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On the preferential heating and acceleration of helium ions: Collisions versus wave effects

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We show statistical results on the relative flow speed and the temperature ratio of alpha particles and protons, and on their connections to the helium ion abundance, the collisional age, and the power of transverse waves having frequencies between 0.01 and 1.0 normalized to the proton gyrofrequency in the solar wind frame. It is found that the alpha-to-proton temperature ratio, T_α/T_p, anti-correlates with the helium ion abundance. Despite a relatively high collisional age and small wave power, the ratio T_α/T_p can reach comparatively high values (even above 2) whenever the helium ion abundance is below about 0.02. In contrast, the differential speed of alpha particles with respect to protons is correlated with the total wave power and anti-correlated with the collisional age. Ultimately, the individual heating of each ion species is positively correlated with the total wave power. Our findings suggest that strong collisions could be efficient in reducing the differential speed between alpha particles and protons, but appear not to be sufficient to equalize the alpha and proton temperatures, i.e., to make $T_\alpha = T_p$. This is a hint that the local wave heating process is acting on a timescale shorter than the collision time.