Ultra-cool dwarfs in wide binaries from *Gaia*

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Context Ultra-Cool dwarfs (UCDs, M7 and later types [1]) serve as a link between the lowest mass stars and the brown dwarfs. Yet they remain elusive due to their low brightness, and the modeling of their cold and complex atmosphere, and in particular the onset of dust formation, remains challenging. Improving our knowledge of binary systems including UCDs can bring constraints on their formation mechanisms. Systems with a higher mass and well characterized primary are benchmarks to constrain the atmospheric parameters and ages of the UCDs (e.g. [2]).

Method Gaia [3] offers the means to uncover nearby ultra-cool dwarfs through astrometric, rather than purely photometric, selection. Starting from a sample of 16 526 UCDs [4] selected from the clean colour-absolute magnitude diagram (Fig.1) offered by *Gaia* DR2 [5], we searched for companions from their common parallax, proper motion, position on the sky, with a limit on the projected separation of 100,000 AU, following criteria defined in [6]. We found 3,445 stars in multiple systems and used a Bayesian method [7] to remove by chance aligned pairs.

Results The resulting sample contains 1,714 stars in wide and ultra wide systems (Fig.2), most of them being unknown prior to *Gaia*. This yields to a multiciplity rate of 10.4%. This is smaller than the 26.8% rate found by [9] but from a M0-M9.5 sample. The sky separation suggests a resolution limit around 6″, which is higher than the 0.4″ spatial resolution of *Gaia* DR2, but not surprising for our sample dominated by faint stars. We used 190,000 objects with spectral type from a SIMBAD [8] query to define a spectral type calibration from the median absolute magnitude M_G, and used it to estimate the spectral types of the companions. The distribution of primaries and secondaries (and higher order multiplicity objects) is shown in Fig.3. We found 57 L dwarfs in multiple systems, and 48 white dwarfs in systems dominated by a separation lower than 10,000AU, as expected for older systems that are less likely to survive with large separation than younger systems. 4 UCDs lie in the Barnard 59 and Lupus 1 star forming regions (Fig. 4) where Young Stellar Objects are found as companions.

Future work We will confront our findings with recent similar searches [10,11] using *Gaia* EDR3 [12]. We started spectroscopic follow-up of these pairs to learn UCDs physical properties from the higher mass primary [13].

References
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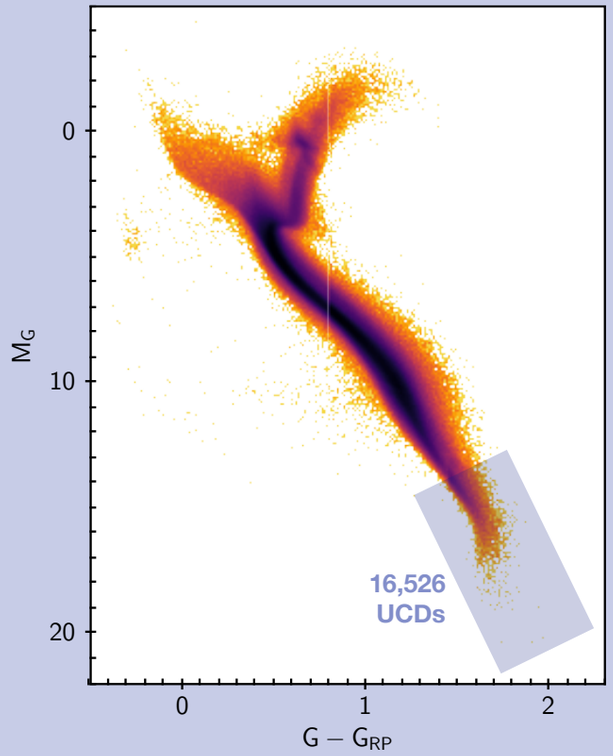

Fig.1 *Gaia* DR2 colour-absolute diagram of 3,716,407 stars with reliable astrometric and photometric solutions, avoiding Galactic regions with high extinction, and after removing stars showing color excess using G-J [4]. The UCDs are selected from their expected position on the diagram defined by a sample of spectroscopically characterized UCDs [6].

