Mesoscale Structure of an Interplanetary Shock near 1 au: A Multi-spacecraft Case Study of the 04 February 2026 Shock

Manuel Cuesta[1], D. Turner[2], S. Raptis[2], T. Horbury[3], J. S. Rankin[1], D. J. McComas[1], C. M. S. Cohen[4], E. Christian[5], N. Schwadron[6], M. Gkioulidou[2], M. Finalyson[3], H. A. Farooki[1], L. Y. Khoo[1], B. Shrestha[1], R. Jain[1], N. Walia[1], S. Pak[1], S. Kasapis[1], M. M. Shen[1], G. Livadiotis[1], J. R. Szalay[1], Z. Xu[4], G. D. Muro[4], J. G. Mitchell[5], N. Subashchandar[7], L. L. Zhao[7], M. A. Dayeh[8], M. I. Desai[8]

[1]Princeton University, United States, [2]Johns Hopkins University Applied Physics Laboratory, United States, [3]Imperial College in London, United Kingdom, [4]California Institute of Technology, United States, [5]NASA Goddard Space Flight Center, United States, [6]University of New Hampshire, United States, [7]University of Alabama in Huntsville, United States, [8]Southwest Research Institute, United States

Interplanetary shocks play a fundamental role in heliospheric plasma dynamics, particle acceleration, and plasma heating; they also strongly influence the geoeffectiveness of space weather events. In this work, we present an automatic shock detection algorithm designed to operate based on in situ solar wind plasma moments and magnetic field measurements provided by the SWAPI and MAG instruments on board the Interstellar Mapping and Acceleration Probe (IMAP) mission. The algorithm combines physically motivated thresholds on plasma magnetic field discontinuities with adjustable criteria on the level of discontinuity and windowing, such as the upstream and downstream duration. This enables robust shock identification across a wide range of solar wind types and physical scales. As a result, we will generate, update, and maintain a publicly available living catalog of IP shocks that will include common shock parameters, such as compression ratios, speed, and geometry. We plan to use this living catalog throughout the IMAP mission to support future scientific discoveries.

Based on this algorithm, we detect a shock observed by IMAP and other Lagrange-1 spacecraft on 04 February 2026 and estimate the shock's local geometry at each spacecraft. We also estimate the diffusion coefficient by combining second-order quasi-linear theory and unified non-linear transport theory to quantify the diffusion parallel and perpendicular to the magnetic field, respectively (see Subashchandar et al. 2025). When combined with the estimated direction of the shock's normal, via several methods including magnetic coplanarity (Colburn Sonett 1966), minimum variance analysis (Sonnerup Cahill Jr. 1967), and multi-spacecraft timing (Russel et al. 1983), we can compare the effective diffusion along the local shock's normal computed locally at each spacecraft. From these results, we discuss whether the mesoscale structure of the shock can be inferred or if the variations can be explained by inaccurate estimations of the shock's geometry.

References:

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