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Interactive comment on "On modelling the kinematics and evolutionary properties of pressure pulse driven impulsive solar jets" *by* Balveer Singh et al.

Balveer Singh et al.

balveersingh.rs.phy17@itbhu.ac.in

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Dear Editor; Thanks for your email and the referee's comments. Here we reply to all the mentioned comments by the editor.

Major Comments:-

1st Comment: Fig. 1 shows magnetic field geometry. The evolutionary properties of jets may depend not only on this but also on the strength of the background field, as well as other background physical quantities. I kindly ask the authors to show maps of the background quantities as well, as they can have a direct impact on the results. In

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this regard, it would be also worthwhile to discuss, and possibly study, the effects of different background field strengths on the evolution of jets.

Reply:-

We are agreed with the referee, and even we have made the simulations for the two different magnetic field strength to compare the results.

As per the suggestions of the referee, we have shown now the background physical quantities (density profile, pressure profile, plasma-beta profile, magnetic field, sound speed, Alfven speed) for the model gravitationally-stratified and magnetized solar atmosphere. We have shown these profiles for the atmosphere which have source magnetic field value of 112 Gauss.

(i) Mass density profile:

The mass density at y = 2.7 Mm (at the transition region) is 4.595 * 10-12 kg m-3. It grows with the depth and attains 1.537*10-7 kg m-3 at y = 1.5 Mm (which is located within the chromosphere). Figure 1. Equilibrium profiles of mass density vs. height in the solar atmosphere.

(ii) Gas pressure profile:

The gas pressure at y = 2.7 Mm (at the transition region) is 1.26 * 10-3 Pascal. It grows with the depth and attains 6.411*10-1 Pascal at y = 1.5 Mm (which is located within the chromosphere). Figure 2. Equilibrium profiles of gas pressure vs. height in the solar atmosphere.

(iii) Magnetic Field profile:

The magnetic field at y = 2.7 Mm (at the transition region) is 6.884 Gauss while It grows with the depth and attains 7.646 Gauss at y = 1.5 Mm, which is located within the chromosphere. Figure 3. Magnetic field profiles (By) vs. height (y) in the solar atmosphere.

(iv) Plasma-beta profile:

The plasma-beta at y = 2.7 Mm (at the transition region) is 0.0005 while It grow with the depth and attains 0.219 at y = 1.5 Mm, which is located within the chromosphere. Figure 4. Plasma-beta vs. height (y) in the solar atmosphere.

(v) Sound speed profile:

The sound speed at y = 2.7 Mm (Transition region) is 21.392 km-sec-1 while it decreases with the depth and attains 2.638 km sec-1 at y = 1.5 Mm which is located within the chromosphere. Figure 5. Sound speed (Vs) vs. height (y) in the solar atmosphere.

(vi) Alfven speed profile:

The Alfven speed at y = 2.7 Mm (Transition region) is 1015.583 km sec-1 while it decreases with the depth and attains 6.167 km sec-1 at y = 1.5 Mm which is located within the chromosphere. Figure 6. Alfven speed (VA) vs. height (y) in the solar atmosphere.

The various physical quantities, their values, and variations with the height in the structured solar atmosphere clearly indicate their smooth extension into the inner corona. Their reasonable values are set for the model atmosphere and are appropriate for launching the perturbations and associated jets.

2nd Comment: I find odd the adoption of a threshold based on the RGB values of the maps in Fig. 3 to track the jets. Indeed, this is not a physical quantity and color bars in figure 3 are not even shown to help the reader.

Reply:-

Yes, the color of the maps (RGB Values) is not a physical quantity but in the map, we are plotting it for representing the density. Different values of density have been assigned a different RGB value as it is a color map, so indirectly we can say that color

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(RGB Values) are related to the density values. Also, we are attaching color bars scheme for the continuous range of density. We attach all the different plots (density maps) of the jets with the color bars. The RGB analyses have already been explained in the manuscript. Figure 7. Color bars scheme (RGB value) of density map.

3rd Comment: It appears that the data points in Fig. 7 have nothing to do with a linear trend. I, therefore, recommend not to try to fit any linear function to them.

