Stellar Winds in Single and Binary Star Systems

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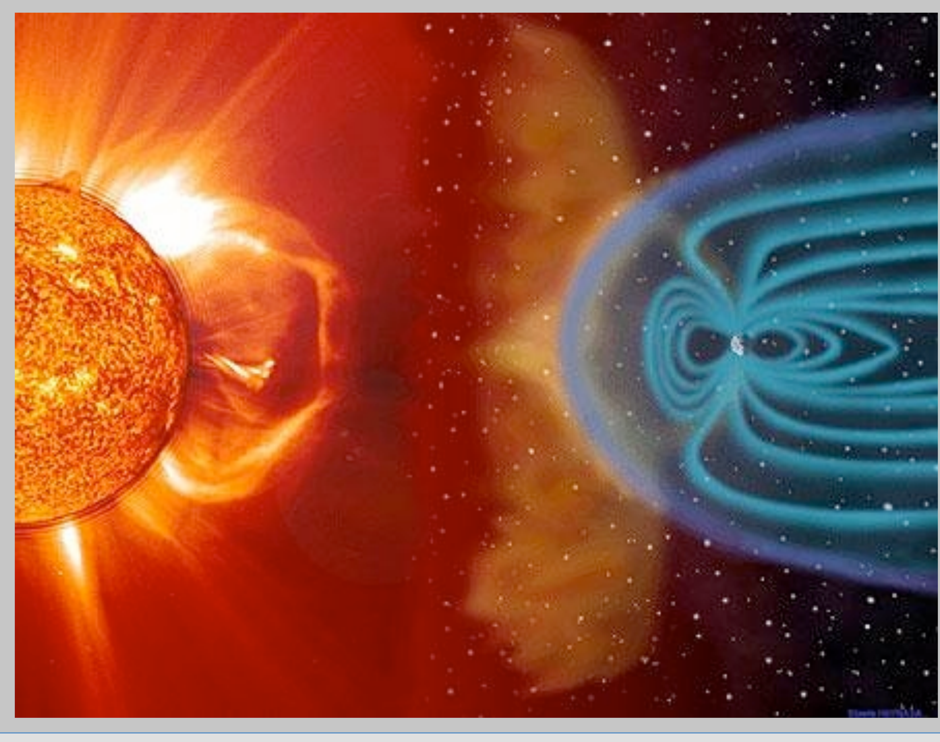
Young low-mass stars are continuously losing mass in the form of stellar winds. These winds can influence the evolution of the atmospheres of planets that orbit these stars. Supersonic winds from the parent star compress the planetary magnetosphere and can lead to mass loss from the atmosphere. In order to understand how the atmospheres of planets evolve, it is necessary to know the properties of these stellar winds. We study the winds of low-mass stars within the framework of the project Pathways to Habitability project (http://path.univie.ac.at/). We investigate the winds in both single star and binary star systems.

