Wide companions to M and L subdwarfs with Gaia DR2 and the Virtual Observatory

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Context

- **Subdwarfs are population II dwarfs which appear bluer than solar metallicity stars due to the dearth of metals in their atmospheres**
- **There are different subclasses of subdwarfs based on the metallicity index: subdwarfs (sd), extreme subdwarfs (esd) and ultra subdwarfs (usd)**
- **The esdM and usdM are usually halo members, and sdM mostly are thick disk members. They belong to the first generations of stars, being important tracers of the chemical enrichment history of the Galaxy**
- **Ultracool subdwarfs have effective temperatures under 3100 K (spectral types later than M5)**
- **M dwarfs are prime targets for planet search with the radial velocity and transit methods, which take advantage of the relatively large planet-to-star mass and radius ratios, respectively**
- **It has been noticed a direct correlation between the metallicity of a star and the probability of having a planet orbiting around it. However, the estimation of M dwarfs metallicity is difficult**

Objectives

This work is motivated by the finding of high-mass physically bound companions to our M and L low metallicity sample which metal content is well determined.

1. **Search for wide companions to a sample of M and L subdwarfs**
2. **Determination of the rate of multiplicity of the elements of our sample**
3. **Comparison of the obtained multiplicity fraction with the value found in the literature for similar SpT and different metallicity content, and for different SpT and similar metallicity content**

Sample

The sample is composed of 219 spectroscopically confirmed M and L subdwarfs reported into the literature [1-6]:

- **185 sources: 100 from the SVO late-type subdwarf archive, plus another 85 [1-2]**
- **Additional 34 sources were taken from other works [3-6]**

It contains 170 M subdwarfs and 49 L subdwarfs, with different contents of metallicity including extreme subdwarfs and ultra subdwarfs.

Search procedure

1. **Proper motion and distance compilation from Gaia DR2, or computation from public astrometric catalogues and spectrophotometric relations.**
2. **Definition of the search radius (r) for each source using a minimum binding energy over the most massive possible companion (A0V):**

$$W = \mathrm{G}\frac{m_1 m_2}{r} = 10^{33}\mathrm{J}$$

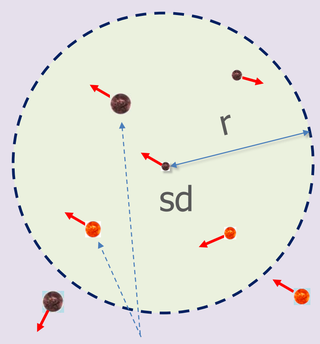
3. **Search for companion candidates applying proper motion and distance criteria:**

$$\mu\alpha_{sd} - 3\sigma_{\mu\alpha-sd} \leqslant \mu\alpha_{comp} \leqslant \mu\alpha_{sd} - 3\sigma_{\mu\alpha-sd}$$

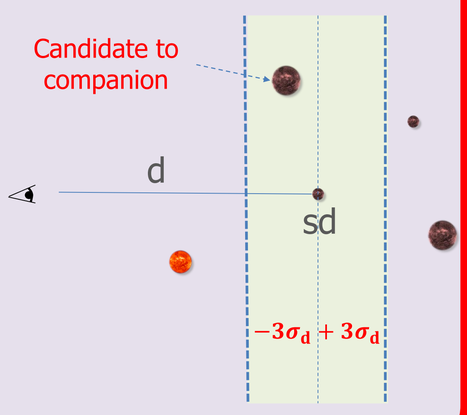
$$\mu\delta_{sd} - 3\sigma_{\mu\delta-sd} \leqslant \mu\delta_{comp} \leqslant \mu\delta_{sd} - 3\sigma_{\mu\delta-sd}$$

$$d_{sd} - 3\sigma_{\mathrm{d}-sd} \leqslant d_{comp} \leqslant d_{sd} - 3\sigma_{\mathrm{d}-sd}$$

Same proper motion inside an area of the sky:

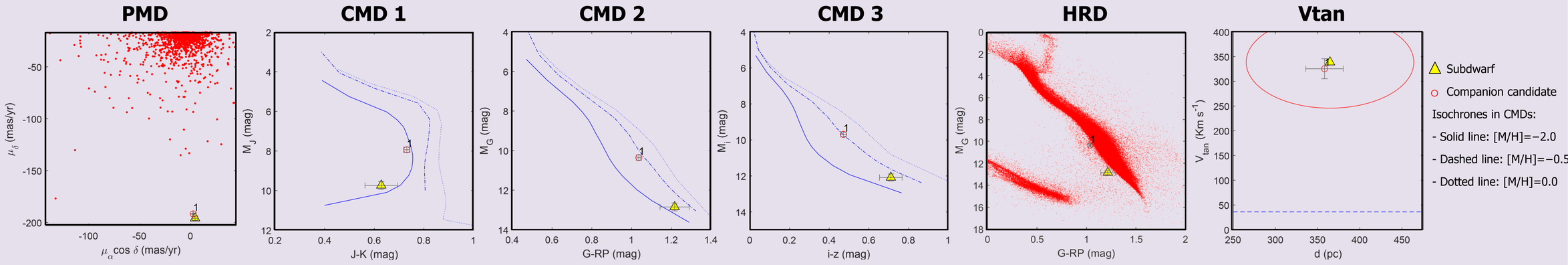


Same distance to observer:



Companion candidates analysis

- **Analysis of proper motion, colour-magnitude, Hertzprung-Russell and tangential velocity diagrams. Shown below one of the found pairs:**



- **SED analysis of the systems using VOSA [7] and the available literature**
- **Spectroscopic confirmation, if possible**

Found pairs

Found 6 possible pairs:

- **2 M-M pairs**
- **4 M-L pairs**

Type	SpT 1	SpT 2	Sep (pc)	Sep (')
M-M	sdM5.5	sdM1.5	0.007	0.063
M-M	dM4.5	dM1.5	2.64	15,9
M-L	sdM5.0	sdL0.0	0.69	13.4
M-L	esdM1.0	esdL0.0	0.08	1.9
M-L	sdM5.5	sdL0.0	0.62	10.9
M-L	sdM7.0	sdL5.0	0.16	8.9

Found M-M pair separated 0.007 pc, showing the different positions in 2003, 2010 and 2015

Results

- **Influence of metallicity on the multiplicity of ultracool dwarfs (>M5)**
- **Pioneer binary frequency estimate for L subdwarfs: 4 out of 49 L subdwarfs part of an M-L system**
- **Identification of benchmark binary systems at low masses and metallicities**
- **Binary fraction of 1.2% for M subdwarfs, much lower than solar metallicity M dwarfs (10–27% for SpT later than M5 and projected physical separations less than ~300 au [8,9], and lower than earlier type subdwarfs [10]**
- **Binarity fraction for M and L extreme subdwarfs of 1.6%, in agreement with the 2.5% found in other works [11]**
- **Not found any ultra-subdwarf as wide secondary, implying a multiplicity below 1% consistent with the 0.78% found into the literature [11]**

References

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