Reply:- We show the width of these jets w.r.t. pressure pulse strength(Ap). We have revisited carefully the width estimation after re-running the simulation for two different magnetic field strengths. Kindly see the revised plot in the manuscript as well as below in the reply.

4th Comment: Again in fig. 7, there is a big jump between Ap=10 and Ap=12 which I do not physically understand and is not commented in the text.

Reply:-

As we mentioned above that we have made the simulation of various jets for two different magnetic field strengths. We have re-estimated the width carefully for both the cases. For different pulse strength, the width of the jets varies from 0.8 Mm to 1.0 Mm. This trend is almost the same for both the magnetic field strengths. Earlier the range of the width was also between 0.65 Mm to 0.9 Mm. Therefore, quantitatively our result remains the same. However, it is found that the width of jets w.r.t pressure pulse strength is almost constant for two different configurations of the magnetic field(B= 56 Gauss and also B=112 Gauss). Figure 8. Width of jets vs. pressure pulse strength (Ap) in the solar atmosphere for magnetic field B= 56 Gauss and B=112 Gauss.

5th Comment: Page 9 lines 7-9. The effects of the downward propagating counterpart of the perturbation are mentioned but, there is not supporting plot showing the temporal evolution of the jets and, in particular, these effects.

Reply:-

We are interested in the evolution of the first isolated jet that is generated due to the forward propagating components of the disturbance. The down-drafting disturbance is usually weak while moving towards the denser lower solar atmosphere, therefore, it is not seen well in the form of significant density perturbations below in the density maps. However, its effect can be visible only once it rebounds back at certain time later and will help in the formation of secondary jets coming from below and interacting with the falling material of the first jet. However, since we are studying the propagation and evolutionary properties of the first upward propagating isolated jet (at different pressure pulse strength and different background magnetic field), therefore, we do not consider the other secondary jets and their evolution.

We have added this justification in the revised manuscript also.

6th Comment: It would be nice to show the evolution of the pulses for different quantities (e.g. Bz). This would increase the value of the results and provide a more complete characterization of the process.

Reply:-

We investigate and show the evolution of the pulses and associated jets at two different configurations of the magnetic field (B = 56 Gauss and B = 112 Gauss) and their mosaic diagram. The automatically detected height-time profiles (see Figure 10) for the jets are originated by imposing different pressure pulses. We also show the profiles of the max. Height (Figure 11), lifetime (Figure 12), and their width(Figure 12) w.r.t. pressure pulse strength for these two magnetic fields, and also compare them.

Figure 9. Evolution of the plasma jets at different pressure pulse and two different configurations of magnetic fields B=56 Gauss and B=112 Gauss. The Mosaic diagram shows the maximum height of the evolved jets at different pressure pulses, e.g., Ap=4, Ap=6, Ap=8, Ap=10, Ap=12, Ap=14, Ap=16, Ap=18, Ap=20, and Ap=22. Horizontal (x) and vertical(y) axes are in Mm.

Figure 10. Height of the jets and their evolution w.r.t. the time Figure 11. Maximum height of the model jets vs. pressure pulse strength(Ap). Figure 12. Life-time of the model jets vs. pressure pulse strength (Ap). Figure 13. Width of the jets vs. pressure pulse strength(Ap) in the solar atmosphere for two different configurations of the magnetic field (B= 56 Gauss and B=112 Gauss).

We have put the revised version of these plots in the manuscript now, and explained them physically. Moreover, we compared the variations that we obtained for two background magnetic field strengths, i.e., B=56 Gauss and 112 Gauss.

Minor Comments:-

1st Comment: End of Page 4. It is said that the vertical coordinate of the magnetic pole is in the convection zone. It would be good to extend the axis range of Fig. 1 to this layer for consistency.

Reply:-

Yes, the magnetic pole is set in the convection zone. The jet is triggering still from the chromosphere (1.8 Mm) along with the open magnetic field lines and the pulse is initially lunched there. So, there are no dynamics occurred in the convection zone related to the evolution of these isolated chromospheric jets. Our realistic temperature mode smoothly extends from the convection zone to the photosphere and thereafter it couples to the chromosphere, TR, and corona. In order to save the computing time, we do set lower boundary at the photosphere. For the visualization, we have already given the magnetic field variations in the plot (see above for B=112 Gauss pole strength) starting from the photosphere to the corona. It clearly shows that the magnetic pole is set somewhere in the convection zone deeper, and the magnetic field is smoothly decayed and extended into the solar atmosphere at higher heights exponentially. Putting the pole deep below in the convection zone is the requirement as we keep the magnetic singularity away from the simulation box in order to set an appropriate initial force and current free magnetic fields.

