

The CARMENES radial velocity instrument

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comenes the project



Observations from the ground: RV



Planets

- Search for temperate rocky exoplanets
- Characterization of planetary systems
- Exoplanet atmospheres

Observations from space: Transits

comenes the project

- Stellar structure and evolution
- Stellar interior physics
- High-precision M, R and T

Stars

Asteroseismology



Observations from the ground: RV



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Observations from space: Transits



CARMENES concept

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A high resolution multi-object spectrograph for Calar Alto

Eike Guenther, Thueringer Landessternwarte

Up to now, most infrared high resolution spectrographs have only limited spectral ranges. However, the large detector arrays that are now available allows us to built cross-

A high-resolution near-infrared spectrograph for the CAHA 3.5-m telescope Pedro J. Amado González , IAA

In this talk, we present a proposal for a new instrument for the 3.5m telescope at Calar Alto, Almería, Spain. This instrument will be a high-resolution near-infrared spectrograph

Multi-Object High-Resolution Spectrograph Andreas Quirrenbach, Landessternwarte Heidelberg

Scientific drivers, technical approaches, and potential consortium arrangements for the construction of a (massively?) multiplexed high-resolution spectrograph will be discussed.

Pre-selection	January 2009
CDR	October 2009
pCDR	July 2010
Green light	November 2010
PDR	July 2011
optics-FDR	April 2012
FDR	February 2013
ΜΑΙν	October 2015 (2.5y)
Commissioning	December 2015
Survey (GTO)	January 1st, 2016



The niche





The niche





The niche





Global science questions: M-dwarf planets

- How many planets are there?
- What are they like?
- How do planets form and evolve?
- What are the architectures of planetary systems?

CARMENES:

Find and measure a significant number of planets



CARMENES project summary

- Search for Earth-like planets around 300 M dwarfs
 + asteroseismology and stellar activity
- Survey on-going since Jan 1, 2016 (1st yr -> 300+ spectra)
- CARMENES Consortium: 11 Institutions
- GTO: 750 "useful" nights guaranteed
- Funded by MPG, CSIC, National German and Spanish funds, Andalucía Regional funds and European FEDER funds + others.



Quirrenbach, Amado & the CARMENES Consortium, 2012 (SPIE, 8446-25)

Amado, Quirrenbach & the CARMENES Consortium, 2012, (Highlights of Spanish Astrophysics VII, eprint arXiv:1210.5465)

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Calar Alto high Resolution search for M dwarfs with Exoearths with Near-infrared and optical Echelle Spectrographs

- Single-purpose, high-stability instrument
- Wide wavelength coverage for discrimination against intrinsic variability

the instrument

Near-Infrared channel

- Precision ~1 m/s (SNR=150, J=9, 15 min)
- 960-1710 nm, R = 80,400, 2.8pix sampling
- In vacuum, stabilized at 140 K
- Mosaic 2 2kx2k Hawaii2RG 2.5 μm
- UNe lamp (+F-P etalon)

2000 -

Visible channel

- Precision ~1 m/s
- 520-960 nm, R = 94,600, 2.5 pix sampling
- In vacuum, stabilized at ambient temperature
- 4kx4k CCD E2V
- ThAr, UNe & UAr lamps (+F-P etalon)

the instrument



200

the instrument



NIR 28 orders 0.96-1.71 μm

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		NIR snectrum
		nin speed and
		VIS spectrum

VIS 55 orders 0.52-0.96 µm



CARMENES spectrum





CARMENES-VIS survey of M dwarfs



- CARMENES-VIS: Similar precision to HARPS.
- CARMENES optimal for very low-mass stars.
- CARMENES-NIR: still to be exploited at its maximum.

the instrument

comenes







3.5m @ Calar Alto Observatory (Southern Spain)



CARMENES at Calar Alto Obs.



CCD (DLR)



Calar Alto

Brief Calar Alto history

Economic interest group formed by: Max-Planck-Gesellschaft (MPG), Germany, (MPIA-Heidelberg) and Consejo Superior de Investigaciones Científicas (CSIC), Spain, (IAA-Granada)

1968-1970	Site testing in different places in Spain, Greece.
1972	The first agreement was achieved between the goverments of Spain and the Federal Republic of Germany (1973-2003)
1975	The first facility at Calar Alto - 1.23m
1979	First light for the 2.2m;. Schmidt camera was transferred and the 1.5m Spanish telescope was built. Official inauguration of CAHA
1984	First light of the 3.5m telescope.
2004-2018	Renewal of the agreement and joint operation by MPG and CSIC at 50/50
2016-2018	CARMENES
2018	MPG withdrawal.

Calar Alto Observatory

- Largest observatory in mainland Europe.
- Excellent sky quality.
- Large slots of observing time, even beyond 2019.
- Staff with wide expertise, very well trained, and long-standing tradition developing outstanding instrumentation.
- ICTS funding lines. 80% FEDER funds in CAHA case.
- Very well defined strategic roadmap.

Future of CAHA is guaranteed

Why Calar Alto future is guaranteed?

Andalusian Regional Government commit support as new long-term major partner after German withdrawal at the end of 2018

• First contacts start in 2014

- Visit of the president of Junta de Andalucía in 2016
- Creation of a joint commission CSIC-JdA to study the viability of the future of Calar Alto.
- Both partners agree on the continuity of the facility



b)

2.5

The CARMENES search for exoplanets around M dwarfs

First visual-channel radial-velocity measurements and orbital parameter updates of seven M-dwarf planetary systems*

T. Trifonov¹, M. Kürster¹, M. Zechmeister², L. Tal-Or², J. A. Caballero^{3, 5}, A. Quirrenbach⁵, P.J. Amado⁶, I. Ribas⁷,...



A&A, accepted



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Summary

- CARMENES regular operations since Jan 1, 2016 for a 750 useful nights survey (2016-2020?)
- Both channels are online and acquiring data with results already in press and providing planet candidates
- Currently:
 - VIS → 2-4 m s⁻¹ rms (uncertainty + activity jitter) over timescale of months
 - NIR→ few m s⁻¹ over timescale of several nights
 - Working to improve both (precision & timescale)
- CARMENES Consortium readying for TESS and PLATO followup programs.