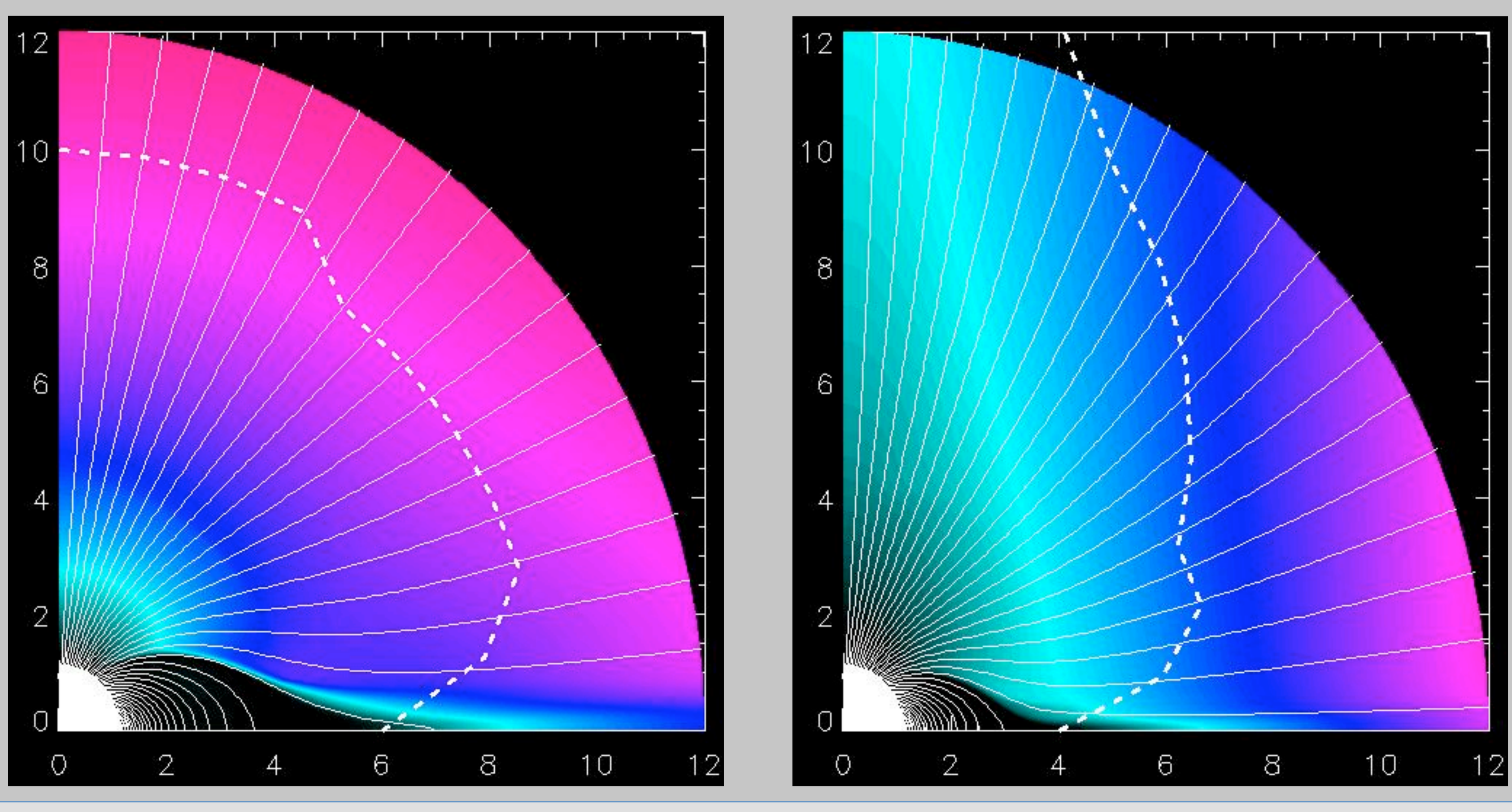


The standard cartoon showing the interaction between a star and a planetary magnetosphere. Credit: NASA.

