The Polytropic Index of Interplanetary Coronal Mass Ejections and Stream Interaction Regions near L1

Christos Katsavrias[1], Georgios Nicolaou[2], Georgios Livadiotis[3], Angelos Vourlidas[4], Daniel Verscharen[2]

[1]National and Kapodistrian University of Athens, Athens, Greece, [2]Department of Space and Climate Physics, Mullard Space Science Laboratory, University College London, UK, [3]Princeton University, New Jersey, USA, [4]Johns Hopkins University, Applied Physics Laboratory, USA

A polytropic process describes the transition of a fluid from one state to another through a specific relationship between the fluid density and temperature, and the value of the polytropic index that governs this relationship determines the heat transfer and the eective degrees of freedom of this specific process. In this study, we investigate in depth (for the first time to such an extent) the behaviour of both the total and partial proton polytropic indices in ICMEs and SIRs. To that end, we used Wind measurements over more than two solar cycles (1995–2022), from which we derived the distributions of the polytropic index in the near-Earth space (L1) for 186 SIRs and 401 ICMEs. Our results show that sheaths and interaction regions are sub-adiabatic, indicating compression and turbulent heating. Furthermore, the polytropic behaviour of the protons inside the ICME magnetic obstacles is dependent on the magnetic field configuration, with flux ropes with rotation above 90 deg exhibiting sub-adiabatic, while ejecta with no clear rotation exhibiting super-adiabatic, supporting the scenario that changes during the interplanetary evolution might aect the magnetic field configuration inside the magnetic obstacle. Finally, high-speed streams exhibit a super-adiabatic polytropic behaviour, which is consistent with a decrease in the eective degrees of freedom and/or an additional energy release mechanism. We discuss the consistency of our findings with the fluctuating-moment eect in large-scale compressive fluctuations as such an energy release mechanism.