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CARMENES: Blue Planets Orbiting Red Dwarfs

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Abstract. CARMENES (**C**alar **A**lto high-**R**esolution search for **M** dwarfs with **E**xo-earths with **N**ear-infrared and optical **E**chelle **S**pectrographs) will conduct a radial-velocity survey of $\sim$ 300 M dwarfs with the 3.5 m telescope at the Calar Alto Observatory. The CARMENES instrument is currently under construction; it consists of two independent échelle spectrographs, which together cover the wavelength range $0.55 - 1.7\,\mu$m at a spectral resolution of $R = 82,000$. The spectrographs and the fiber input are designed with a goal of 1 m/s radial velocity precision using simultaneous calibration with emission-line lamps.

Keywords. instrumentation: spectrographs, techniques: radial velocities, stars: late-type, (stars:) planetary systems

1. Introduction

M-type stars span the mass range of $0.1 - 0.6\,M_{\odot}$, and therefore obtaining statistics of planetary system occurrence and architecture for these stars is of great importance for understanding the physics of planet formation and evolution, and its dependence on stellar host mass. Radial-velocity searches for planets around M dwarfs benefit from a large signal and a short orbital period of planets in the habitable zone, which provides an opportunity for finding habitable planets in the Solar neighborhood. However, the current number of planet detections with M-star hosts is still low, due to the faintness of the targets in the visible wavelength range and the intrinsic stellar jitter. The CARMENES

project (see also Quirrenbach et al. 2010, 2012) is aimed at filling this gap, by constructing a radial-velocity instrument optimized for planet searches of mid- to late-type M dwarfs.

2. The CARMENES Instrument

For mid-M to late-M spectral types, the wavelength range around 1000 nm (Y band) is the most important region for RV work. Therefore, the efficiency of CARMENES will be optimized in this range. Since CCDs do not provide high enough efficiency above 900 nm, a near-IR detector is required. It is thus natural to adopt an instrument concept with two spectrographs, one equipped with a CCD for the range 550 – 1050 nm, and one with HgCdTe detectors for the range from 0.9 – 1.7 μm.

Each spectrograph will be coupled to the 3.5 m telescope with its own optical fiber. The front end will contain a dichroic beam splitter and an atmospheric dispersion corrector, to feed the light into the fibers leading to the spectrographs. Additional fibers are available for simultaneous injection of light from emission line lamps for RV calibration.

The spectrographs are mounted on benches inside vacuum tanks, which are located in climatic chambers inside the coudé laboratory of the 3.5 m dome. The near-IR vacuum tank is equipped with a temperature stabilization system; the thermal design of both spectrographs provides the capability of keeping the temperature of the optical bench constant to within ± 0.01 K over 24 h. The visible-light spectrograph will be operated near room temperature, the NIR spectrograph will be cooled to ~ 140 K.

3. The CARMENES Survey

The main scientific driver for CARMENES is the search for very low-mass planets (i.e., Earth-analogs and "super-Earths") around mid- to late-type M dwarfs. A long-term RV precision of $1\,\mathrm{m\,s^{-1}}$ is sufficient to detect a $2\,M_\oplus$ planet in the middle of the HZ of an M5 star. For stars later than $\sim$M4 ($M < 0.25 M_\odot$), such precision will yield detections of super-Earths of $5 M_\oplus$ and smaller inside the entire width of the HZ.

Our survey strategy is to intensively monitor a well-characterized sample of ~ 300 M dwarfs. If we assume that about 30-40 % of the M dwarfs have low-mass planets and a high chance of some being in the habitable zone, we may expect to find between 50 and 100 suitable planets. Even if the real frequency is much lower, still a substantial number of detections will be available, and CARMENES will put tight constraints on the abundance and orbital parameters of low-mass planets in the investigated mass regime.

The expected CARMENES planet harvest is, at any rate, sufficient to carry out a reliable statistical analysis of the planet population and shed light on the architecture of planetary systems and on their formation mechanisms. The CARMENES survey will also provide valuable constraints on $\eta_\oplus$ for M dwarfs. Given the transit probability and the favorable selection bias, there is a good chance of finding 1 or 2 transiting low-mass planets in the habitable zone. These hold extraordinary value for future investigations.

References

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