The Effect of Combined Magnetic Geometries on Thermally Driven Winds

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Abstract

Cool stars with outer convective envelopes are observed to have magnetic fields with a variety of geometries, which on large scales are dominated by a combination of the lowest order field modes such as dipole, quadrupole and octupole. Magnetised stellar wind outflows are primarily responsible for the loss of angular momentum from these objects during the main sequence. Previous works have shown the reduced effectiveness of the stellar wind braking mechanism with increasingly complex magnetic field geometries. The stellar magnetic field acts as a lever arm for the braking torque, which controls the angular momentum loss through the stellar wind. We quantify the impact of mixed field geometries on the spin-down torque with MHD simulations using the PLUTO code. Our 2.5D wind solutions range in magnetic field strength and reside in the slow-rotator regime. For Solar mass loss rates and field strengths, we argue that the stellar wind braking torque from combined geometry cases are generally described by the dipole component of the total field strength. We produce broken power law scalings to describe this behaviour for different field combinations. This behaviour is shown for dipole, quadrupole and octupole mixed field combinations.

Keywords: PLUTO, MHD, stellar wind, combined magnetic fields, outflows, cool stars, rotation, evolution

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