Solar photospheric spectrum microvariability. Theoretical and observational searches for proxies of radial-velocity jittering

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To understand the physical origins of radial-velocity jittering, stellar spectra are assembled, as far as possible, from basic principles. Solar surface convection is modeled with time-dependent 3D hydrodynamics, followed by the computation of complete stellar spectra, densely sampled in wavelength (lambda/delta-lambda about = 1,000,000), at numerous instances in time during the simulation sequences (e.g., A&A 649, A16; A17, 2021). Signatures of atmospheric dynamics and evolving surface granulation affect different classes of spectral lines to varying degree.

Throughout the visual range, groups of specific spectral lines (weak or strong, neutral or ionized, atomic or molecular) were selected and their changing profile shapes and wavelength shifts followed throughout the simulations. In response to granular evolution, radial velocities averaged over the small simulation areas jitter by about +-300 m/s, scaling to about +-2 m/s for the full solar disk. Most spectral lines vary in phase but with different amplitudes between lines of different strength. The relative radial-velocity excursions vary somewhat between ionization levels and change among different wavelength regions.

On the observational side, 1000 full spectra were retrieved from the HARPS-N archive of the Sun-as-as-star, and various spectral-line indices measured. Photometric parameters for the G-band, Mg I triplet, hyperfine-structure Mn I, Balmer lines, etc., augment the classical Ca II K line index toward a more comprehensive identification of photospheric and magnetic activity. Provided the spectrophotometric stability can be maintained on a sub-percent level, theoretically expected fluctuations in the strength of specific absorption lines might be used as proxies for simultaneous radial-velocity excursions.