We have added these justifications in the revised manuscript. We request referee to kindly consider our justification and explanations regarding the simulation.

2nd Comment: In order to be consistent with the notation of equations in Sect. 2.1.1, the pressure pulse in Fig. 3 should be indicated as Ap=4–22 not “p”.

Reply:- we have now consistent with the notation of equations and pressure pulse strength ‘p’ replaced by ‘Ap’ at all positions.

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2019-67/angeo-2019-67-AC2-supplement.pdf

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Interactive comment on Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2019-67, 2019.

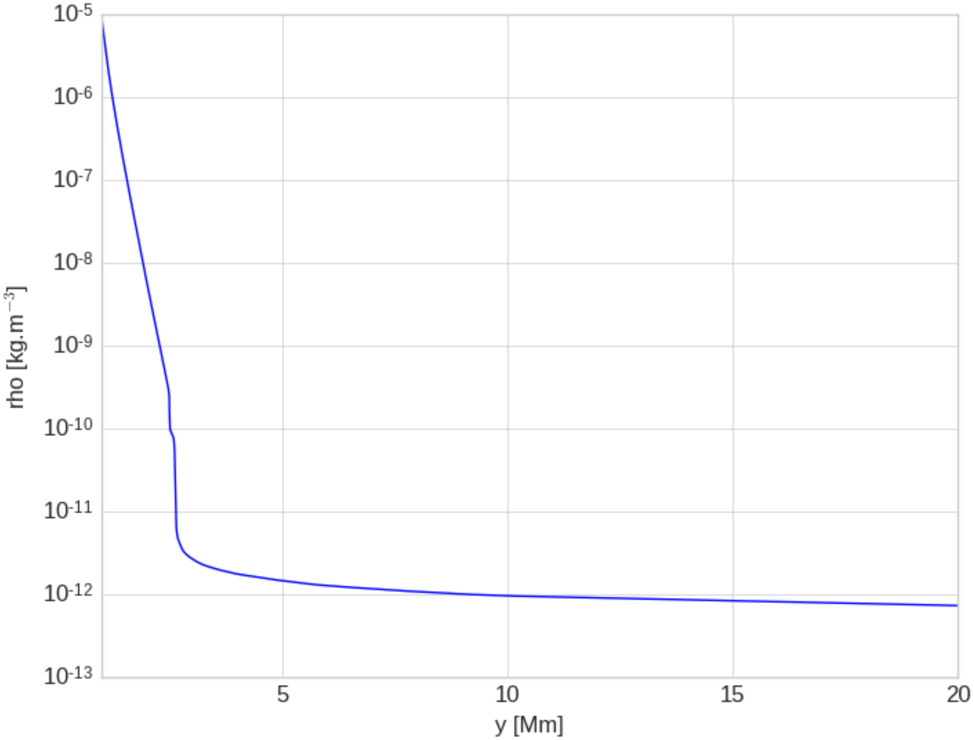

Fig. 1. Equilibrium profiles of mass density vs. height in the solar atmosphere.

