

CARMENES: Calar Alto High-Resolution Search for M Dwarfs with Exo-earths with a Near-infrared Echelle Spectrograph

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Abstract. CARMENES, *Calar Alto high-Resolution search for M dwarfs with Exo-earths with a Near-infrared Echelle Spectrograph*, is a study for a next-generation instrument for the 3.5 m Calar Alto Telescope to be designed, built, integrated, and operated by a consortium of nine German and Spanish institutions. Our main objective is finding habitable exoplanets around M dwarfs, which will be achieved by radial velocity measurements on the m s^{-1} level in the near-infrared, where low-mass stars emit the bulk of their radiation.

1. Introduction

So far, radial velocity exoplanet searches have mainly focused on Solar-like main sequence stars. However, searches for exoplanets around M dwarfs have also been successful, and knowing the frequency of these objects places important constraints on planet formation scenarios. Some of the least massive exoplanets known orbit low-mass M dwarfs (e.g. GJ 581 and GJ 876 – Rivera et al. 2005; Udry et al. 2007; Mayor et al. 2009).

M dwarfs are the most common stars in the solar neighborhood, and their habitable zones lie close to them. This means that “habitable” planets around M dwarfs have large radial-velocity signatures and a large probability of showing transits. In spite of their interest, M dwarfs have not been searched for planets as extensively as late-F, G, and K stars, because of their faintness in the optical, where most radial velocity searches are being performed. A near-infrared (NIR) spectrograph with a radial velocity accuracy on the m s^{-1} level would be more efficient to detect Earth-like planets around stars with spectral types later than

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about M3. Radial velocities measured in the near infrared would also be less susceptible to stellar radial-velocity noise. As a high-resolution near-infrared spectrograph dedicated to a planet survey does not exist yet, we have performed a study of such an instrument for the Calar Alto Astronomical Observatory.

2. CARMENES Design Overview

The CARMENES study was initiated as a joint Spanish-German response to a call for ideas for new instruments for Calar Alto. In this contribution, we describe a summary of the CARMENES configuration as it was presented in the Conceptual Design Review in early October 2009. (The configuration may have changed since then; visit our webpage¹ for later developments). CARMENES is expected to become operational in 2013.

CARMENES will be fiber-fed from a front-end at the prime focus of the 3.5 m Calar Alto Telescope. The three cross-dispersed echelle spectrograph channels (NIR, VIS, MOS; see below) will be located in the coudé room of the telescope, where they can be thermally and mechanically stabilized. The instrument will cover from 500 to 1800 nm in one shot with a near-IR radial velocity precision requirement of 3 m s^{-1} .

Thanks to an optical design with a mosaic of two $2 \text{ k} \times 2 \text{ k}$ detectors and an R2.9 echelle grating, the NIR channel will cover from 950 nm (*Y* band) to about 1800 nm (*H* band) with a spectral resolution $R = 85\,000$ in 31 echelle orders. The cross disperser will consist of two S-NPH2 prisms. Most of the opto-mechanical components of the NIR channel will be located inside a vacuum tank at $T = -30^\circ\text{C}$. The NIR channel needs an image slicer and an image scrambler.

The design of the visible (VIS) channel, which will cover from 500 to 900 nm with $R = 60\,000$ in 42 echelle orders, will be based on the successful FEROS instrument. Simultaneous observations with the NIR and VIS channels will allow us to monitor the main activity indicators ($\text{H}\alpha$ and the calcium triplet) with the same temporal sampling as the radial-velocity curve, which will help us discriminate between activity-induced and planet-induced radial-velocity variations.

The multiobject (MOS) visible channel takes advantage of the $\sim 0.8 \text{ deg}^2$ field of the 3.5 m telescope to acquire the spectra of ~ 12 bright stars during the M dwarf observations; in this way a survey of G and K giants can be conducted without any additional telescope time.

CARMENES may share the telescope prime focus with another instrument. The design therefore, foresees a common front end mounted at the primary focus behind the K3 corrector. This front end will contain the fiber positioners for the CARMENES NIR, VIS, and MOS channels. Our primary channels (NIR and VIS) require two fibers each: one for the object and one for a ThAr lamp or sky.

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¹<http://www.ucm.es/info/Astrof/carmenes>.

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