Data Visualisation - 2

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I. Introduction

This report contains the visualisations and findings for the IEEE Visualization 2008 Design Contest. This part explores Streamlines, 3D visualisation of the isosurfaces and Volume Slicing. It explains the approach used for performing Oblique slicing and moving along the normal of the slicing plane.

II. Streamline Visualisations

The streamline visualisations are direct representation of the velocity values in the selected plane - XZ. In the case of quiver visualisation we were dealing with the curl of the velocities - specifically the projection of the curl onto the XZ plane.

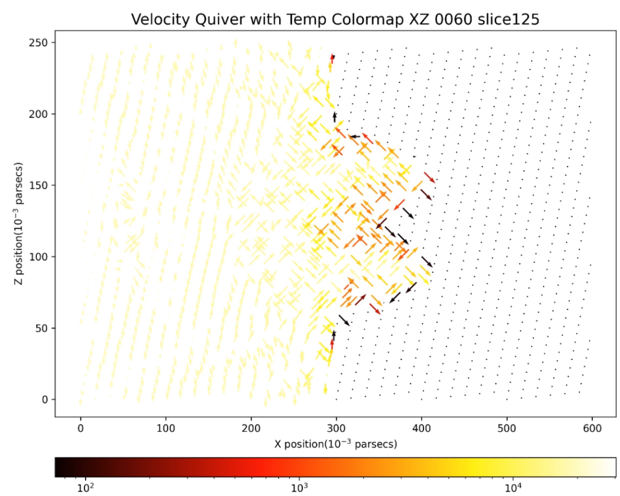
As we can see in Fig 1 it is not representing the same quantity. The direction shown in the Streamlines is the true direction of the flow in the XZ plane. One may notice that when we reach the point in space where the cone-like-shaped entities exist, the streamlines turn into different directions based on the position. Towards the center of the cone, they move inwards, else outwards. When we look at the quiver plot, we get to know about the direction of rotation of the gas and the magnitude. We do see that the arrows move inwards in the cone indicating, that the gas is turning inwards, thus supporting the streamline visualisations.

One might wonder about the difference in the straight lines in the streamline plot which is along positive X axis while the yellow arrows in the quiver plot directed at an angle of 45degrees. So the streamlines as I mentioned denote the actual velocity, denoting that the gas is flowing in the positive x direction in the XZ plane. The purpose of the curl is to denote fluid rotation, but here since the fluid is flowing in a straight line, the net rotation can be assumed to be 0 which means they rotate when the space approaches infinity. So, the net curl in the yellow region is in a positive X direction.

III. Isosurface Visualisation

The visualisations seen here represent 5 isosurfaces present in the density property volume. The main reason for choosing the density property was that the instability in the density plot created in the previous part showed stark differences in different values. Hence, I assumed that visualising it will let us view much better isosurfaces.

So, in the previous part, one of the observations that I made were that there might exist a symmetric conic structure in the space. After visualising the volume(opacity 1) as in Fig 2 I was able to visually see the instability [1]. After seeing this, one



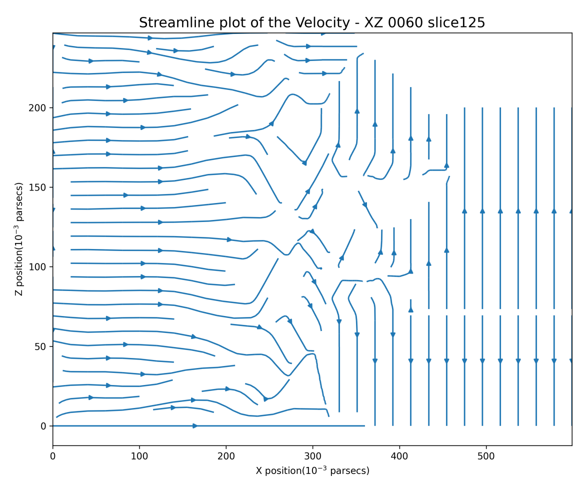


Fig. 1. Top: Quiver plot for Curl of the Velocity in XZ plane at timestep 60 Bottom: Streamlines for Velocity in XZ plane at timestep 60

of the predictions was that this entire structure could belong one isosurface.

So, after reducing the opacity and plotting the isosurface, I was able to visually verify (Fig 4) that it indeed has an isosurface.

