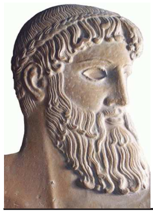
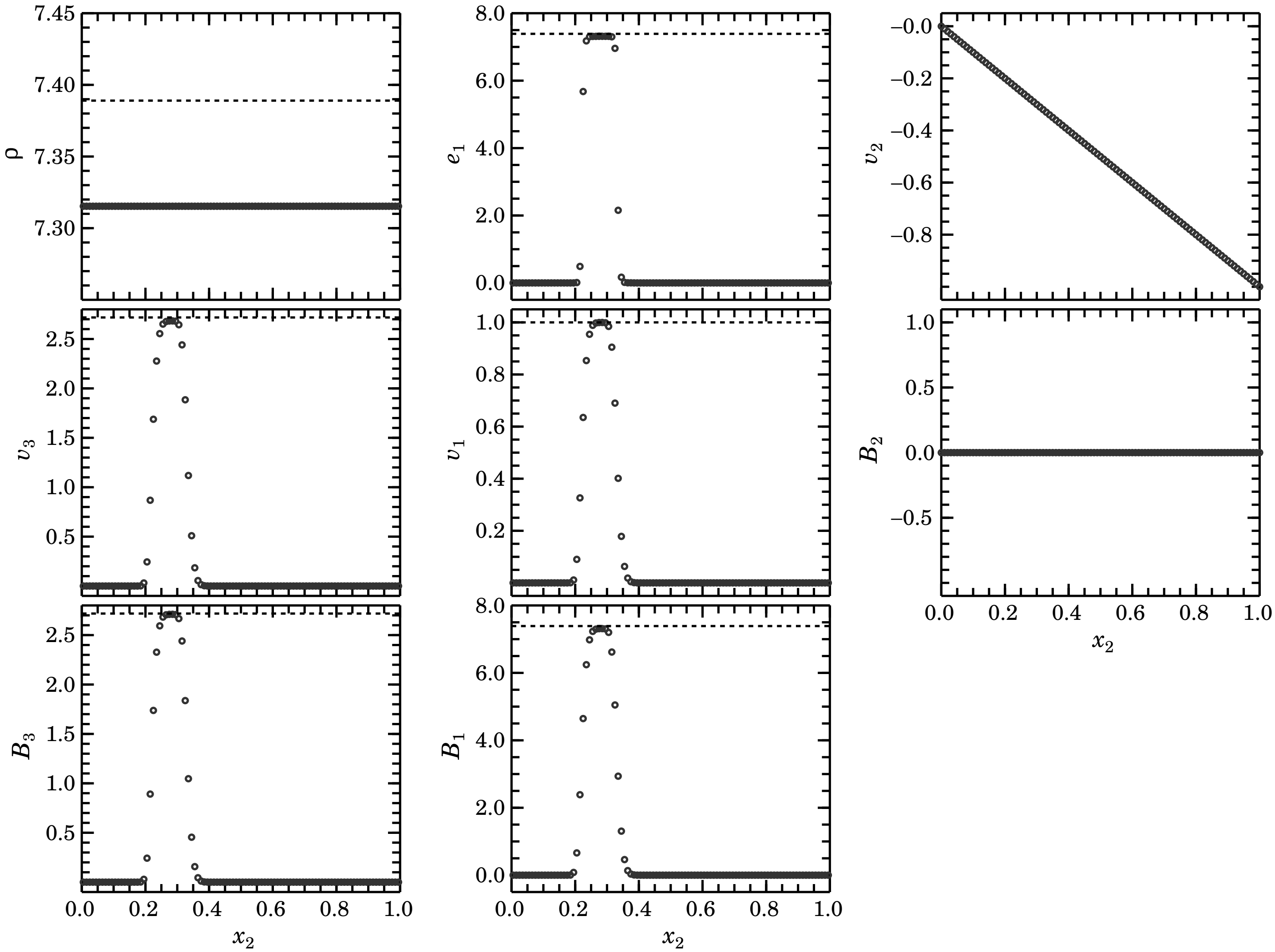


ZEUS-3D 1-D Gallery #2: Advection in Cylindrical Coordinates



This is an advection problem[1] in cylindrical coordinates, where a square wave in each of e_1, v_3, v_1, B_3, and B_1 of amplitude 1 is initialised in $0.6 \le x_2 \le 0.9$ and allowed to migrate on a 1-D (radial) grid toward $r = x_2 = 0$ with an imposed velocity profile $v_2 = -x_2$. Density also evolves but as a uniform background quantity rather than a pulse which would interfere with the advection of velocity waves. Analytical expectations are ρ, e_1, $B_1 \sim e^{2t}$, v_3, $B_3 \sim e^t$, and $v_1 \sim$ constant, with pulse widths narrowing as e^{-t}. Issues to be concerned with include monotonicity, widths and levels of pulses, 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`. Dashed lines are the expected levels of the pulses at $t = 1$. Disagreement between numerical and analytical solution is most apparent on the density plot (note ordinate scale), and is due to second-order temporal discretisation errors which are most apparent in advection problems. The origin of these errors is discussed on the page for advection in spherical polar coordinates.

These solutions are virtually identical to those from all versions of *ZEUS* since `zeus04`.

[1] See the webpage for Cartesian advection for a working definition of *advection*.