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Characterising MHD waves produced by bursty reconnection in the solar atmosphere

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Magnetic reconnection is a fundamental astrophysical process: it plays a key role in the dynamics of the Sun's atmosphere and planetary magnetospheres, as well as other astrophysical objects. It facilitates the rapid conversion of stored magnetic energy into other forms such as kinetic and thermal energy. This drives phenomena such as flares, eruptions and jets in the Sun, stars, and beyond, as well as contributing to coronal heating. In astrophysical plasma regimes the reconnection process is often dynamic and "bursty", mediated by current sheet instabilities and occurring in a fragmented volume. The paths for energy conversion in such a dynamic reconnection process remain to be understood. One component of the outgoing energy flux is carried by (MHD) waves, which are naturally produced as part of time-dependent reconnection. We demonstrate this using the results of 3D MHD simulations [1,2].

Characterising the wave modes present in an evolving 3D MHD simulation is a challenging endeavour. To this end we introduce a new method for exact decomposition of propagating, nonlinear magnetohydrodynamic (MHD) disturbances into their component eigenenergies associated with the familiar slow, Alfvén, and fast wave eigenmodes [3]. First, the mathematical formalism is introduced, where it is illustrated how the ideal-MHD eigensystem can be used to construct a decomposition of the time variation of the total energy density into contributions from the eigenmodes. The decomposition method is then demonstrated by applying it to the output of three separate nonlinear MHD simulations. The analysis of the simulations confirms that the component wave modes of a composite wavefield are uniquely identified by the method. The slow, Alfvén, and fast energy densities are shown to evolve in exactly the way expected from comparison with known linear solutions and nonlinear properties, including processes such as mode conversion. We will discuss the future use of the method for understanding the wave modes produced in dynamic, 3D MHD simulations, including those involving bursty magnetic reconnection processes.

References

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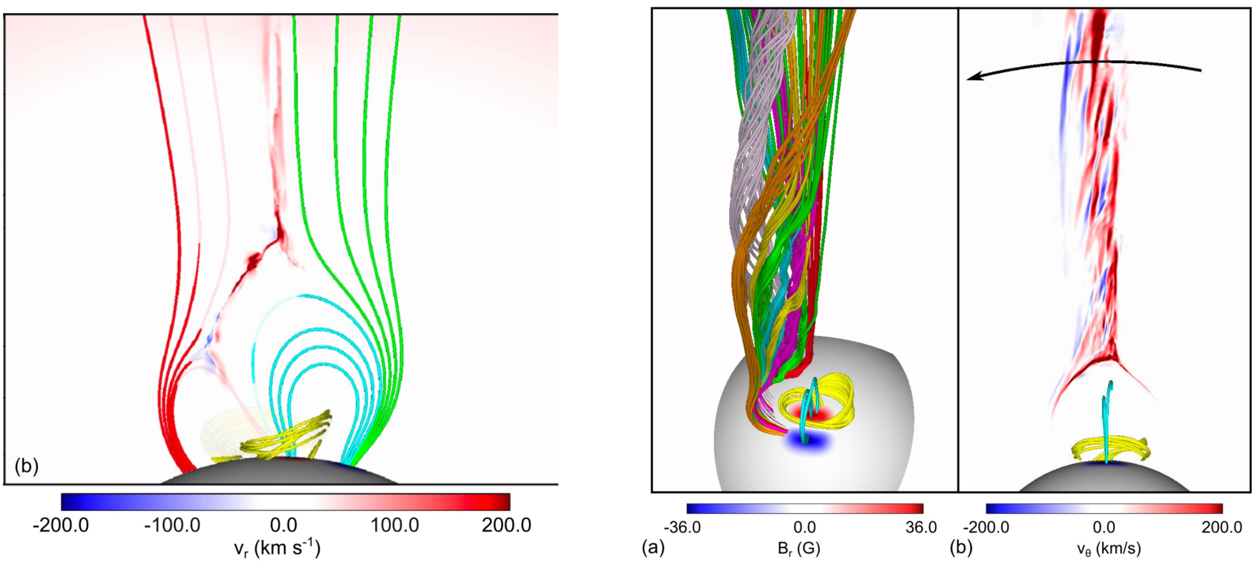

Figure 1. Dynamic MHD simulations of bursty magnetic reconnection in the solar corona, producing propagating wave trains (right), from [2].