Now, the goal was to be able to view five different iso-surfaces. For doing this I had reduce the value range that I

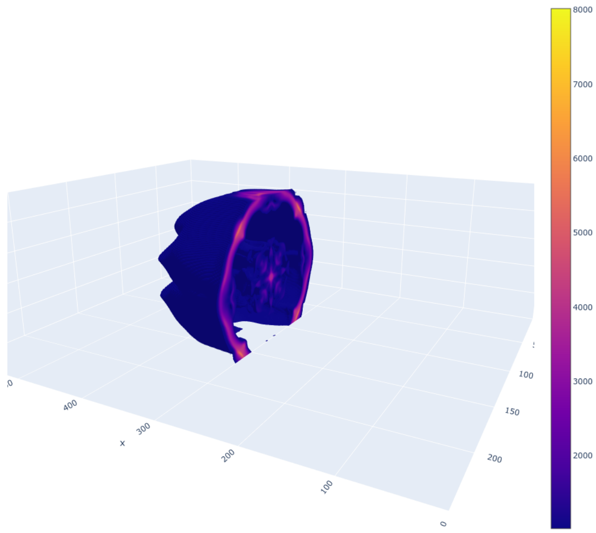


Fig. 2. Density Isosurface with opacity=1

considered [2]. It is not the case that in every timestep we reach a maximum value of 18K. Hence I set the range from the global minimum for density property to 8K. This was useful in being able to get much clear difference in the isosurfaces visually.

The isosurface values that I selected for making the visualisations were : 1000, 2000, 4000, 6000, 8000. The reason for selecting the 1000-2000 value was to specifically being able to visualise the instability. This was one of the major surface that could be considered an isosurface. The reason for selecting 8000 was that it represented the second maxima that seems to arise at the base of the instability.

Next, I tried testing out with various opacities to decide which one provides the best analytical value. So, if you see in Fig 3 you can see the isosurfaces generated with 0.1 opacity value. Now, in this case one can clearly see even the innermost isosurface. But, one thing that might be an issue is that the colors seem to be so light that it might not be easy for everyone to notice the surfaces.

Hence, I tried out higher opacities and I found that at opacity 0.5 (Fig 4) one can easily see the difference in different isosurfaces and there is no occlusion of any surface.

IV. Oblique Volume Slicing

I have selected density property to be visualised and selected the same colormapping as the previous part - Blues_r. The goal of this part is to be able to return an in-situ slice of the volume given a slicing plane. So for the purpose of the assignment I chose to represent a plane as $\mathbf{A}x+\mathbf{B}y+\mathbf{C}z=\mathbf{D}$. Given the fact that I am considering the XZ plane, the goal is to find the Y coordinates which should be a part of the visualisation for a given X and Z coordinate.

