Characterization of SB1 detected in the Gaia-ESO Survey iDR5

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Abstract

Multiplicity among field and cluster stars is ubiquitous. This property is needed to explain entire classes of stars with photometric or chemical peculiarities (Ba stars, extrinsic S stars, blue stragglers, etc.). While we have efficiently detected multiple-component spectroscopic binaries[a] (~350 SB2, SB3 and SB4) in the Gaia-ESO Survey[b,c] (GES) iDR4 using a new method based on the successive derivatives of the Cross-Correlation Functions (CCFs), we now explore the GES iDR5 to search for SB1, i.e. **spectroscopic binaries using temporal variations of their single-lined CCFs**. Tracking variabilities in the GES time series of radial velocity (RV) measurements allows us to find ~700 new SB1s and characterize them using Gaia DR2 parallaxes and photometry[d].

1. Data

The GES is a spectroscopic survey complementing the Gaia mission to provide accurate RVs and chemical abundances for 10^5 stars. Almost 61 % of GES sources are observed with FLAMES/GIRAFFE using HR10 ([534–561] nm with R ~21500) and HR21 ([849–900] nm with R ~18000) setups.

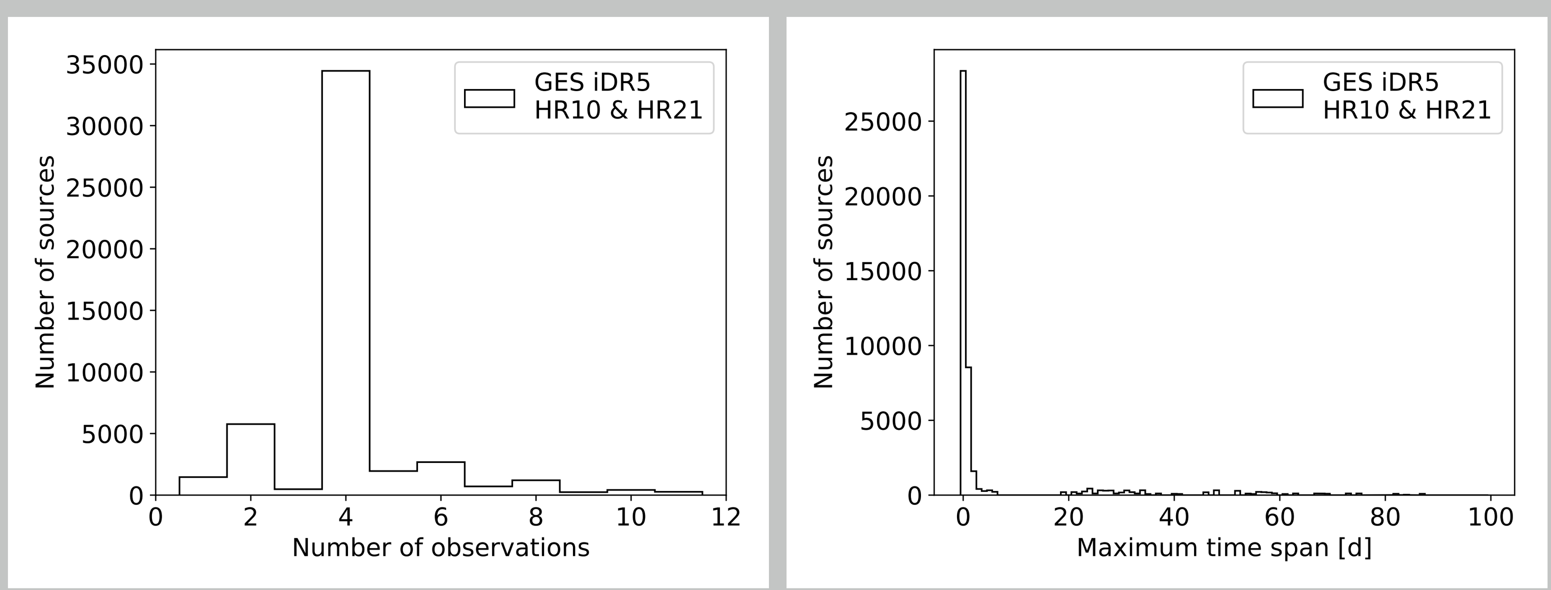

Figure 1: Left: number of observations (single exposures) per source within the GES iDR5. Even numbers are favoured because each source is observed both in HR10 and HR21. Right: distribution of the maximum time span per source.

