The star-planet interaction by combining asteroseismic and space weather techniques

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Abstract

The characterization of exoplanets conditions cannot be based solely on the knowlegde of the planetary main parameters, since the properties and the activity level of the host star, as well as the effects of extreme space weather phenomena, need also to be considered. Here we propose a synergic strategy based both on an asteroseismic approach and a space weather/space climate analysis. By studying the oscillation spectra it is possible to derive the host star fundamental parameters, including a precise determination of the age. Combining this informations with those coming from observations in the UV spectrum of the star (Ca II H & K lines), and by using relations which we have already calibrated on the Sun (Reda et al. 2021 submitted), we are able to estimate the mean stellar wind acting on the exoplanets, enabling to estimate the erosion of their atmospheres. The best targets for this approach consists of terrestrial planets orbiting around solar-like stars, which are exactly the primary targets of the PLATO mission.

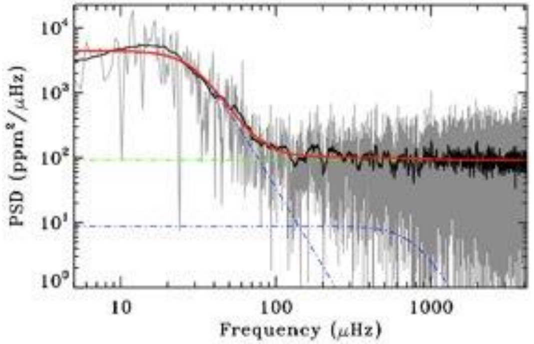
Star chracterization: asteroseismic analysis

The global parameters and the atmospheric characteristics of a star constitute fundamental informations in order to study the star-planet interaction. Thus, to assess the habitability of an exoplanet we need to characterize its host star.

By using asteroseismic analysis and looking to the light curve as deduced by observations of current photometric missions (e.g. Kepler, TESS), we are able to obtain an accurate estimate of the main global stellar parameters, such as stellar mass and radius, as well as the age of the star.

The information coming from this asteroseismic approach, together with an evaluation of the stellar magnetic activity allow to have an almost full-characterization of the host star.

The best targets for applying this approach include Earth-like planets orbiting around solar-like stars.



Oscillation spectrum of the solar-type star GJ 504, as derived from TESS observations.

Di Mauro (2017)

	SUN-LIKE MS		
	R	M	Age
CD diagram			15%
Scaling laws	5-7%	5-7%	-
frequencies	0.3%	0.8%	3.7%

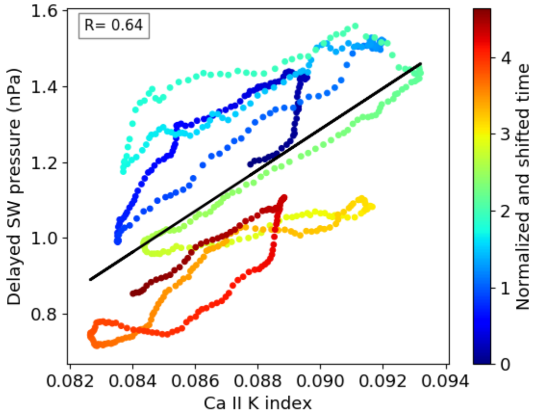
Accuracy with which stellar parameters can be determined by using asteroseismic tools.

Star-planet interaction: the stellar activity – stellar wind connection

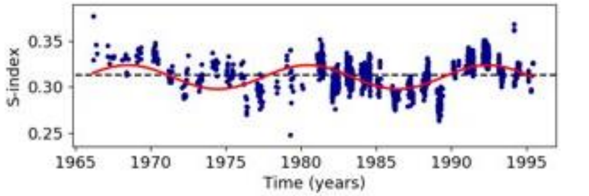
To assess the habitability conditions of exoplanets we need to study the stellar magnetic activity, as well as its effects on the circum-planetary environment. In order to connect the stellar activity variability to stellar wind response, we started by analyzing the solar activity-solar wind case. We found a time lag in the correlation between a solar activity proxy, such as the Ca II K index, and two solar wind parameters (speed and dynamic pressure), even if the time delay resulted to be not constant due to the different main periodicities of the signals. By taking these periodicities into account and by calibrating over 5 solar cycles, we obtained correlation relations useful to study the connection between stellar activity and stellar wind.

The advantage of having used a chromospheric proxy, as the Ca II K index, is that the relations found for the Sun can be employed to connect stellar variability to stellar wind properties in solar-like stars. Measurements in the Ca II H & K lines from Mount Wilson Observatory are already available for several stars.

From **Reda et al. (2021)**, submitted to MNRAS.



Scatter plot showing the relation between Ca II K and solar wind dynamic pressure normalizated to their main periods.



S-index data from MWO for the solar-like star GJ 504, showing a clear 12-year cycle.