$$Y = \frac{D - Ax - Cz}{B} \tag{1}$$

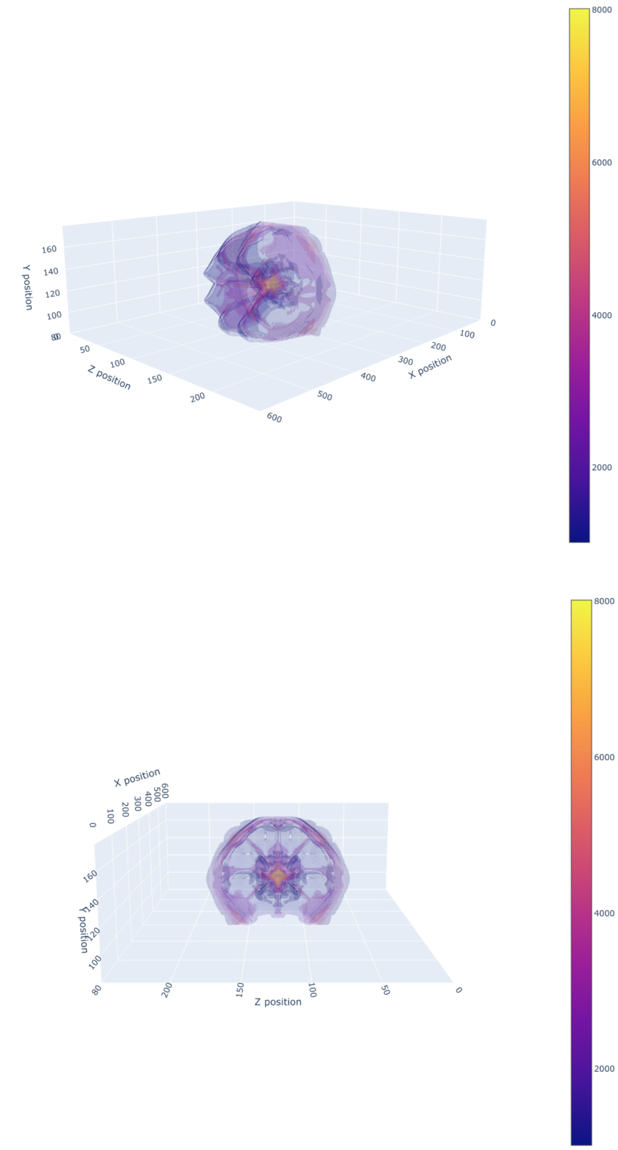


Fig. 3. Density Isosurface with opacity=0.1

So there are three different cases that arise now that can guarantee the closure of the proposed method - plane is parallel to the Y axis, plane parallel to XZ plane or an arbitrary plane exclusive of the aforementioned cases.

A major issue will be caused in the case of plane parallel to Y axis. Because that would imply that the y coefficient - B is 0 in the equation resulting in divide-by-zero error. So in this case, even though the value doesn't depend on the Y value, we still need to render the plane hence we keep the value of Y coordinate equal to the Z coordinate.

For the remaining two cases, the equation for Y coordinate can be directly used without any trouble.

Now, the next requirement is determining the values at these points. These can be easily found by calculating the index and reading that from the file. But the case that we need to consider

