The Gaia-ESO Survey: Extracting diffuse interstellar bands from cool star spectra DIB-based interstellar medium line-of-sight structures at the kpc scale

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Abstract

Aims We study how diffuse interstellar bands (DIBs) measured toward distance-distributed target stars can be used to locate dense interstellar (IS) clouds in the Galaxy and probe a line-of-sight (LOS) kinematical structure, a potentially useful tool when gaseous absorption lines are saturated or not available in the spectral range. Cool target stars are numerous enough for this purpose. Methods We devised automated DIB-fitting methods appropriate for cool star spectra and multiple IS components. The data were fitted with a combination of a synthetic stellar spectrum, a synthetic telluric transmission, and empirical DIB profiles. The initial number of DIB components and their radial velocity were guided by HI 21 cm emission spectra, or, when available in the spectral range, IS neutral sodium absorption lines. For NaI, radial velocities of NaI lines and DIBs were maintained linked during a global simultaneous fit. In parallel, stellar distances and extinctions were estimated self-consistently by means of a 2D Bayesian method from spectroscopically-derived stellar parameters and photometric data. Results We have analyzed Gaia-ESO Survey (GES) spectra of 225 stars that probe between ~2 and 10 kpc long LOS in five different regions of the Milky Way. The targets are the two CoRoT fields, two open clusters (NGC 4815 and γ Vel), and the Galactic bulge. Two OGLE fields toward the bulge observed before the GES are also included (205 target stars). Depending on the observed spectral intervals, we extracted one or more of the following DIBs: $\lambda\lambda$ 6283.8, 6613.6, and 8620.4. For each field, we compared the DIB strengths with the Bayesian distances and extinctions, and the DIB Doppler velocities with the HI emission spectra. Conclusions For all fields, the DIB strength and the target extinction are well correlated. For targets that are widely distributed in distance, marked steps in DIBs and extinction radial distance profiles match each other and broadly correspond to the expected locations of spiral arms. For all fields, the DIB velocity structure agrees with HI emission spectra, and all detected DIBs correspond to strong NaI lines. This illustrates how DIBs can be used to locate the Galactic interstellar gas and to study its kinematics at the kpc scale, as illustrated by Local and Perseus Arm DIBs that differ by > 30 km s-1, in agreement with HI emission spectra. On the other hand, if most targets are located beyond the main absorber, DIBs can trace the differential reddening within the field.

Keywords

ISM general, Dust extinction, ISM lines and bands, Galaxy general.