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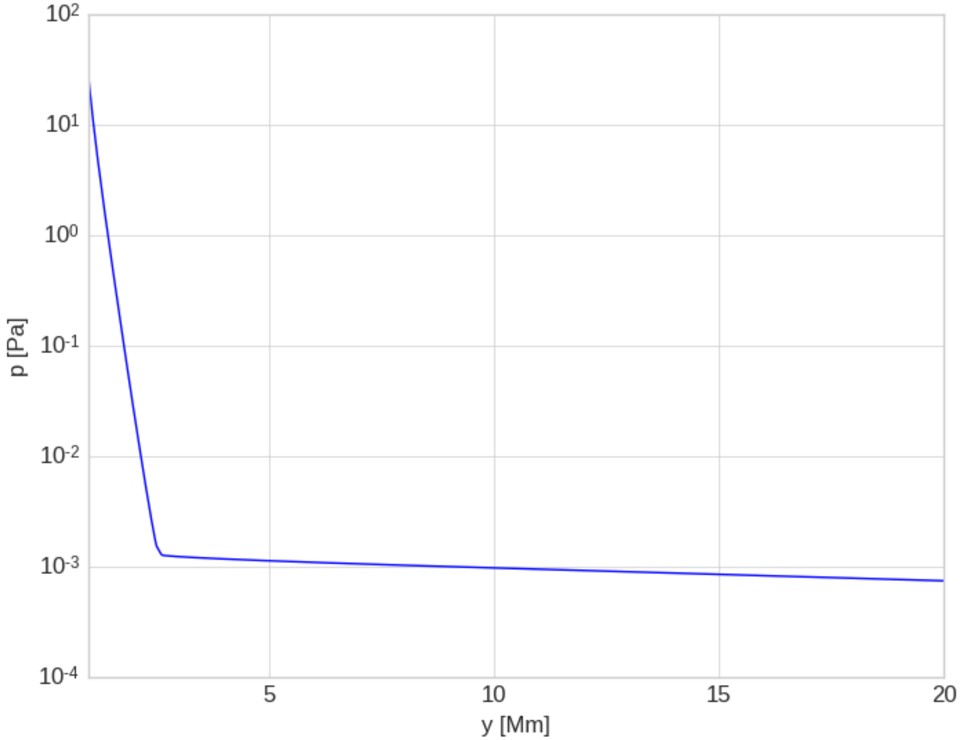

Fig. 2. Equilibrium profiles of gas pressure vs. height in the solar atmosphere.

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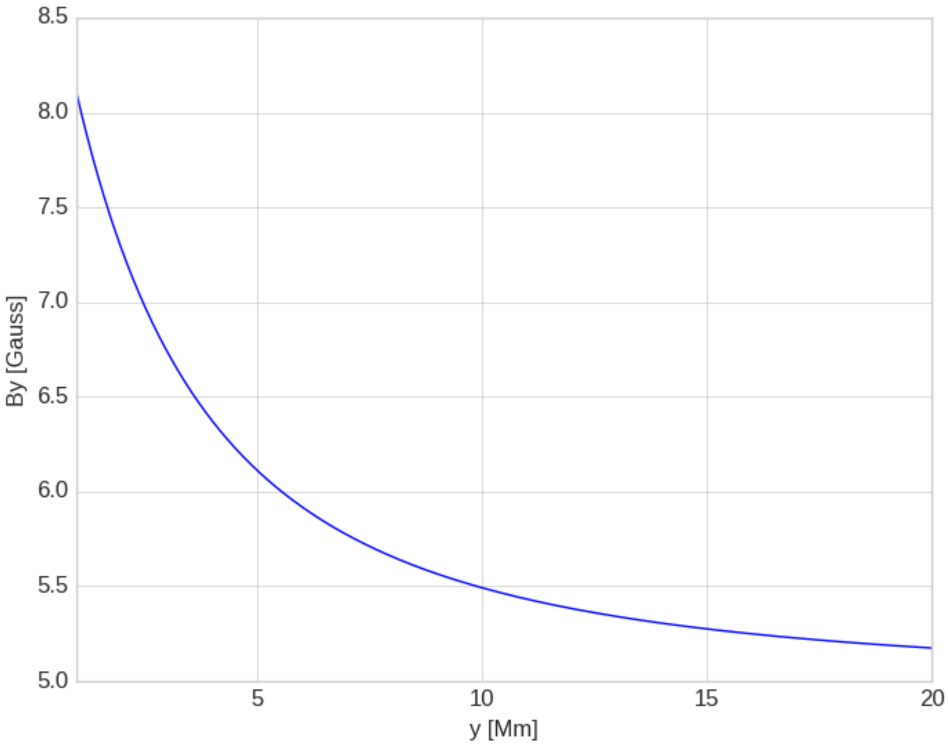

