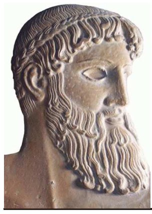
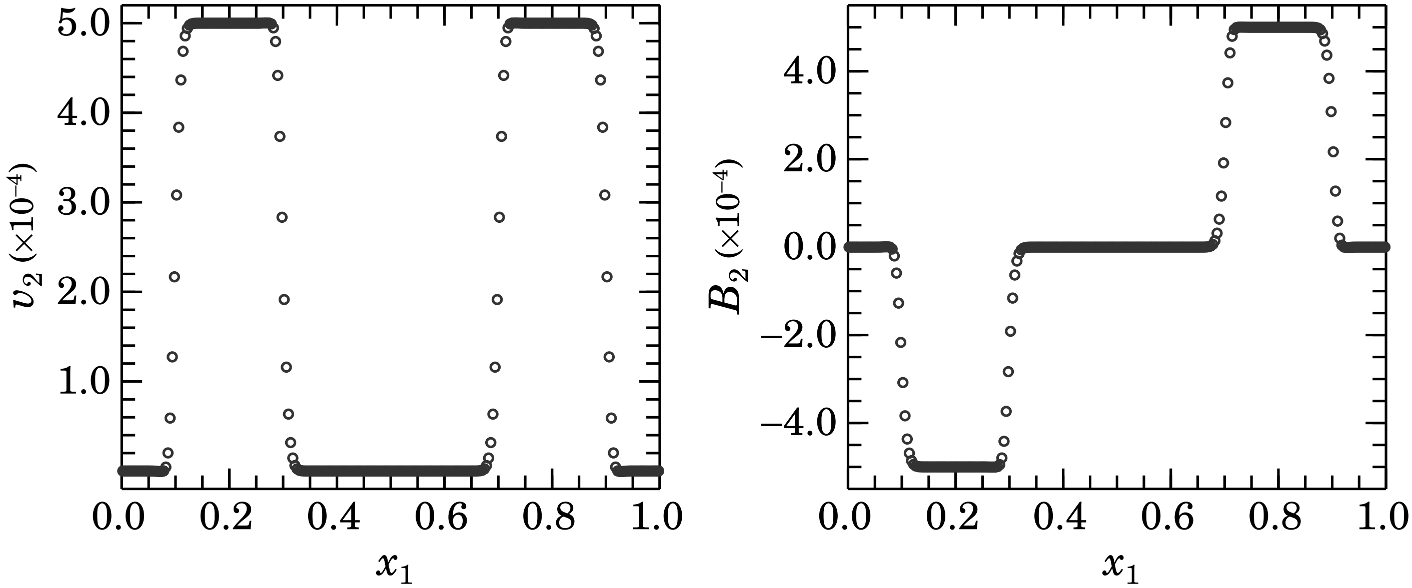


ZEUS-3D 1-D Gallery #7: 1-D Alfvén Waves with Periodic Boundary Conditions



The *Method of Characteristics* (`MoC`; Stone & Norman, 1992, Ap. J. S., 80, 791) was among the first—if not the first—MHD algorithms known to propagate shear Alfvén waves stably. `CMoC` (*Consistent* `MoC`; Clarke, 1996, ApJ, 457, 291) is built upon `MoC`, and inherits this stability.

A 1-D Cartesian grid ($0 \le x_1 \le 1$) resolved with 250 zones is initialised with $\rho = 1$, $c_{\rm s} = 1$, $B_1 = 1$ (and thus $a_{\rm Alf} = 1$), and all other variables zero. A weak square pulse in v_2 and v_3 with amplitude 0.001 is set in the inner 50 zones ($0.4 \le x_1 \le 0.6$), and the ensuing shear Alfvén waves are allowed to propagate in both directions. Periodic boundary conditions are used, and the pulses move off and then back onto the grid to the locations shown. Thus, the centroids of the pulses propagate a distance $\Delta x_1 = 0.7$.

Open circles are the `dzeus36` solution using `CMoC` and second-order interpolation. Propagation of Alfvén waves in 1-D is CFL limited (see the footnote on the 2-D advection page for an explanation of "CFL limited"), with a maximum `courno` of $\sqrt{c_{\rm s}^2 + a_{\rm Alf}^2} = \sqrt{2}$ allowed. In these panels, `courno=1.0`. Values for v_3 and B_3 (not shown) are identical to v_2 and B_2 respectively to machine round-off error. Further, a grid set wide enough (*e.g.*, $-0.5 \le x_1 \le 1.5$) so that the periodic boundary conditions are not engaged give identical pulses as those shown to machine round-off error.

Solutions from versions 3.5 and 3.6 are identical. This test was not among those included in the Version 3.5 website Gallery.