Within the GES, **four observations per source** are the dominant mode: two exposures in HR10 and two in HR21 (left panel of Fig. 1). In total, more than 200000 exposures were analyzed corresponding to almost 50000 stars of the GES iDR5. The distribution of the maximum time span of observations per source is shown on the right panel of Fig. 1. Almost 80% of them cover less than one week **biasing the SB1 detection toward short period binaries**. In addition, we only consider exposures with S/N≥3.

2. Methods

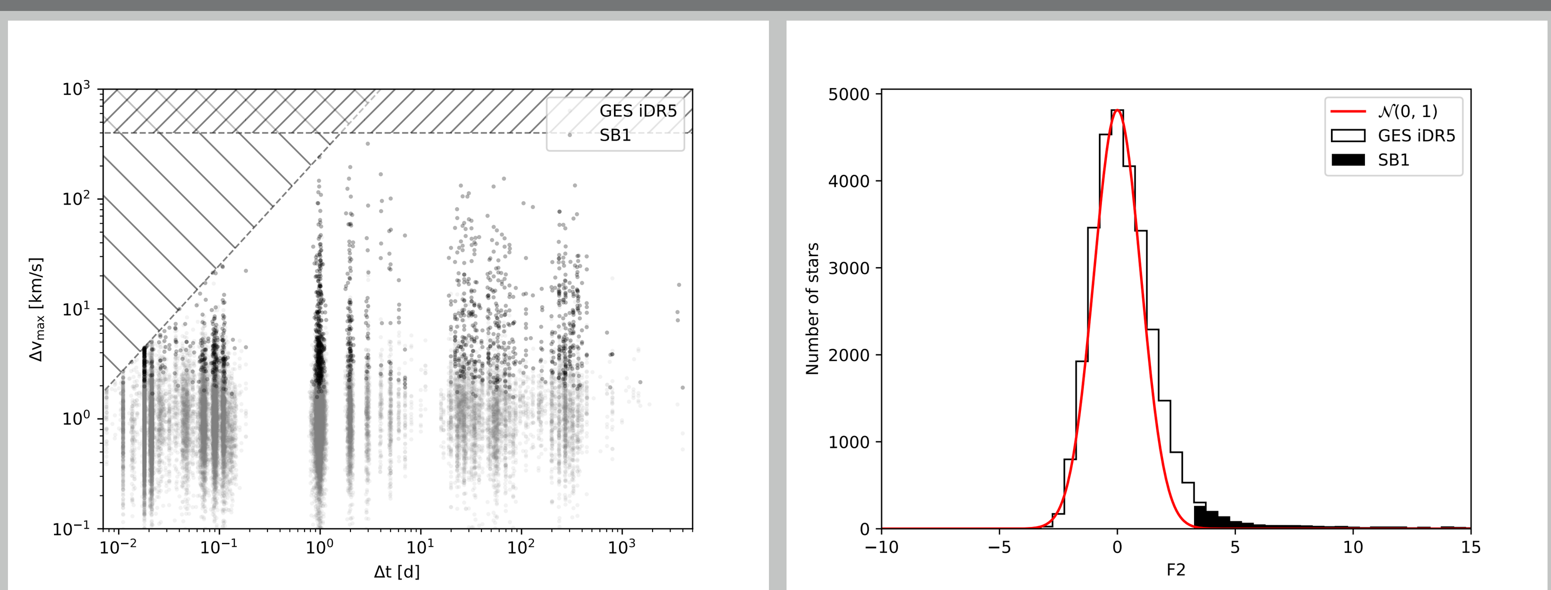

Figure 2: Left: the maximum RV differences as a function of their time separations. Right: F2 distribution of the RV uncertainties compared to the Normal distribution (red curve).

The method is based on the statistical analysis of the RV measurements performed on **recomputed CCFs with narrower peaks**[c]. For each source, we use a **statistical χ^2-test** to assess whether the RV dispersion is related to binarity effect. Precise estimation of the errors becomes crucial to this end. We exclude stars with RV variations not physical: $\Delta v_{\max} \geq 400$ km s^{-1} and $\Delta v_{\max}/\Delta t \geq 250$ km s^{-1}/d (left panel of Fig. 2). The **normality of the errors** are controlled by the statistical F2 distribution which should follow the Normal distribution for single stars. The right tail on right panel of Fig. 2 is the clear signature of the presence of SB1 in the sample. We choose a statistical criterion with a **confidence level of 99.9%** to select the sample of SB1 candidates (the black histogram).

