

1 Overview

Magnetic reconnection is believed to be a likely cause of energy release to the corona, including phenomena such as spicules, flares, and coronal mass ejections (CMEs). Reconnection occurs when two open field lines separated by a current sheet cross. Post-reconnection, the flux tubes shorten at the Alfvén speed [3]. The dynamics of this retraction are governed by equations of thin flux tubes ([1] and [2]). In particular, the equation of motion is:

$$\rho \frac{d\vec{v}}{dt} = -\hat{\mathbf{b}} \frac{\partial p}{\partial l} + \frac{B^2}{4\pi} \frac{\partial \hat{\mathbf{b}}}{\partial l} - \frac{1}{4\pi} \nabla_{\perp} B^2 + B \frac{\partial}{\partial l} \left(\frac{\mu}{B} \hat{\mathbf{b}} \hat{\mathbf{b}} \cdot \frac{\partial \vec{v}}{\partial l} \right) \quad (1)$$

We solve these equations using a Lagrangian numerical method (PREFT, written by Dana Longcope). Initial conditions are chosen to represent a low-lying flux tube with high density, and a large, low-density coronal flux tube. This introduces additional shocks. We then investigate the dependence of solutions upon different combinations of angles and densities.

2 Methods

Initially, we create a numerical model of a flux tube immediately post-reconnection with a dense lower portion and a less-dense vertical portion. Below is a sample run with the angle set to 60° and the lower tube twice as dense as the vertical.

Figure 1: Spatial progression of the flux tube from time = 0.0 to 0.725 seconds. (arrows indicate velocity)

