Magnetic Fields throughout Stellar Evolution
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High-resolution spectropolarimetry of κ Cet: A proxy for the young Sun

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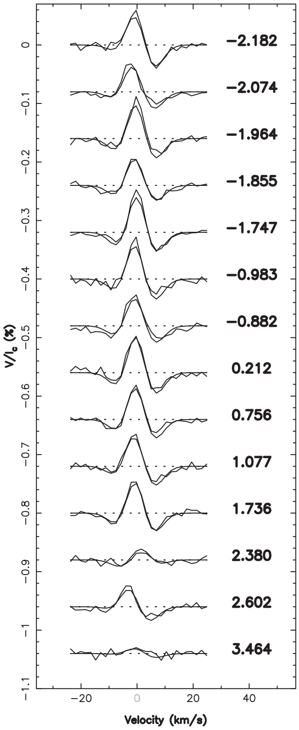
Abstract. κ^1 Cet (HD 20630, HIP 15457, d = 9.16 pc, V = 4.84) is a dwarf star approximately 30 light-years away in the equatorial constellation of Cetus. Among the solar proxies studied in the Sun in Time, κ^1 Cet stands out as potentially having a mass very close to solar and a young age. On this study, we monitored the magnetic field and the chromospheric activity from the Ca II H & K lines of κ^1 Cet . We used the technique of Least-Square-Deconvolution (LSD, Donati *et al.* 1997) by simultaneously extracting the information contained in all 8,000 photospheric lines of the echelogram (for a linelist matching an atmospheric model of spectral type K1). To reconstruct a reliable magnetic map and characterize the surface differential rotation of κ^1 Cet we used 14 exposures spread over 2 months, in order to cover at least two rotational cycles (Prot ∼ 9.2 days). The Least Square deconvolution (LSD) technique was applied to detect the Zeeman signature of the magnetic field in each of our 14 observations and to measure its longitudinal component. In order to reconstruct the magnetic field geometry of κ^1 Cet , we applied the Zeeman Doppler Imaging (ZDI) inversion method. ZDI revealed a structure in the radial magnetic field consisting of a polar magnetic spot. On this study, we present the fisrt look results of a high-resolution spectropolarimetric campaign to characterize the activity and the magnetic fields of this young solar proxy.

Keywords. κ^1 Cet , HD 20630, HIP 15457, solar analogs, magnetic field

1. Introduction

The observational programme *Sun in Time* (Ribas *et al.* 2005) is focused on a small sample of carefully-selected and well-studied stellar proxies that well represent some key stages in the evolution of the Sun. These authors used X-ray, EUV, and FUV domains to characterize some solar proxies. Among the solar proxies studied in the Sun in Time, κ^1 Cet stands out as potentially having a mass and metallicity very close to solar with an estimated age of ∼0.7 Gyr (Ribas *et al.* 2005). This could be a very good analog of the Sun at the critical time when life is thought to have originated on Earth 3.8 Gyr ago. The star was discovered to have a rapid rotation, roughly once every nine days. κ^1 Cet is also considered a good candidate to contain terrestrial planets. In spite of our in-depth knowledge of κ^1 Cet , including its radiative properties, abundances, atmospheric parameters, and evolutionary state, we know little or nothing about the magnetic field properties of this important solar proxy. On this study we present the first look results from a regularly observational campaign using the NARVAL spectropolarimeter at the Télescope Bernard Lyot (Pic du Midi, France) to observe κ^1 Cet , and infer the intensity and nature of its magnetic field. The Zeeman-Doppler Imaging technique is employed to reconstruct the large-scale photospheric magnetic field structure of κ^1 Cet and to investigate its short-term temporal evolution.



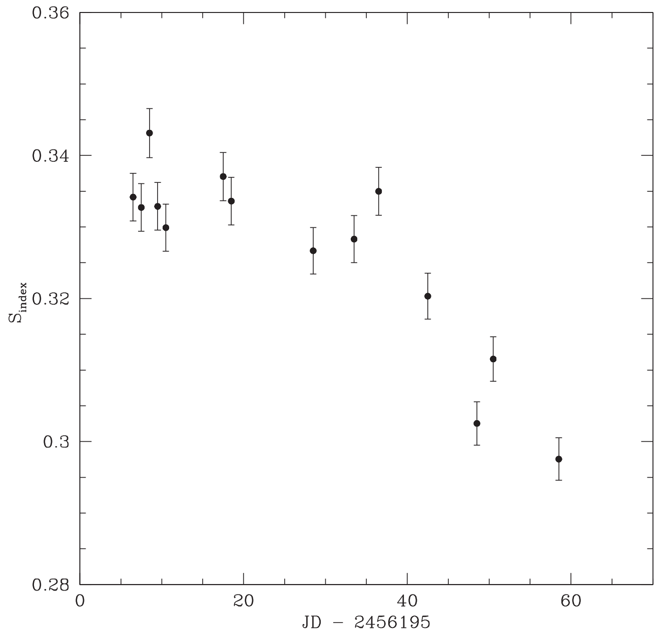


Figure 1. *Left*: The normalized Stokes V profiles of κ^1 Cet . Continuum line represent the data and dashed line correspond to synthetic profiles of our magnetic model. Successive profiles are shifted vertically for display clarity. Rotational phases of observations are indicated in the right part of the plot. *Right*: From the Stokes I spectra, we determined the S_{index} (calibrated from the Mount Wilson S_{index}) to quantify the chromospheric emission changes in the Ca II H line. The complete pipeline of the computation is described in Morgenthaler *et al.* (2012) and Wright *et al.* (2004).

2. First look results

From a careful spectral analysis by Ribas *et al.* (2010) and the comparison of different methods these authors give for κ^1 Cet the following atmospheric parameters: Teff = 5665 ± 30 K (Hα profile and energy distribution), log g = 4.49 ± 0.05 dex (evolutionary model and spectroscopy) and [Fe/H] = +0.10 0.05 (Fe II lines). In the left panel of Fig. 1, we show the normalized Stokes V profiles of κ^1 Cet . The Least Square deconvolution (LSD) technique was applied to detect the Zeeman signature of the magnetic field in each of our 14 observations to measure its longitudinal component, leading to B_l =+7.0 ±0.9 Gauss. The main structure observed in the ZDI model is a structure in the radial magnetic field consisting of a polar magnetic spot. In this study, we present the first look results of a high-resolution spectropolarimetric campaign to characterize the activity and the magnetic fields of this young solar proxy.

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