3. Results

To unravel the possible **contamination by photometric variable stars**, we use the Gaia DR2 G-band photometry[d] to estimate the intrinsic photometric variability of the GES SB1 candidates. Fig. 3 shows the **intrinsic RV dispersion vs. G-band dispersion** for dwarfs and giants.

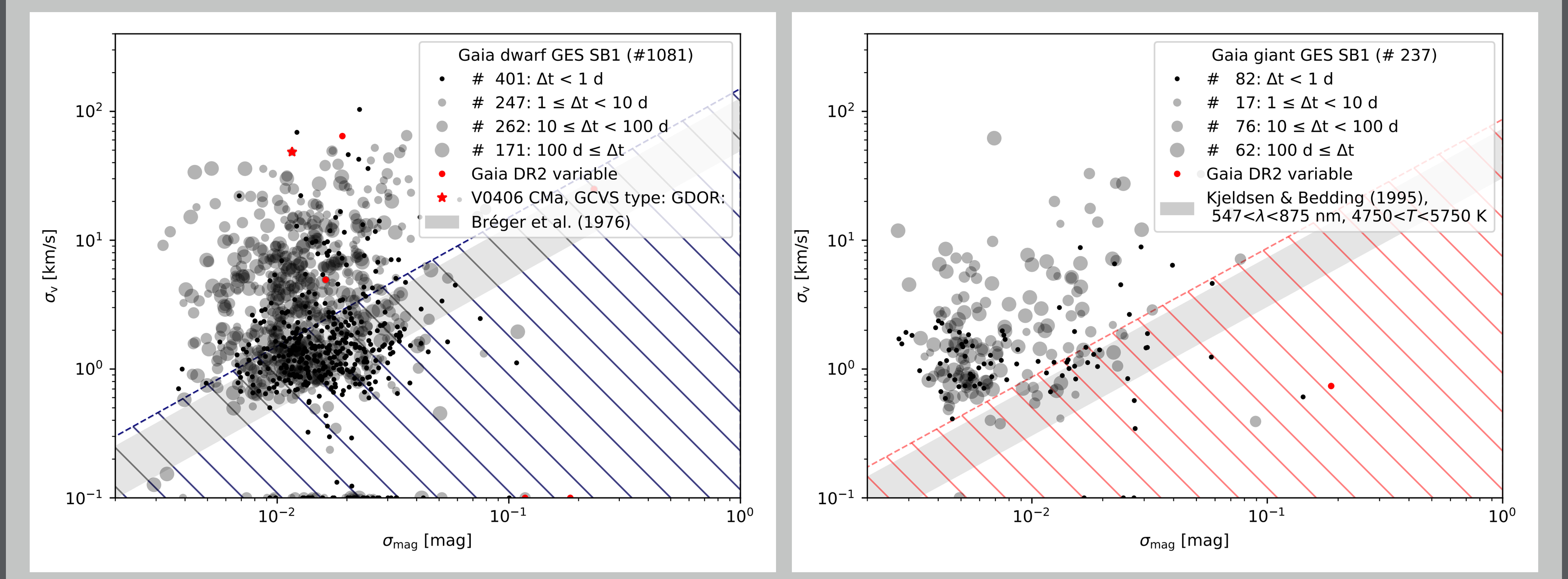

Figure 3: Intrinsic RV vs. G mag. dispersion for dwarf (left) and giant (right) SB1s.

Shaded areas[e,f] correspond to photometric variable dwarfs (as δ Sct stars) and giants. We excluded all the candidates that fall below the blue and red hatched areas. The cleaned sample decreases to **681 SB1s (490 dwarfs and 191 giants)**.

4. Characterization of the SB1s

Fig. 4 shows the color-magnitude diagram (CMD) of the GES iDR5 sources using the Gaia DR2 parallaxes, the G, BP, RP photometry, extinction and redenning (quality filters are applied).