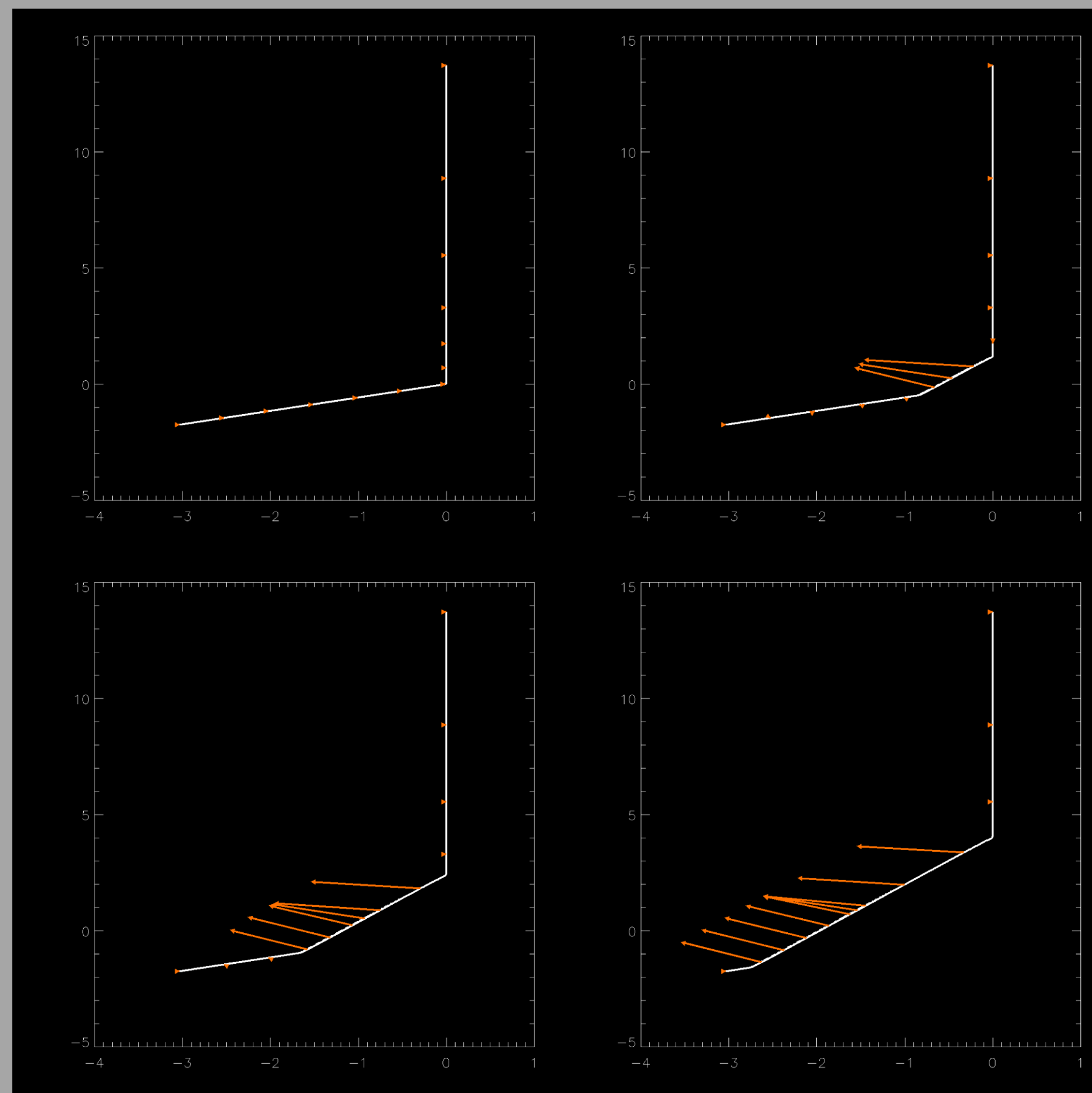