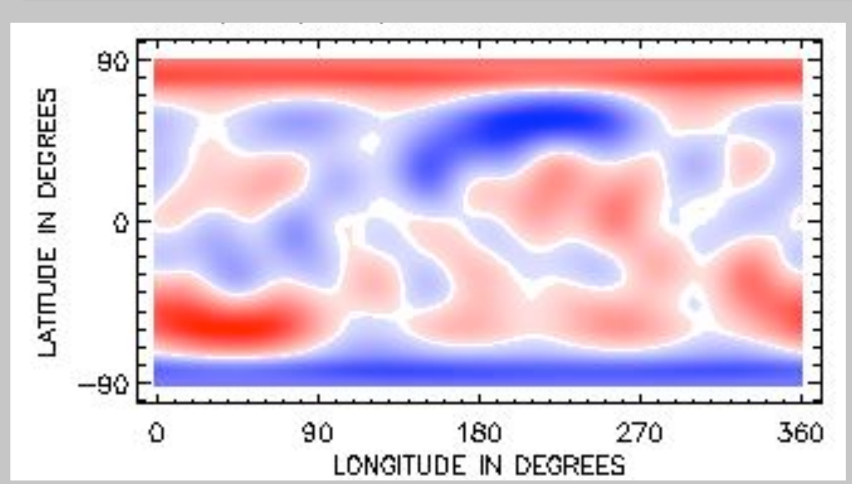
Single Star Winds

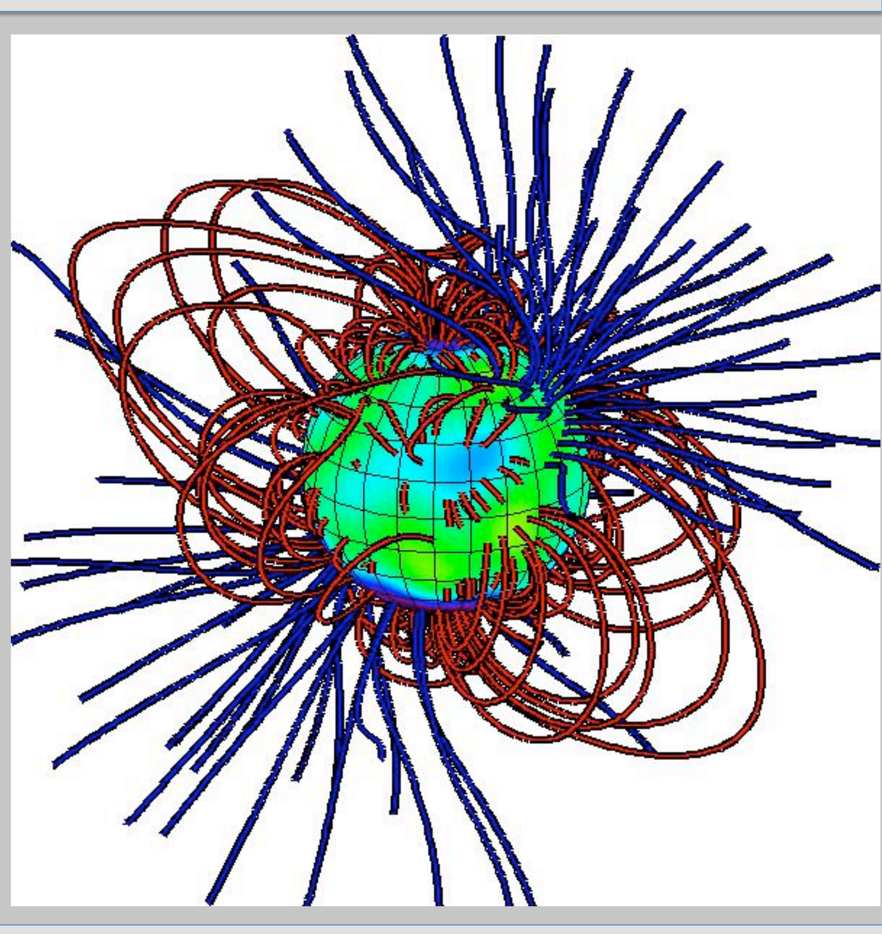
Unfortunately the properties of low-mass stellar winds are constrained by neither theory nor observation. Since the driving mechanisms of these winds, including those of the solar wind, are not known, recent studies drive the winds by thermal pressure and assumed simple models to heat the plasma (e.g. Vidotto et al. 2010; Matt et al. 2012). These models contain free parameters which we hope to constrain observationally. We will do this using radio interferometric observations (for more information, see Poster 1K098 by B. Fichtinger), and other observational constraints.

no rotation | fast rotation



Velocity contour plots showing the expansion of 2D axisymmetric winds with a dipole magnetic field run using the MHD code Nirvana (Ziegler 2005). The plasma is assumed to be isothermal, leading to implicit heating as the winds expand. The dashed white lines show the Alfven surfaces.





