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Towards a physical and operational solar wind: Combining polytropic approximation and Alfvén waves

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The anticipation of eruptive events and their impact on Earth has become a top priority for space weather at an international scale.[1] But to do so, it is necessary to understand in detail the interplanetary medium in which these events propagate in order to estimate properly their time of arrival and strength. This is made difficult by the complexity of the heliosphere, modulated on short time scales by the solar wind accelerated by the hot solar corona[2], and on long time scales by the dynamo-generated magnetic field taking the form of the Parker spiral[3] and depending on the phase of the 11-year solar cycle[4].

The question of the modelling of the coronal heating is thus extremely crucial. Most solar wind MHD models oscillate between simple approximations such as polytropic heating[5], which yield fast but simplistic results, and detailed heating models coupling Alfvén waves, radiations and thermal conduction[6], which yield realistic but slow solutions[7]. We suggest a middle-ground with a model that uses both polytropic and Alfvén waves heating in order to reproduce the bimodal distribution of the solar wind. We will present a parametric study on a simple dipole case to explain the interaction between these two heating terms, before presenting more realistic cases in 2.5D and 3D applied to real solar configurations. Finally, we will compare these results with more traditional approaches, such as only polytropic or Alfvén waves, or semi-empirical WSA-like models.[8]

References

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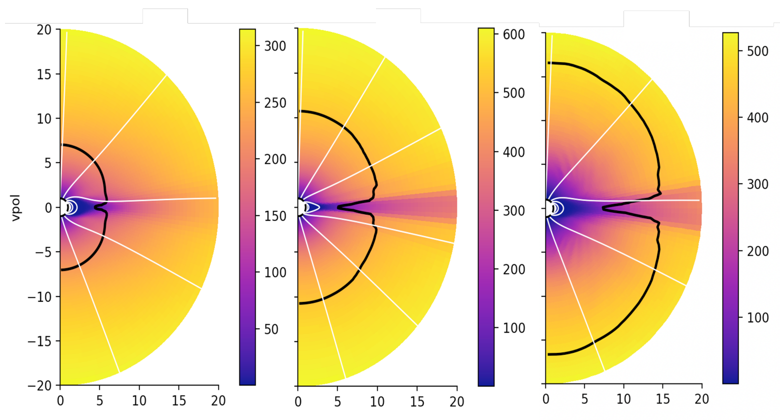

Figure 1. Comparison of three models for the coronal heating in 2.5D for a dipolar magnetic field, and the resulting solar wind. In color we show the poloidal speed of the wind in km/s, in white the magnetic field lines and in black the Alfvén surface. The left panel shows the polytropic solution, the middle panel the Alfvén waves + thermal conduction solution, and the right panel the polytropic + Alfvén waves solution.

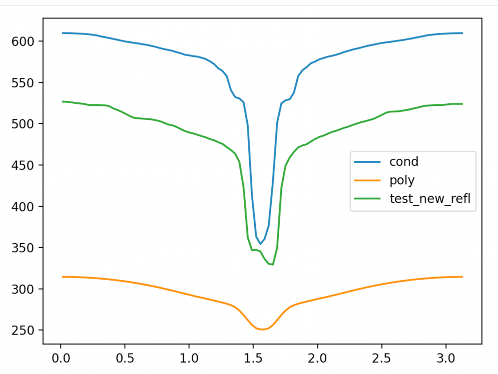

Figure 2. Comparison of three models of coronal heating at 20 solar radii. The orange line shows the polytropic solution, the blue line the Alfvén waves + thermal conduction solution, and the green line the polytropic + Alfvén waves solution.