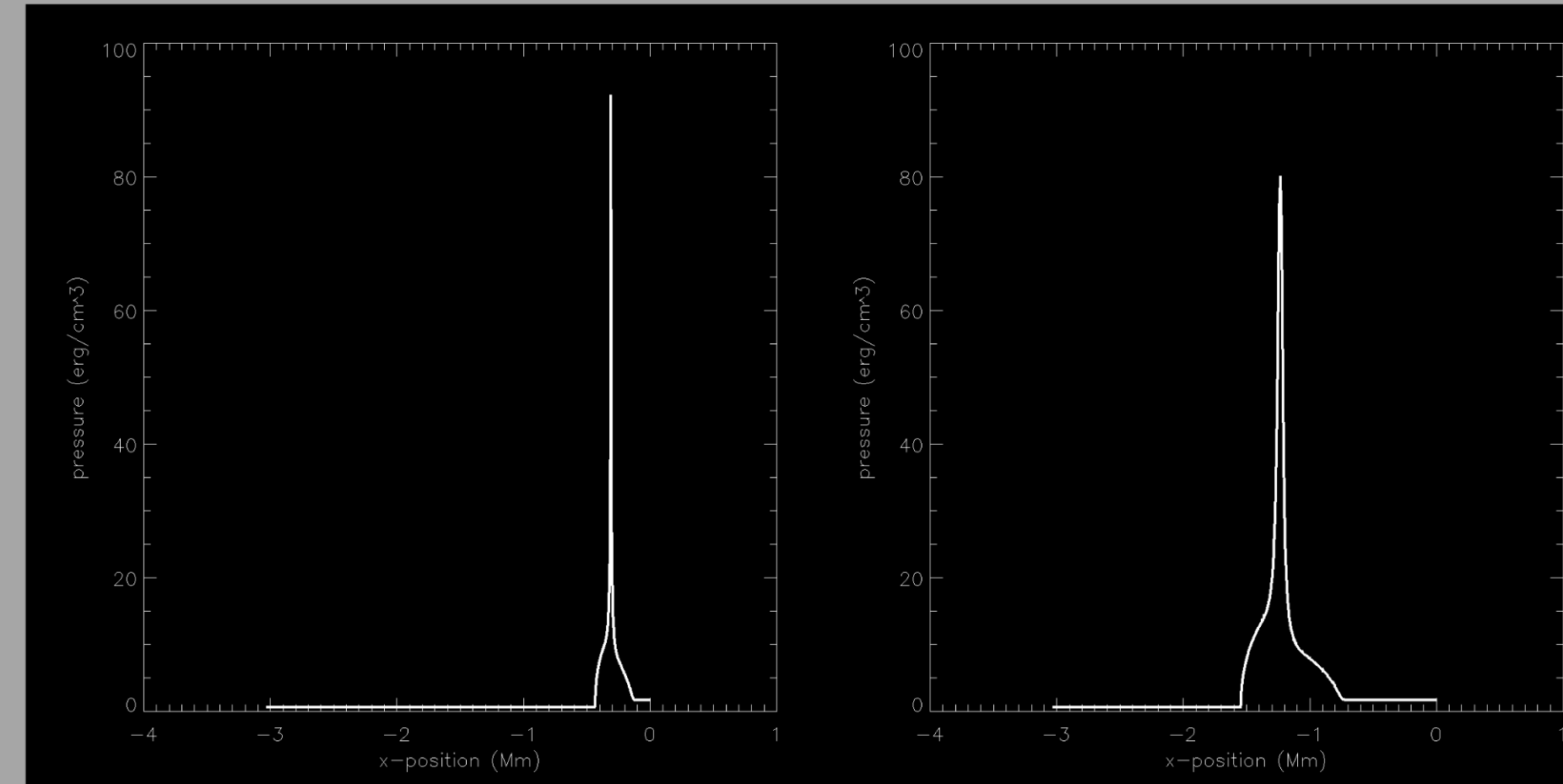


