Rediscovering our Galaxy
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Stellar multiplicity in the Milky Way Galaxy

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Abstract. We present our models of the effect of binaries on high-resolution spectroscopic surveys. We want to determine how many binary stars will be observed, whether unresolved binaries will contaminate measurements of chemical abundances, and how we can use spectroscopic surveys to better constrain the population of binary stars in the Galaxy. Using a rapid binary-evolution algorithm that enables modelling of the most complex binary systems we generate a series of large binary populations in the Galactic disc and evaluate the results. As a first application we use our model to study the binary fraction in APOGEE giants. We find tentative evidence for a change in binary fraction with metallicity.

Keywords. general – surveys – methods: analytical – methods: statistical – binaries

1. Introduction

Stellar multiplicity leads to many interesting astrophysical phenomena, for example, gravitational wave sources, gamma-ray bursts, and type Ia supernovae. It is known that 34% ± 2% of solar-type (F6–K3) stars in the Solar Neighbourhood are in binaries (Raghavan *et al.* 2010), but the frequency of binary stars outside the Solar Neighbourhood is uncertain. For ongoing and up-coming large spectroscopic surveys, such as RAVE (Kunder *et al.* 2017), APOGEE (Majewski *et al.* 2015), *Gaia*-ESO (Gilmore *et al.* 2012), GALAH (De Silva *et al.* 2015), LAMOST (Deng *et al.* 2012) or 4MOST (de Jong *et al.* 2016) it is important to identify as well as quantify the binaries to clean the survey products from potentially faulty results.

2. The effect of binaries on high-resolution spectroscopic surveys

As an application we make mock APOGEE observations of red giants and subgiants. Our stars selection function mimics the selection function of APOGEE. We selected Galactic disc stars from APOGEE DR 12 where Galactic longitude: $24° \leqslant l \leqslant 240°$ and latitude: $|b| \leqslant 16°$; the signal-to-noise ratio of individual spectra $\geqslant 20$; the effective temperature: $3500 \leqslant \mathrm{Teff} \leqslant 5500$, [K] and $\log(g) \leqslant 4.0$, [cgs]; and stars that have been visited more than two times: Nvists > 2.

Binary and single star evolution is performed by the rapid binary-star evolution (BSE) algorithm (Hurley *et al.* 2002). We assume that the initially more massive stars in the binary have masses between $0.9\,\mathrm{M}_\odot \leqslant m_1 \leqslant 100\,\mathrm{M}_\odot$. We generate m_1 from the initial mass function of Kroupa *et al.* (1993). The mass of the companion is between $0.1\,\mathrm{M}_\odot \leqslant m_2 \leqslant 100$ and is drawn assuming the mass ratio distribution is flat in q, where $q = m_2/m_1 \leqslant 1$. Our next assumption is that our binary stars in the Galactic disc are in three metallicity bins [Fe/H]=($-0.3; 0.0; +0.17$) and have broad uniform age distribution from 0 to 10 Gyr. The distribution of binary periods, P, is log-normal with

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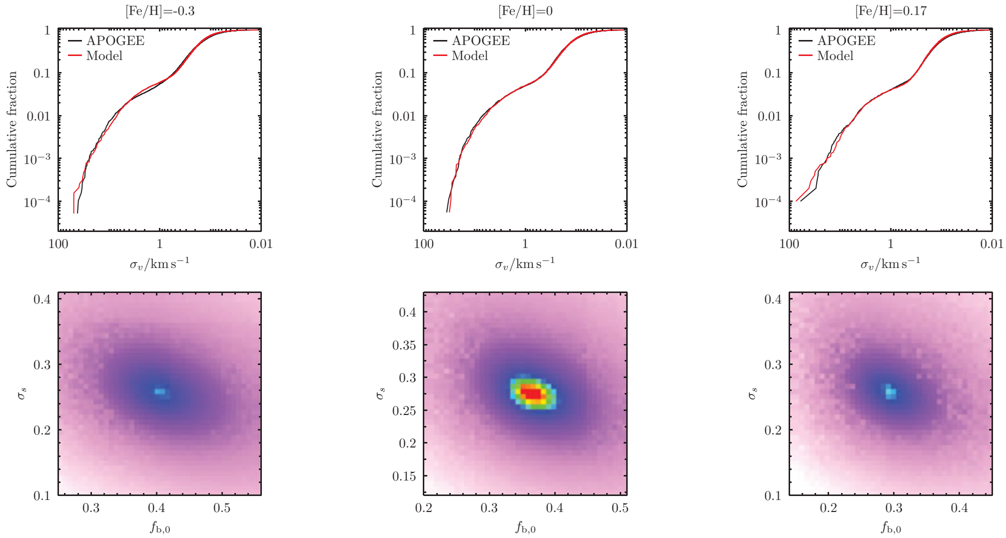

Figure 1. Top: the best fit cumulative distributions of the velocity dispersion of the simulated binaries (red line) and the observed velocity dispersion from APOGEE DR 12 (black line) in three metallicity bins [Fe/H]=($-0.3; 0.0; +0.17$). Bottom: initial binary fraction $f_{b,0}$ versus the nuisance parameter σ_s, that describes the intrinsic scatter of the APOGEE measurements.

$\overline{\log P} = 4.8$ and $\sigma_{\log P} = 2.3$, here the orbital period is in days. The distribution of the orbital eccentricity (e) is chosen to be dynamically relaxed (thermal) $f(e) \propto 2e$.

3. Results

In Fig. 1 the cumulative functions suggest that the model fits the observations well, which is consistent with most of the stars with high velocity scatter being binaries, and with the binary population being the same elsewhere in the Galaxy. The estimated initial binary fraction ($f_{b,0}$) for [Fe/H] = 0.0 is 36% which is consistent with Raghavan *et al.* (2010) for solar-type stars. There is evidence for $f_{b,0}$ decreasing with increasing [Fe/H] consistent with other studies (e.g. Yuan *et al.* 2015).

We intend to investigate to what extent we can constrain the frequency of binaries, and whether we can detect any systematic variation with metallicity in the Galaxy. The detailed results will be presented in Stonkutė, Church & Feltzing 2017 (in prep.).

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