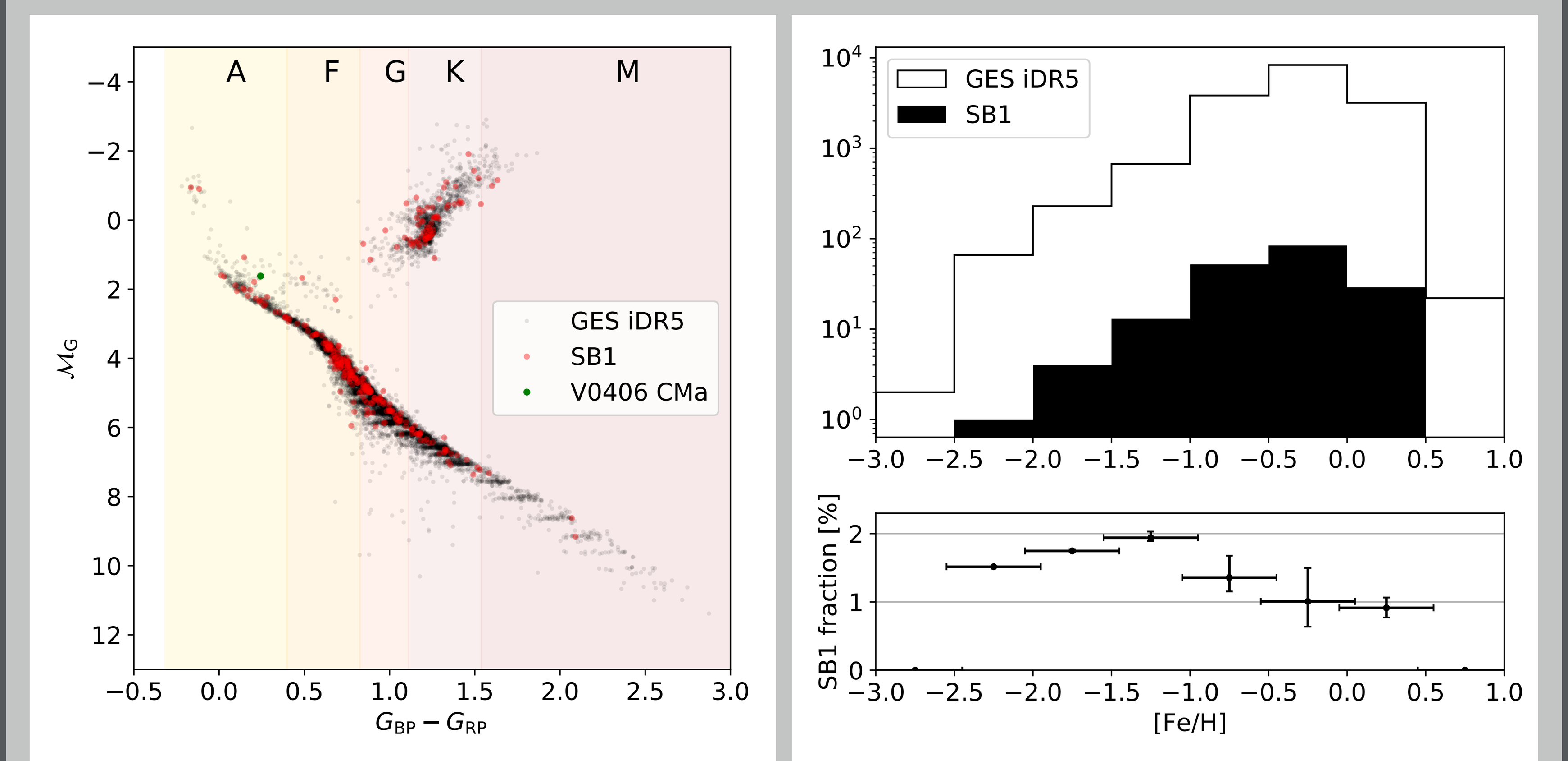

Figure 4: Left: CMD of the GES iDR5 sample using Gaia DR2. Only one SB1 (V0406 Cma) was previously known as a possible γ Dor in the General Catalogue of Variable Stars. Right: SB1 frequency as function of the GES recommended metallicity.

Using a linear fit of the Gaia $T_{\rm eff}$ to the BP-RP color index, we compute a preliminary SB1 frequency per spectral type. For the main sequence stars we find SB1 frequencies of 4.9%, 2.5%, 1.8% and 2.0% for A, F, G and K spectral types, respectively. On the red giant branch, we find SB1 frequencies of 4.6% and 4.4% for G and K giants. In addition we compute the SB1 frequencies as a function of the GES recommended metallicity which seems to decrease toward lower and higher metallicities.

Conclusions

The statistical analysis of the GES iDR5 allows us to identify almost 700 SB1s out of ~30000 stars, **an SB1 frequency of ~2%**. Most of them are new because of their faint visual magnitude. The G & K giant SB1s are more frequent than their main sequence analogs.

References

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