Figure 2: Progression of pressure from time = 0.0 to 0.725 seconds. Temperature and density behave similarly.



3 Parameter Analysis

We ran the code as above for a wide array of different angles and density ratios. We then analysed those results for the location of the maximum velocity and temperature, looking for combinations of parameters that produced results matching known conditions in the sun's corona.

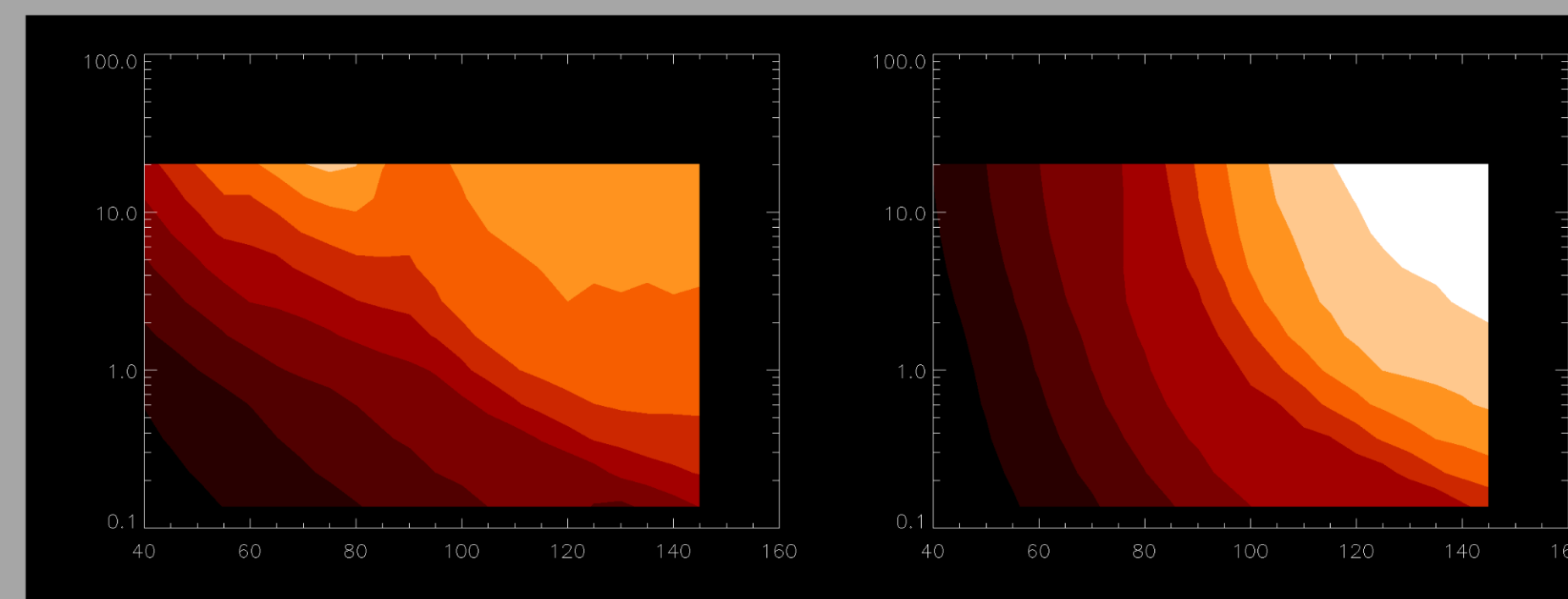


Figure 3: Maximum $|\vec{v}|$ and v_z .

The maximum velocities are on the order of 6 Mm/sec and the maximum temperatures are near 100 MK. Typical observed values for the temperature of plasma in flares are around 15 MK and up to 50 MK for super-hot looptop sources [2]. Our model therefore suggests, though not conclusively, that such reconnections could account for temperatures in this range.

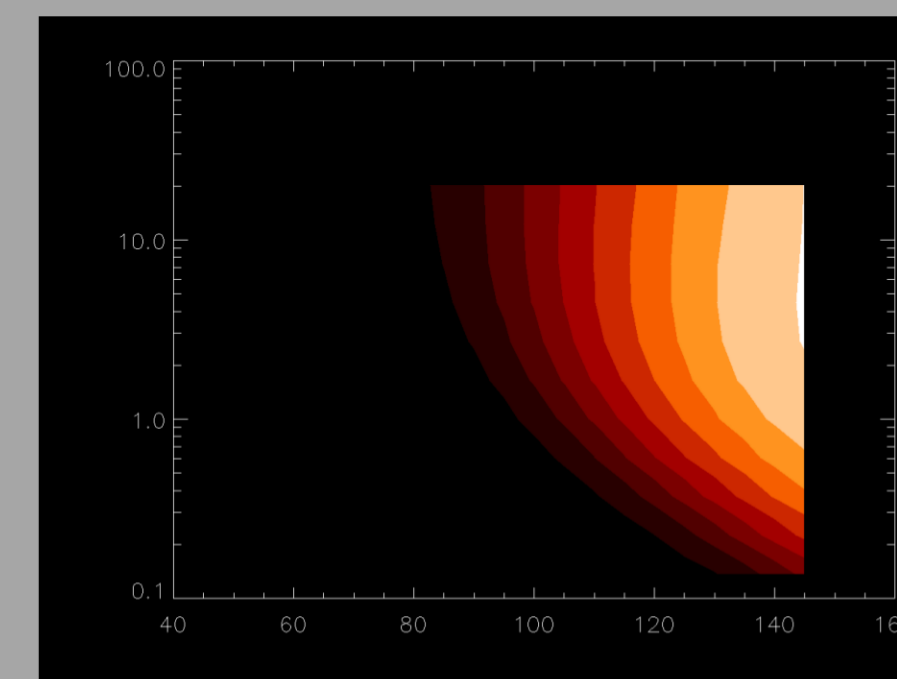


Figure 4: Maximum temperature

4 Analytic Solution

From the above results, we attempted an approximate closed-form solution to the problem. We divided the tube into five pieces and assumed that shocks would occur at the second and fourth. This solution performed well with regard to the velocity parameter, but because it does not take into account thermal conduction, has some discrepancies with other variables.

Figure 5: Comparison of analytic velocity and density.

