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Structure, kinematics and time evolution of the Galactic Warp revealed by Classical Cepheids (online)

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The warp is a well-known undulation of the Milky Way disc. Its structure has been widely studied, but only since Gaia DR2 has it been possible to reveal its kinematic signature beyond the solar neighbourhood. In this work we will present an analysis of the warp's structure by means of a Fourier decomposition in vertical high (Z) and vertical velocity (V_z) traced by Cepheids. We find a clear but complex signal that in both variables reveals an asymmetrical warp. In Z we find the warp to be almost symmetric in amplitude at the disc's outskirts but with the two extremes never being diametrically opposed at any radius and the line of nodes presenting a twist in the direction of stellar rotation for $R > 11$ kpc. In V_z an $m = 2$ mode is needed to represent the kinematic signal of the warp, reflecting its azimuthal asymmetry. We also find that the line of maximum vertical velocity is similarly twisted but does not overlap with the line of nodes, it trails behind by ≈ 25 deg. We will show how the twisted line of maximum V_z creates "arches" in the mean V_z as a function of radii, a signature of global warp kinematics that has been observed with other tracers with less azimuthal coverage of the disc. Finally, a joint analysis of the Fourier decompositions in Z and V_z allows us to develop a new model-independent formalism to derive the pattern speed and change in amplitude of each mode at each radii. By applying it to our results for the Cepheids we find, for the $m = 1$ mode, a constant pattern speed in the direction of stellar rotation of 9.18 km/s/kpc, a constant amplitude up to $R \approx 14$ kpc and a slight increase in amplitude at larger radii, in agreement with previous works.

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