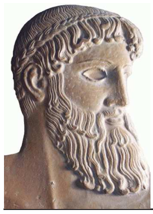
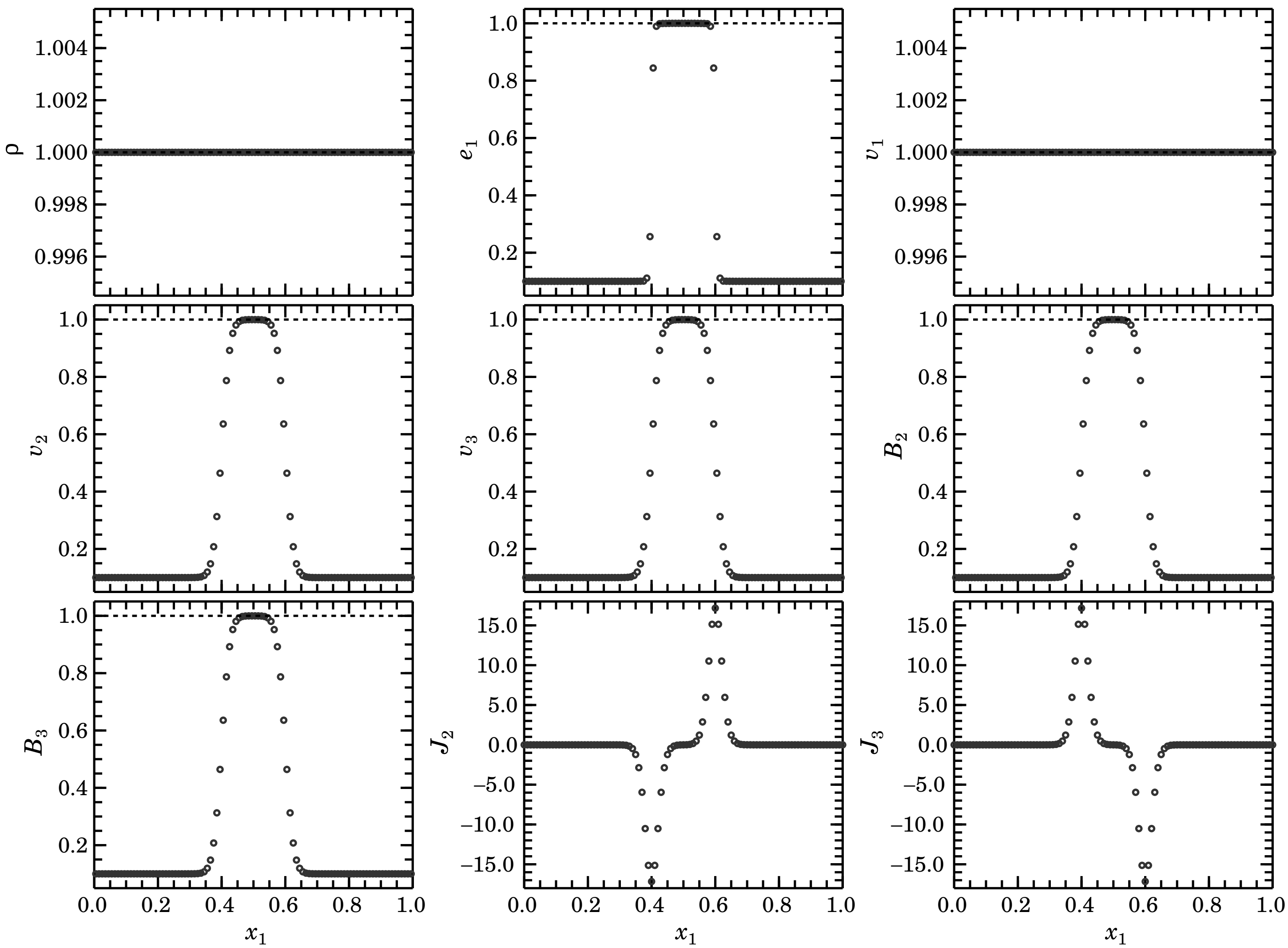


ZEUS-3D 1-D Gallery #1: Advection in Cartesian Coordinates



Advection problems are the first tests to which new (M)HD codes are exposed, and being able to do advection problems to the CFL limit is a necessary but by no means sufficient condition for all explicit fluid codes. Advection is a simplified form of the full (M)HD equations whereby all source terms (*e.g.*, ∇p, PdV cooling, *etc.*) are set to zero and the velocity along the direction of propagation is held constant.

In this test, a square wave in each of e_1, v_2, v_3, B_2, and B_3 is passed through a Cartesian grid once using periodic boundary conditions. The pulses start at the centre of the grid and end up back at the centre, as shown. Issues to be concerned with include monotonicity, conservation (area under pulse should be constant to machine round-off), and diffusion of discontinuities.

Open circles are the `dzeus36` solution using 100 zones, `CMoC`, `FIT`, no artificial viscosity, and `courno=0.5`. Third-order interpolation (`iords=3`) with discontinuity steepening (`istp=1`) is used for the scalars (e_1), and second order van Leer interpolation (`iord=2`) is used for the vector components, which is the highest order of interpolation compatible with `CMoC`. The dashed lines are the initial levels of the pulses.

Transverse components of the current density (J_2 and J_3) are included to illustrate how the first derivative of the magnetic field behaves across the jumps. That they are monotonic and symmetric is a testimony of Constrained Transport (`CT`; Evans & Hawley, 1988, Ap. J., 332, 659) which underpins `CMOC`.

All versions of *ZEUS* since `zeus04` have passed this test satisfactorily.