Polytropic behavior in the compressed solar wind

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The polytropic process in a thermodynamically closed system is a quasi-static change of state in which the specific heat is held constant (e.g., Ref. [1]). Pressure and mass density are related as $P \,/\, \rho^{\alpha} \;= constant$. Here, $\alpha = (c_p - c)/(c_v - c)$, c_p and c_v are the specific heats at constant pressure and volume, and $c = dQ/dT$, where Q is the heat and T is the temperature. α is then an indicator for the type of thermodynamic processes taking place within the closed system. For instance, $\alpha = 0$ for isobaric process (i.e., pressure remains constant), $\alpha = 1$ for isothermal process (i.e., temperature remains constant) and $\alpha = \gamma$ for the adiabatic process (i.e., entropy remains constant), where $\gamma = c_p/c_v$. For $\alpha > 1$, as the gas in the system expands or compresses, the temperature correspondingly decreases or increases. For $\alpha < \gamma$, heat must be supplied to the system for the plasma to expand. Recent results obtained by examining the polytropic process in the substructures of interplanetary coronal mass ejections (ICMEs; [2]) showed that the thermodynamics within ICME sheath regions take the longest time to recover towards the pre-ICME quasi-adiabatic state. On the other hand, the system recovers faster in the quieter ejecta region. The authors interpreted these results as due to enhanced turbulent rates in the sheath region which heats the plasma. Using the same spacecraft data (Wind SWE, [3]; Wind MFI, [4]), we expand their analysis to include compressions from stream interaction regions and corotating interaction regions. In particular, we investigate the polytropic behavior inside and around compression regions and compare with that found in ICME substructures.

References

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