Top: ZDI magnetic map of the classical T Tauri star V2247 Oph produced by Donati et al. (2010). Right: Potential-field extrapolation from Johnstone et al. (submitted).

Stellar magnetic fields and the related activity have an important impact on stellar winds. Based on the Zeeman Doppler Imaging technique, we will study the origin, strength, and distribution of magnetic fields on active stars as a function of age, mass and spectral type. For modeling, we use a state-of-the-art ZDI code that uses self-consistent temperature and magnetic mapping of cool active stars (Kochukhov & Piskunov 2009) including treatment of molecular opacities. To obtain complete sets of circular and linear Stokes parameter observations, we have applied and will apply for first-class spectropolarimetric data obtained with frontier instrumentation such as HARPSpol on the ESO 3.6m telescope, ESPaDOnS@CFHT (Hawaii), and NARVAL@TBL (France).

References
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Kochukhov O., & Piskunov N., 2009, ASPC, 405, 539
Matt S., et al., 2012, ApJ, 754, 26
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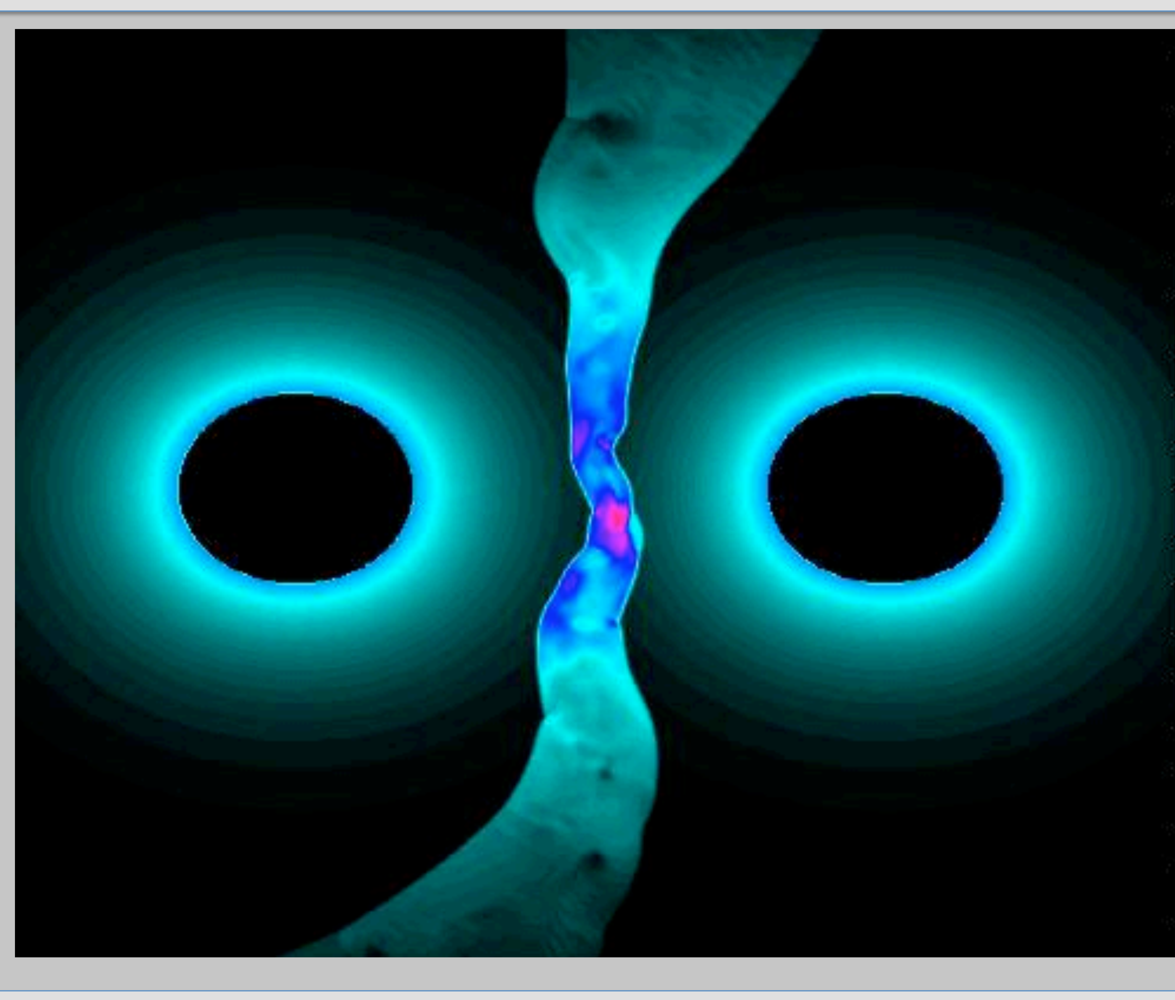
http://path.univie.ac.at/