Fig. 3. Magnetic field profiles (By) vs. height (y) in the solar atmosphere

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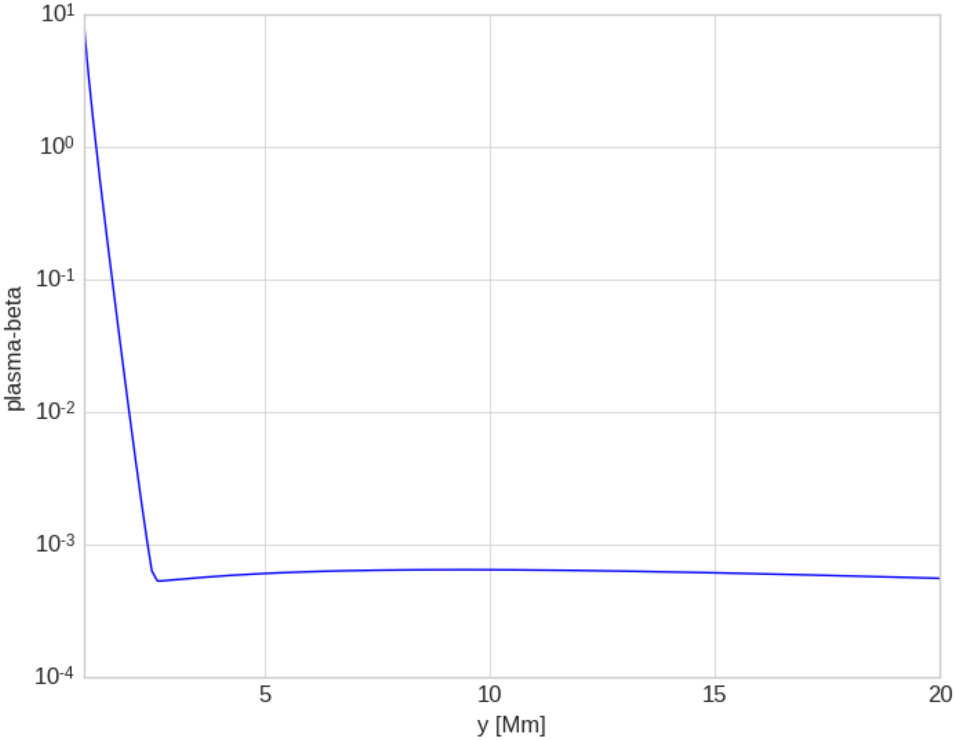