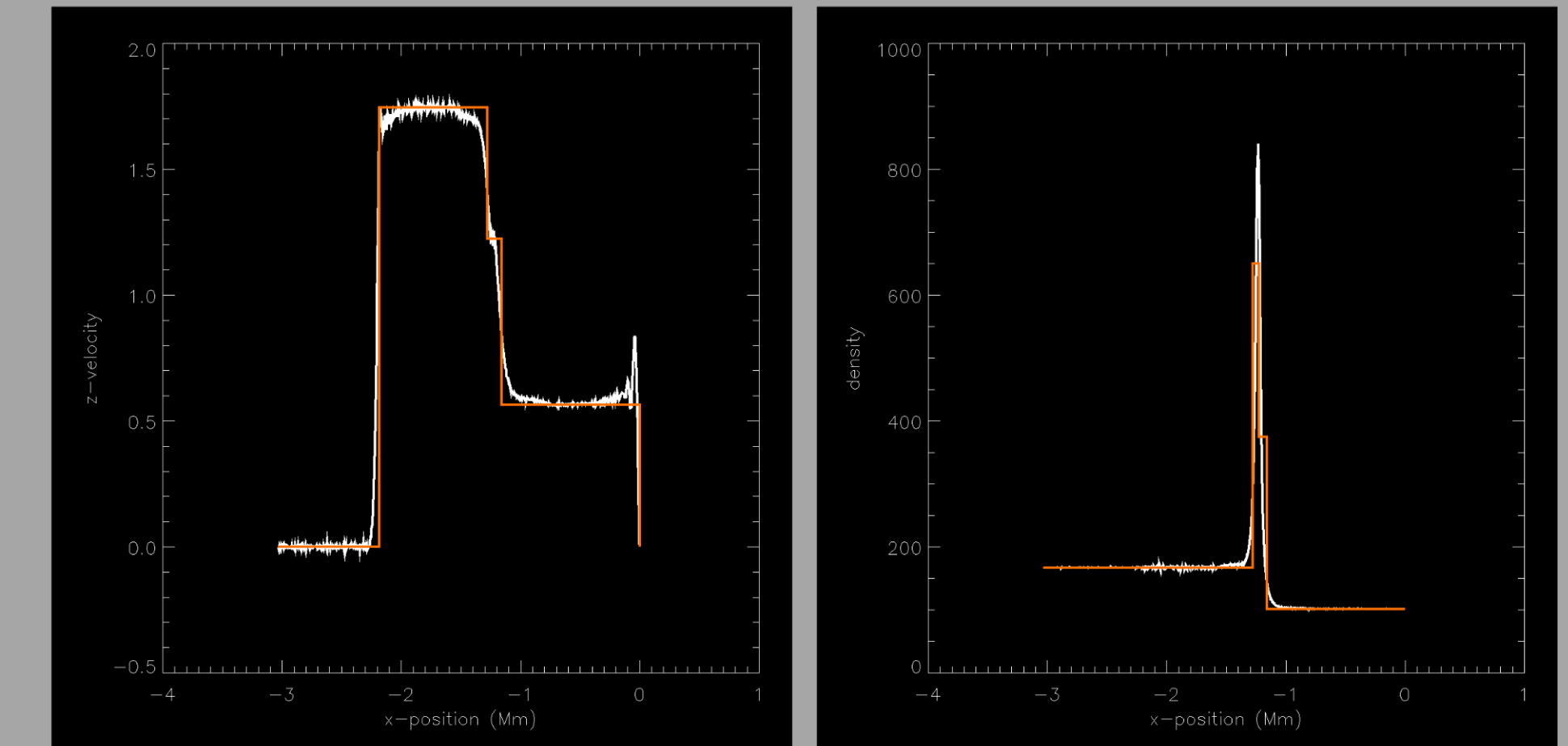
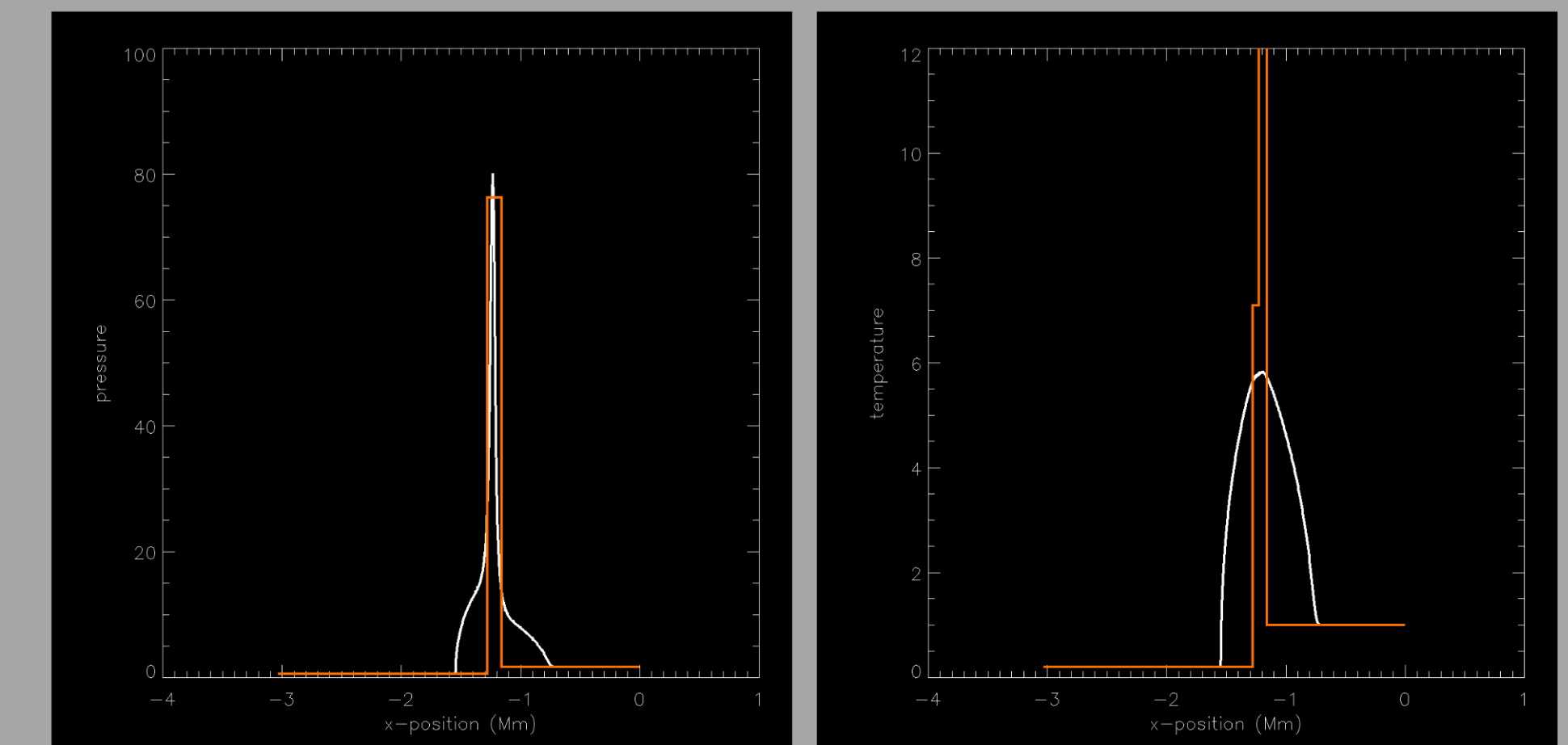


Figure 6: Comparison of analytic pressure and temperature



We note that the division into regions appears justified by the velocity graph, and possibly the density graph. Correctly characterizing temperature, however, is outside the bounds of our model.

References

- [1] Guidoni, S.E., & Longcope, D.W. 2010, ApJ, 718, 1476
- [2] Longcope, D.W., & Guidoni, S.E. 2011, ApJ, 740, 73
- [3] Longcope, D.W., Guidoni, S.E., & Linton, M.G. 2009, ApJ, 690, L18