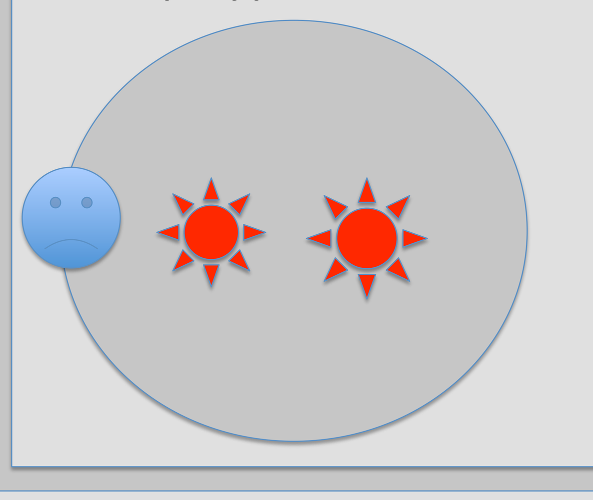
Binary Star Winds

We use magnetohydrodynamic simulations to study the interactions between winds in low-mass binary star systems. As the supersonic winds of two stars collide, they produce interactions regions with increased density and magnetic field strengths. We will combine our studies of the interactions between colliding winds with planetary magnetospheric and atmospheric models to study how habitable planets are affected when they pass through these interaction regions.

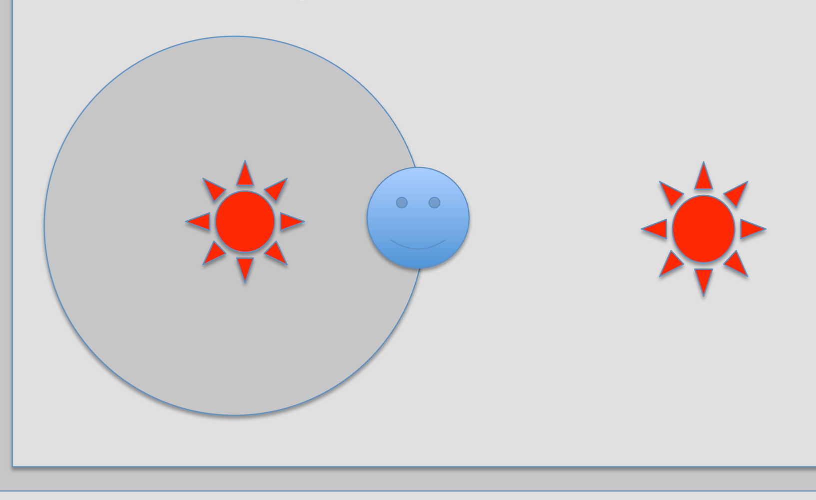


Density contour plot showing the interactions of two solar-like stellar winds in a binary star system. The plasma is assumed to be described by an adiabatic index of 1.1, which leads to a large amount of cooling in the interaction region. The simulation was run using the MHD code Nurgush (Zhilkin & Bisikalo 2010).