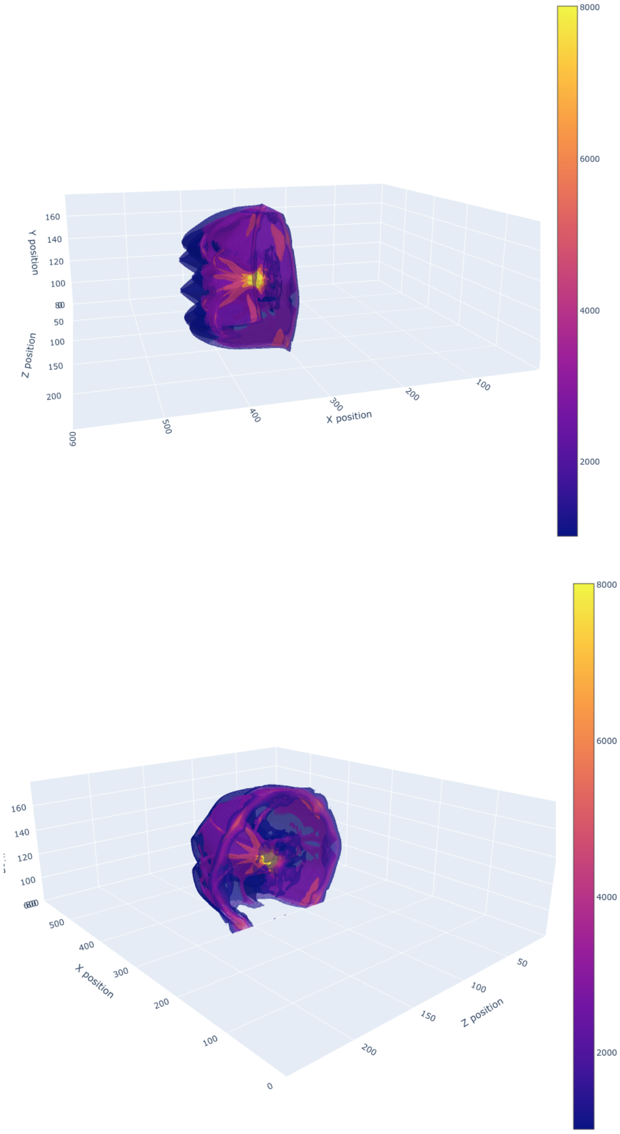


Fig. 4. Density Isosurface with opacity=0.5

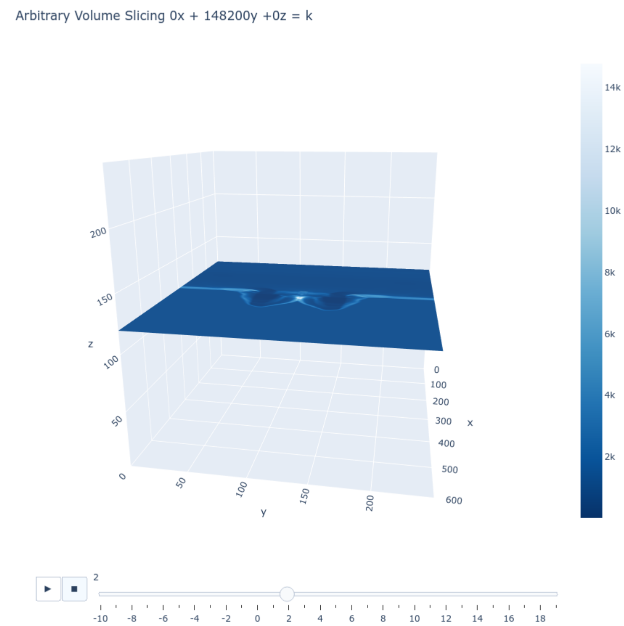


Fig. 5. Volume Slice parallel to the XZ plane

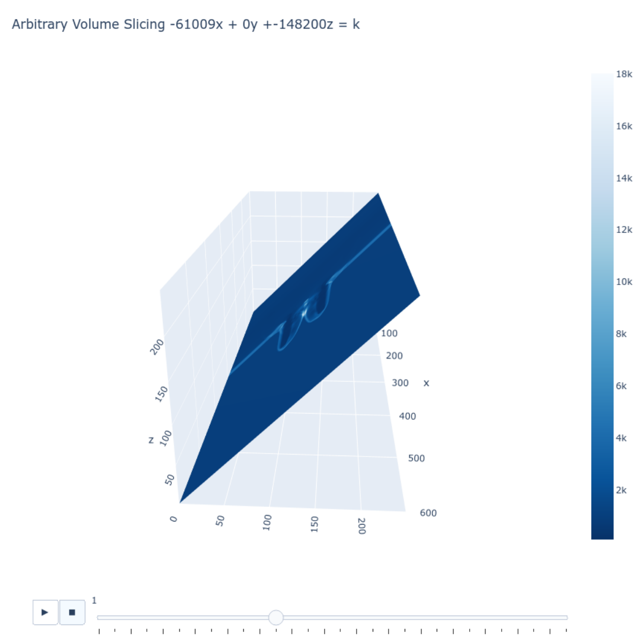


Fig. 6. Volume Slice parallel to the Y axis

explicitly is the case of Y values that go beyond that range i.e. less than 0 or greater than 247. In case the values exceed, I put it's value as the global minimum of the density property, though since I am clipping the volume at Y=0 and Y=248, this part won't be visible so it doesn't matter.

Fig 7 shows an arbitrary plane slicing the volume with the density property. The plane has been moved along the normal to view different slices. For achieving this one can simply change the value of k in Equation 1. This gives us a plane parallel to the original plane.

Fig 6 shows a volume slice parallel to the Y axis. Fig 5 shows the volume slice parallel to the XZ plane.

Shortcomings: One issue that we face is that we see these line artifacts (moire type structures) when we consider an arbitrary plane(not parallel to either XZ plane or Y axis). The major reason for this is that the Y values that is calculated by the Equation 1 may not always be an integer but we need to round it off to an integer to get the values. And since there is no mechanism for specifying an interpolation technique for nonexistent values, the artifacts appear.

V. Results

The streamline visualisations were useful in suggesting the flow of the gases in the space and further comparision with the quiver plot of curl of the velocity helped in confirming the same. Isosurface extraction presented us with surfaces that exist in the volume with same property values and further enabled the instability inferences. The method used for arbitrary volume slicing accounts for the cases and we are able to perform in-situ volume slicing for any provided plane.

