved stars in the Local Group galaxies	In-person Talk
14:15-14:45	Invited	Leonardo Dos Santos	1595	A review on the observations of planetary winds and outflows	In-person Talk
14:45-15:00	Contributed	Hyosun Kim	2096	The porous envelope and circumstellar wind matter of the closest carbon star	In-person Talk
Break					
15:15-15:45	Invited	Susanna Parenti	2281	Updates on recent findings from the solar wind with major facilities	In-person Talk
15:45-16:00	Contributed	Simon Daley-Yates	828	Slingshot Prominences, Formation, Ejection and Cycle Frequency in Cool Stars	Remote Talk
16:00-16:15	Contributed	Giovanni Pinzon	1028	Is the magnetospheric accretion process active in Herbig Ae/Be stars ?	In-person Talk
16:15-16:30	Contributed	Adam Finley	1470	Rotation of the Solar Corona and Solar Wind Angular Momentum-loss	In-person Talk
16:30-16:45	Contributed	Kristina Kislyakova	2585	X-ray observations as a tool to estimate stellar mass losses	Remote Talk
Coffee Break & e-poster					

**Date 10th Aug Wednesday**

Category	Category	Speakers			Type of Participation
		Name	Abs_no.	Title	
	Plenary			See main IAU GA programme	
Coffee Break & e-poster					
10:30-11:00	Invited	Daria Kubyshkina	1214	The origin of planetary winds	Remote Talk
11:00-11:15	Contributed	Dualta O Fionnagain	2626	Coronal Mass Ejections and Type II Radio Emission Variability during a Magnetic Cycle on the Solar-type Star $\epsilon$ Eridani	In-person Talk
11:15-11:30	Contributed	Jean-Michel Desert	3274	Deciphering composition and winds in exoplanet atmospheres	In-person Talk
11:30-11:45	Contributed	Hiroto Mitani	1960	The classification of the atmospheric escape: three types of escape driven by EUV photoionization heating	In-person Talk
11:45-12:00	Contributed	Florian Driessen	1392	'Discrete Absorption Components' from 3-D spot models of hot star winds	In-person Talk
Lunch					
13:30-14:00	Invited	Munehito Shoda	1905	Stellar wind from low-mass main-sequence stars: an overview of theoretical models	In-person Talk
14:00-14:15	Contributed	Catalina Arcos	1612	Hydrodynamic disk solutions for Be stars using HDUST	In-person Talk
14:15-14:30	Contributed	Robert Kavanagh	976	Signatures of star-planet interactions across the electromagnetic spectrum	In-person Talk
14:30-14:45	Contributed	Nicolas Moens	1606	Uncovering the Wolf-Rayet wind launching mechanism through 3D radiation-hydrodynamics	In-person Talk
14:45-15:00	Contributed	Gopal Hazra	2278	Effect of stellar coronal mass ejections and flares on the atmosphere of hot Jupiters and their transit signatures	In-person Talk
Break					
15:15-15:45	Invited	Andreas Sander	624	The driving of hot star winds	In-person Talk
15:45-16:00	Contributed	Takeru Suzuki	872	Role of Longitudinal Waves in Alfvén-wave-driven Solar/Stellar Wind	In-person Talk
16:00-16:15	Contributed	Judy Chebly	2615	Filling the gap in stellar wind observations of cool stars via 3D MHD numerical modelling	In-person Talk
16:15-16:30	Contributed	Ignacio Araya	1647	ISOSCELES: Grid of stellar atmosphere and hydrodynamic models of massive stars. The first results.	In-person Talk
16:30-16:45	Contributed	Julián Alvarado-Gómez	414	Simulating the Space Weather in the AU Mic System: Stellar Winds and Extreme Coronal Mass Ejections	In-person Talk
Coffee Break & e-poster					

**Date 11th Aug Thursday**

Category	Category	Speakers			Type of Participation
		Name	Abs_no.	Title	
	Plenary			See main IAU GA programme	
Coffee Break & e-poster					
10:30-11:00	Invited	Jonathan Mackey	1335	Interaction between massive star winds and the interstellar medium	In-person Talk
11:00-11:30	Invited	Ildar Shaikhislamov	342	Interaction of exoplanetary and stellar winds and its observational manifestations	Remote Talk
11:30-11:45	Contributed	Takashi Moriya	748	Massive star mass loss constrained by supernova radio properties	In-person Talk
Lunch					
13:30-13:45	Contributed	Ashkbiz Danehkar	387	Time-dependent Numerical Modeling of Thermally Driven Stellar Winds	In-person Talk
13:45-14:00	Contributed	Varsha Ramachandran	373	Probing the winds and interactions of OB stars in different environments	In-person Talk
14:00-14:30	Invited	Darius Modirrousta-Galian	287	Role of Planetary Winds in Planet Evolution and Population	In-person Talk
14:30-14:45	Contributed	Pin-Gao Gu	1270	Size Evolution of Close-in Super-Earths through Giant Impacts and Photoevaporation	Remote Talk
Break					
15:15-15:45	Invited	Sung-Chul Yoon	2556	Effects of rotation on the evolution of early-type stars	In-person Talk
15:45-16:00	Contributed	Andrew Allan	2472	The Evolution of Atmospheric Escape of Highly Irradiated Gassy Exoplanets	In-person Talk
16:00-16:15	Contributed	Zsolt Keszthelyi	257	Spin down and reduced mass loss in early-type stars with large-scale magnetic fields	In-person Talk
16:15-16:30	Contributed	Antoine Strugarek	1423	Architectures of rotating star-planet systems: Comparing theoretical predictions to observations	Remote Talk
16:30-16:45	Contributed	Gautham Narayana Sabhahit	1480	Mass-loss implementation and temperature evolution of very massive stars	Remote Talk
Coffee Break & e-poster					