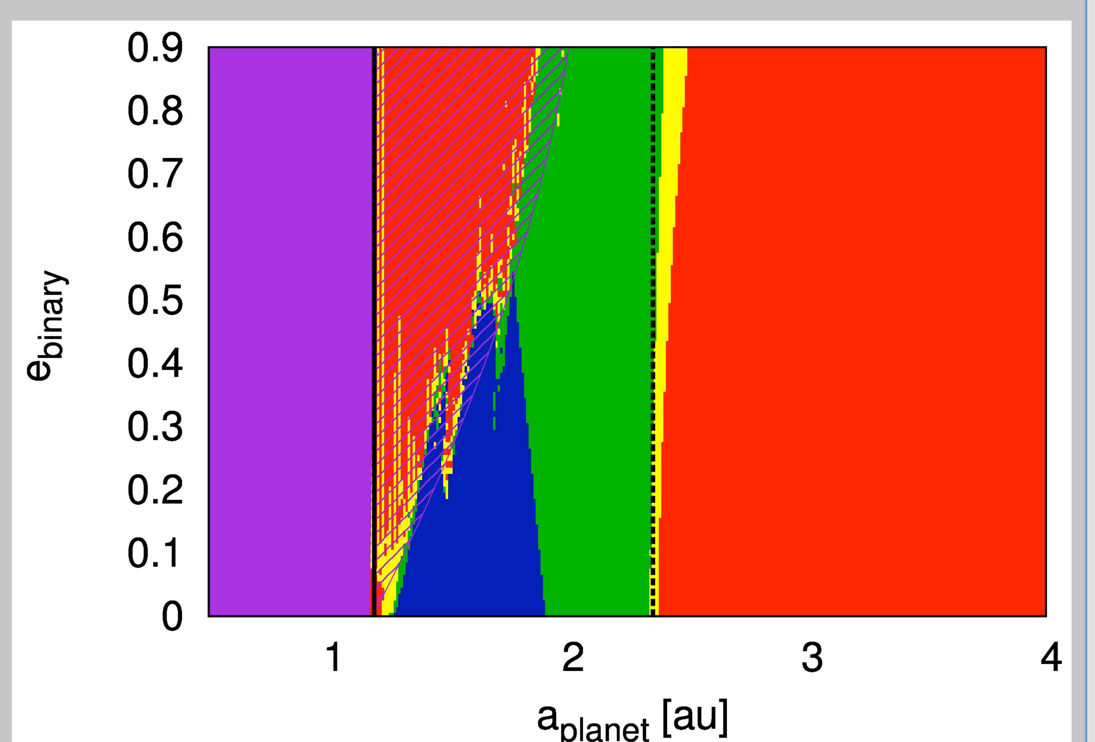
p-type orbits



s-type orbits



In p-type systems, the planet passes through the interaction region twice per orbit. In s-type systems, the planet only passes through the interaction region if the wind from the secondary star dominates the wind from the primary. The configuration of the system is also important for determining the positions of stable orbits and habitable zones. We combine the study of the interactions between winds with stability analysis and habitable zones in binary star systems. For more information, see Poster 2K061 by E. Pilat-Lohinger.



Left: Figure courtesy of E. Pilat-Lohinger showing the locations of stable orbits in habitable zones around two solar-type stars separated by 0.5 AU in a p-type configuration. On the x-axis is the distance from the planet to the centre of the system and on the y-axis is the eccentricity of the binary orbits. The colours represent the following

Purple – Unstable zone
Red – Not habitable zone
Blue – Permanently habitable zone
Green – Extended habitable zone
Yellow – Average habitable zone