

# CARMENES

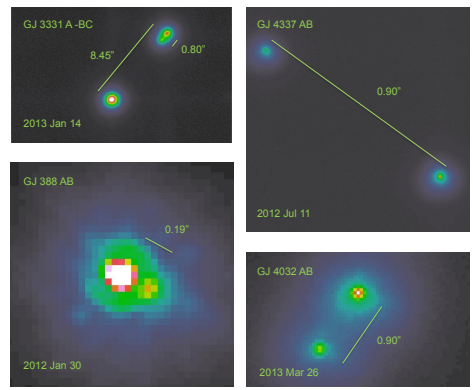
## Preparation of the CARMENES Input Catalogue Multiplicity of M dwarfs from tenths of arcseconds to hundreds of arcminutes



M. Cortés-Contreras<sup>8</sup>, V. J. S. Béjar<sup>7</sup>, J. A. Caballero<sup>10</sup>, B. Gauza<sup>7</sup>, D. Montes<sup>8</sup>, F. J. Alonso-Floriano<sup>8</sup>, I. Ribas<sup>4</sup>, A. Reiners<sup>5</sup>, A. Quirrenbach<sup>3</sup>, P. J. Amado<sup>2</sup> and the CARMENES Consortium<sup>1,2,3,4,5,6,7,8,9,10,11</sup> (<http://carmenes.caha.es/>)

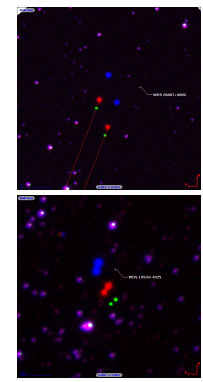
<sup>1</sup>Max-Planck-Institut für Astronomie • <sup>2</sup>Instituto de Astrofísica de Andalucía • <sup>3</sup>Landessternwarte Königstuhl • <sup>4</sup>Institut de Ciències de l'Espai • <sup>5</sup>Institut für Astrophysik Göttingen • <sup>6</sup>Instituto de Astrofísica de Canarias • <sup>7</sup>Thüringer Landessternwarte Tautenburg • <sup>8</sup>Universidad Complutense de Madrid • <sup>9</sup>Hamburger Sternwarte • <sup>10</sup>Centro de Astrobiología • <sup>11</sup>Centro Astronómico Hispano-Alemán – Calar Alto Observatory

With the help of CARMENCITA, the CARMENES Cool dwarf Information and daTA Archive, we investigate the multiplicity of M dwarfs in the solar neighbourhood observable from Calar Alto to prepare and characterize the final sample of stars of CARMENES. Our multiplicity study covers a wide range in projected physical separations, from 0.5 to 55000 AU. The inner range is covered with a lucky-imaging survey of 385 M dwarfs with FastCam at the 1.5 m Telescopio Carlos Sánchez (42.3 mas/pix), complemented with a literature search. We explore visual or physical companions from 0.15 to 18 arcsec around our targets. These observations are important to discard very close companions that may induce spurious variations in the radial velocity of the primary and mimic the presence of planets. The outer range is covered with a detailed analysis of Washington Double Stars catalogue data and optical images taken by us with TCP and CAMELOT at the 0.8 m IAC80 telescope, and an astrometric study of all-sky public images and catalogues. We review the main results of our searches and derive the multiplicity of M dwarfs at close and wide physical separations.



◀ **Lucky imaging with FastCam of close pairs.** We obtained *I*-band imaging of 385 mid to late M dwarfs on 19 nights since Oct 2011 to May 2014 (see four representative examples on the left). We took 10000 frames of 50 ms for each target. We aligned and combined all of them as well as the best 1, 10 and 50% raw frames using the brightest pixel.

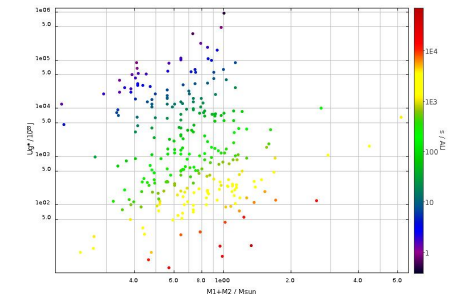
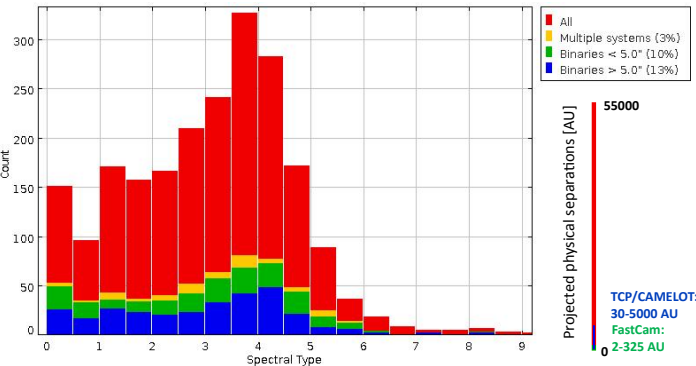
Around 69% of the targets were single, 21% had confirmed or probable physical companions in the range 0.15-17.70 arcsec and the remaining 10% had possible background sources or artifacts that needed extra analysis. We provide new astrometric epochs for over 70 pairs (of which two are discordant with published values) and discover eight new pairs. Twenty physical companion candidates (including three new) have estimated periods shorter than 10 years.



◀ **Imaging with TCP (and CAMELOT) of wide pairs.** We observed 54 pairs with at least one M dwarf during a semester in 2012.

After a comprehensive astrometric analysis, we confirm the physical binding of 52 pairs for which we provide projected physical separations, individual masses, reduced orbital periods and binding energies (Cortés-Contreras et al., subm.). The left panels show false-colour composite images of two high proper-motion pairs (blue: POSS-I ~1950, red: POSS-II ~1990, green: IAC80 ~2012). The bottom pair shows a clear relative movement, which is useful to track orbital variations.

**Spectral type distribution of close and wide binaries and multiple systems (>2) in CARMENCITA (2131 M dwarfs).** The total multiplicity fraction is 26%, in agreement with given values in similar works (Janson et al. 2012, 2014; Jódar et al. 2012). The coloured vertical bar to the far right indicates the projected physical separations coverage of the instruments used in this study and of the sample. ▶



▶ **Binding energy ( $-U_g$ ) vs. total mass** of a representative sample of CARMENCITA. There is a  $U_g$  threshold at  $-10^{33}$  J. Left colour bar indicates projected physical separations.