Transiting planets, vibrating stars & their connection
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Direct characterization of limb darkening dedicated to transit measurements and asteroseismology

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Abstract. The recent development of interferometry allows reaching low visibilities in the visible wavelengths and thus accessing limb darkening measurements. Limb darkening is one of the very few directly measurable constraints on the structure of the atmosphere of a star, and a precise measurement within spectral lines is a very powerful tool to study the temperature and density structure of the atmosphere of distant stars. The determination of stars pulsations also increases our knowledge in stellar structure and evolution, and limb darkening plays an important role in the pulsation modeling. Precise measurements are applied to host stars and help constraining their fundamental parameters. Besides, the detection of exoplanets is also related to this method. Combined with the radial velocity method and the transit method, one can study the atmosphere of exoplanets and learn more about their internal structure.

1. An example of limb darkening characterization: 13 Cygni.

The VEGA instrument, located at Mount Wilson, California, is an interferometer operating in the visible wavelength, and allowing the measurement of visibility function of distant stars. To determine the fundamental parameters of stars, a precise measurement of limb darkening is required. It is derived from the squared visbility (equation 1), itself depending on the wavelength and baseline (equation 2).

$$V^2 = \frac{2J_1(x)}{x^2} \tag{1}$$

$$x = \frac{15.23 \times B \times \beta}{\lambda} \tag{2}$$

with $J_1(x)$ the first order Bessel function, λ the wavelength, θ the uniform angular diameter and B the baseline.
For instance, this has been done for the F4V type star 13 Cygni, for which we found a limb darkened diameter (LDD) of 0,76 mas with less than 2% accuracy. A good determination of its fundamental parameters could then be derived (see Table 1).

2. Asteroseismology and transit measurements

VEGA will soon measure the second lobe of squared visibility and thus precisely characterize the limb darkening of stars. With these data, stars pulsations could be accurately determined, and, combined with asteroseimologic data, the interior of stars, their evolution and chemical composition could be derived. Indeed, asteroseismology is based on the measurement of acoustic waves propagating in stars' interiors. Their speed varies according to the composition and the temperature of the star. In the case of stars observed with the transit method, interferometry is useful to understand the geometrical configuration of spots on stars' surfaces and the effects of rotation.

Table 1.: *13 Cyg, coordinates and fundamental parameters.*

Coordinates		
RA (J2000)	19 : 36 : 26.5	
Dec (J2000)	+ 50°13'16"	
Stellar parameters		
Stellar type	F4V	
V mag	4.5	
K mag	3.5	
Parallax	54.54	
Calculated parameters	**Value**	**Error**
LDD (mas)	0.76	0.014
Radius ($R_{\odot}$)	1.51	0.03
Mass ($M_{\odot}$)	1.60	0.003
Teff (K)	6972	64

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