Winds of stars and exoplanets

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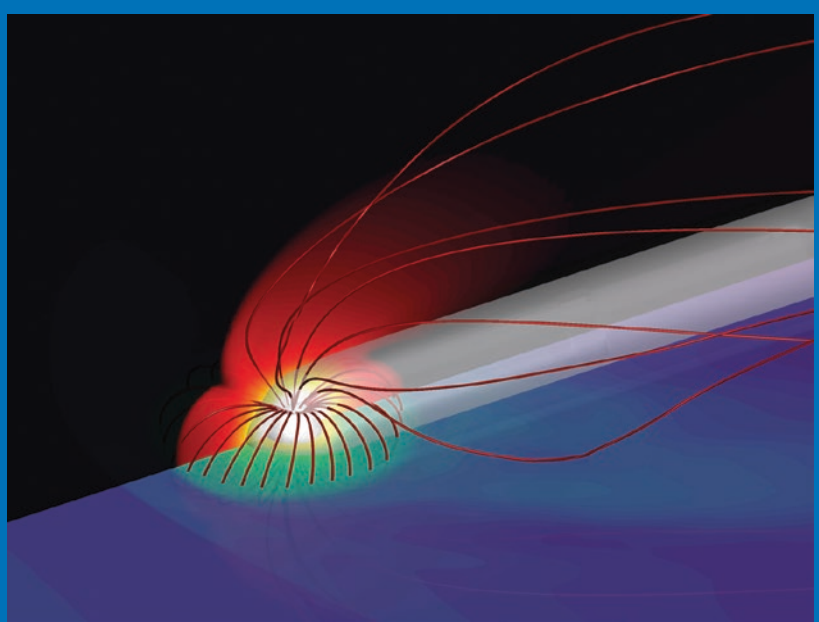

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COVER ILLUSTRATION:

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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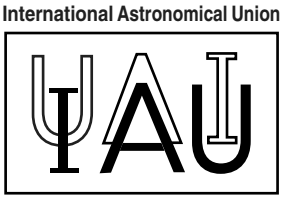

WINDS OF STARS AND EXOPLANETS

PROCEEDINGS OF THE 370th SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION BUSAN, KOREA, REP OF 8–11 AUGUST 2022

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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

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- 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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