References

[1] D. Whalen and M. L. Norman, "Ionization front instabilities in primordial hiiregions," *The Astrophysical Journal*, vol. 673, no. 2, p. 664–675, Feb 2008. [Online]. Available: http://dx.doi.org/10.1086/524400

[2] L. Linsen, T. Long, and P. Rosenthal, "Linking multidimensional feature space cluster visualization to multifield surface extraction," *IEEE computer graphics and applications*, vol. 29, pp. 85–9, 05 2009.

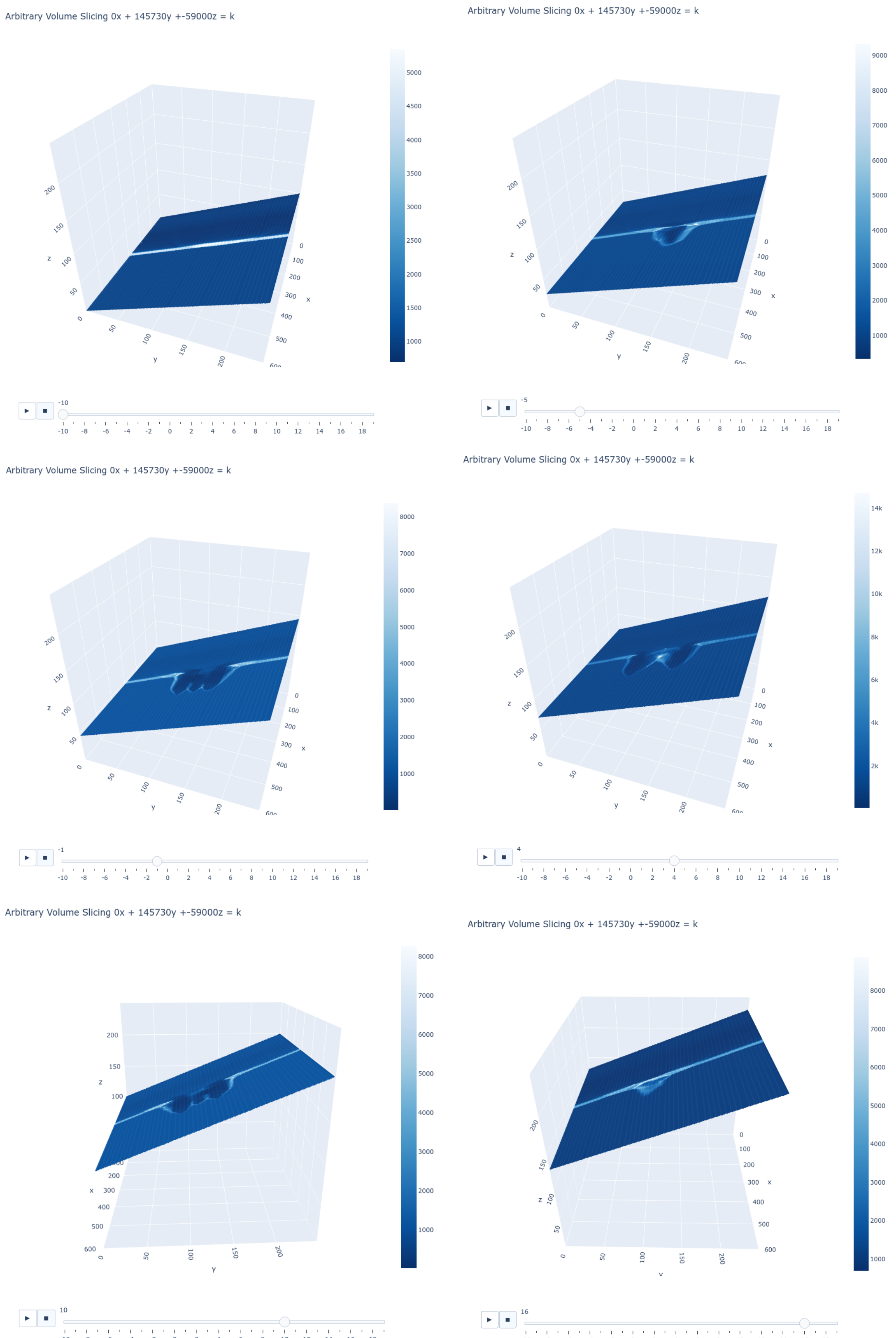


Fig. 7. Oblique Volume Slices using the plane $145730y - 59000z - k = 0$