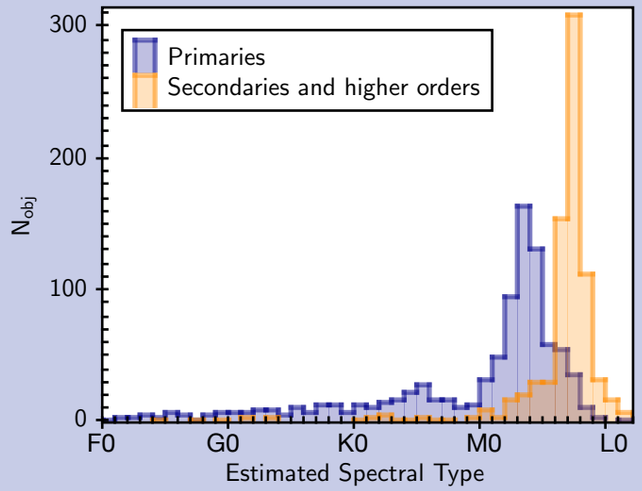

Fig.3 Distribution spectral type of the binary stars. The secondaries distribution peaks at M7 due to the selection of our starting UCDs sample. The primaries distribution peak around M3 since there are the most numerous stars in the Galaxy.

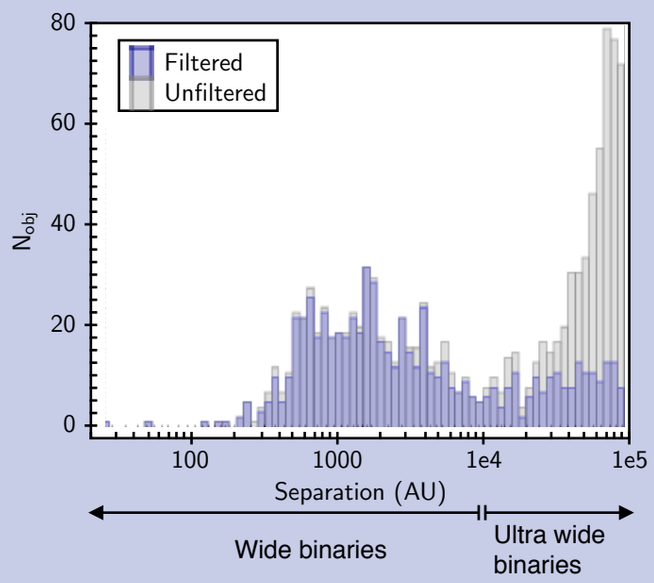

Fig.2 Distribution of logarithmic projected separation in AU before filtering binaries with Bayes probability less than 0.8 (grey) and after filtering (blue). The ultra wide binaries are dominated by chance aligned pairs.

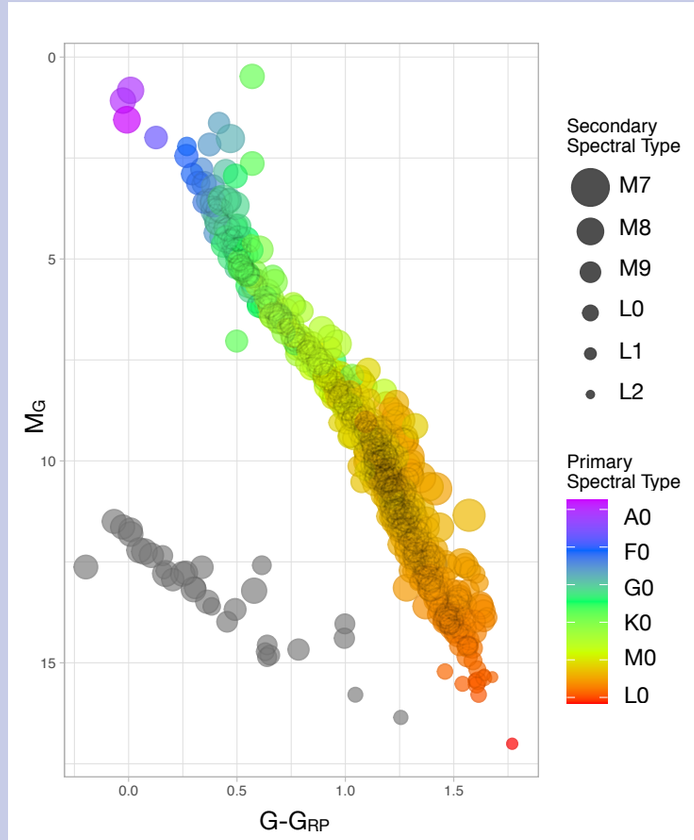

Fig.4 Colour-absolute magnitude diagram of the stars in systems. The colors indicate the primary spectral type (white dwarfs are in grey) and the size indicate the secondary spectral type. Young Stellar Objects lie on the right of the main sequence.