Fig. 4. Plasma-beta vs. height (y) in the solar atmosphere

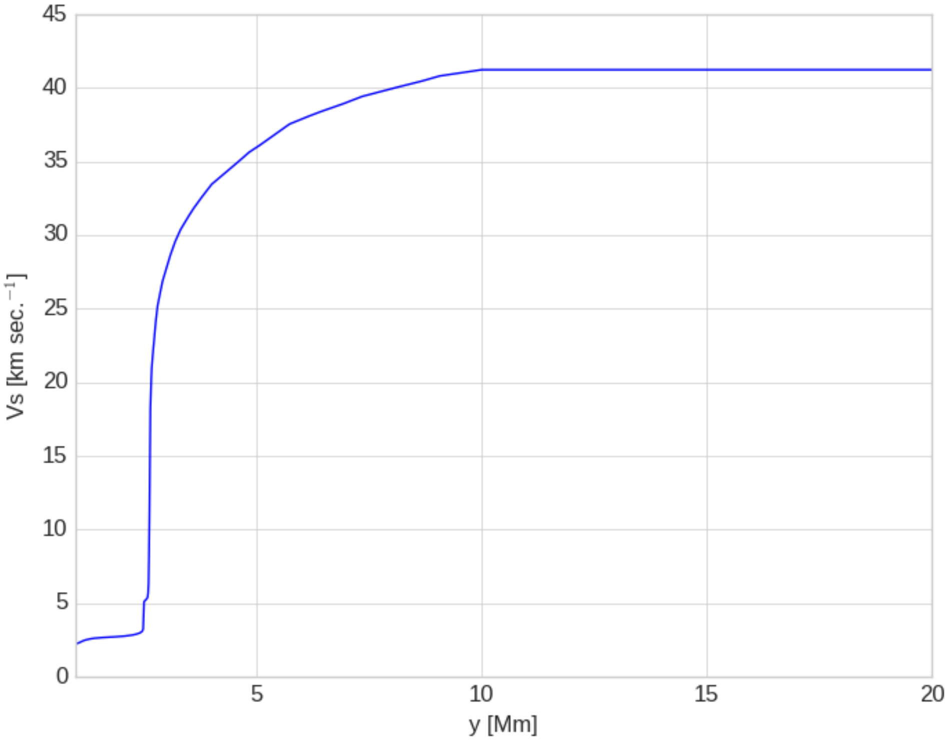

Fig. 5. Sound speed (Vs) vs. height (y) in the solar atmosphere.

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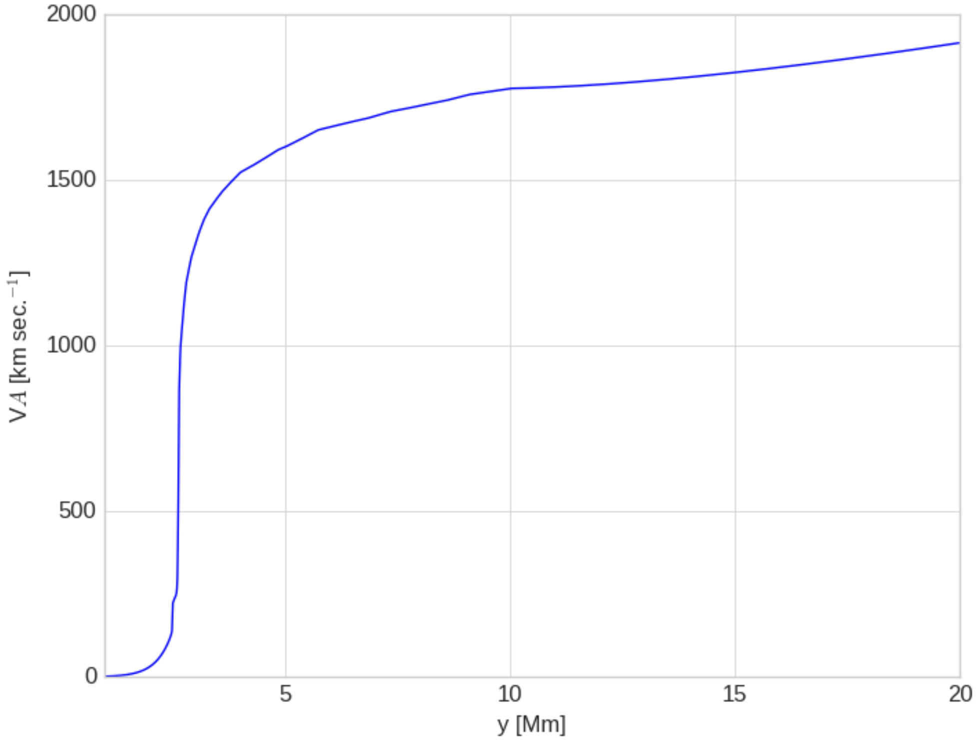

Fig. 6. Alfven speed (VA) vs. height (y) in the solar atmosphere.

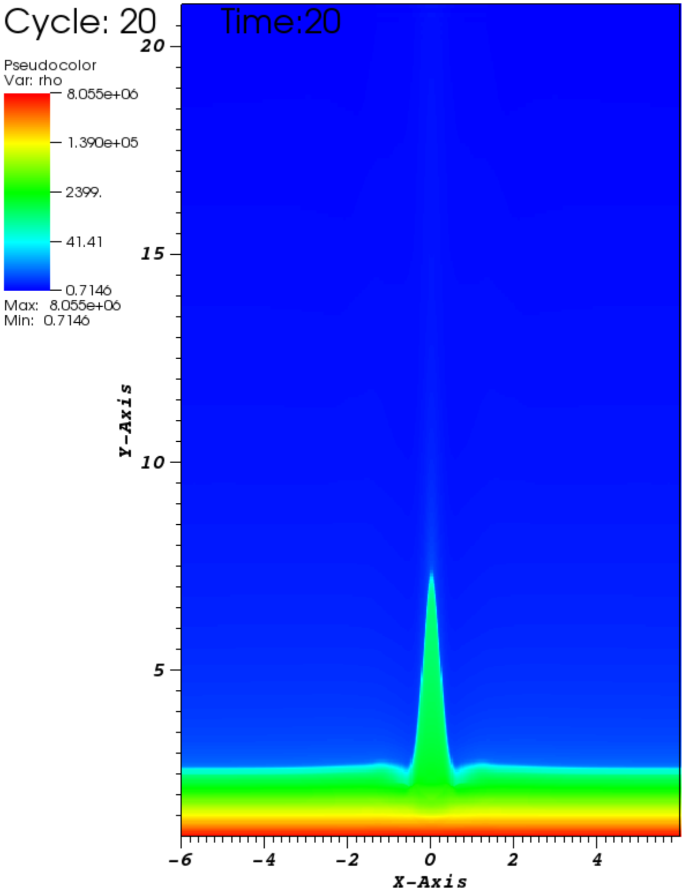

Fig. 7. Color bars scheme (RGB value) of density map.

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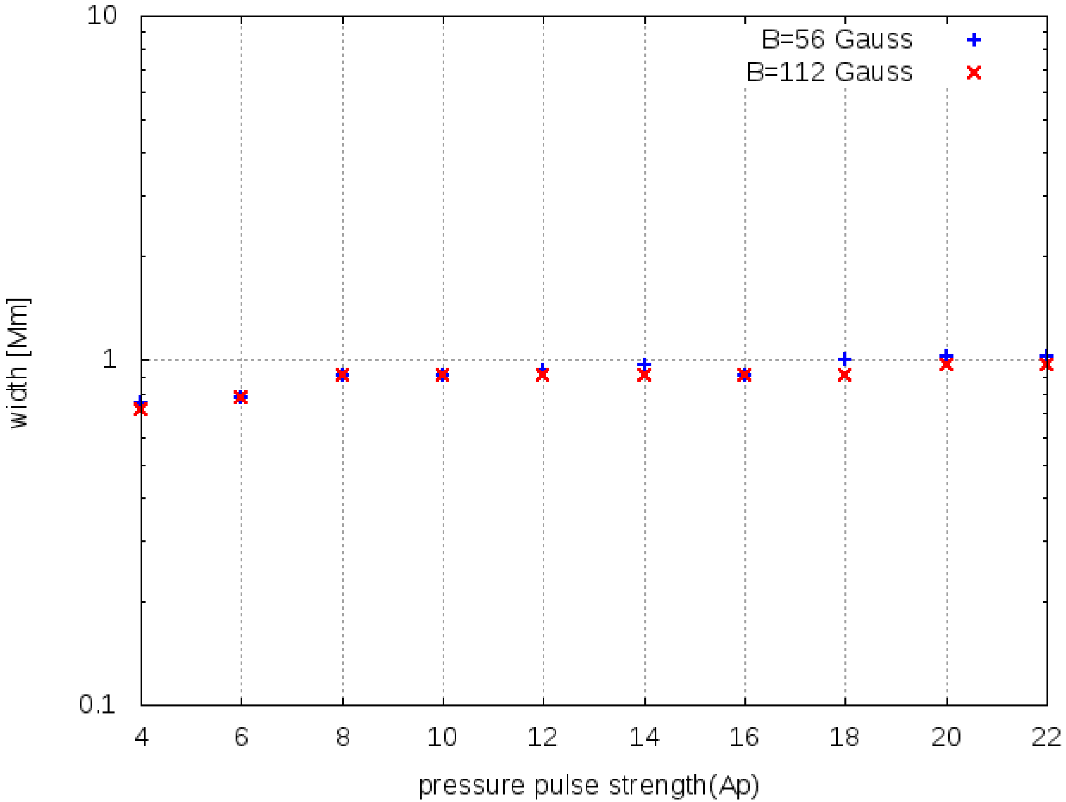

Fig. 8. Width of jets vs. pressure pulse strength (Ap) in the solar atmosphere for magnetic field B= 56 Gauss and B=112 Gauss.

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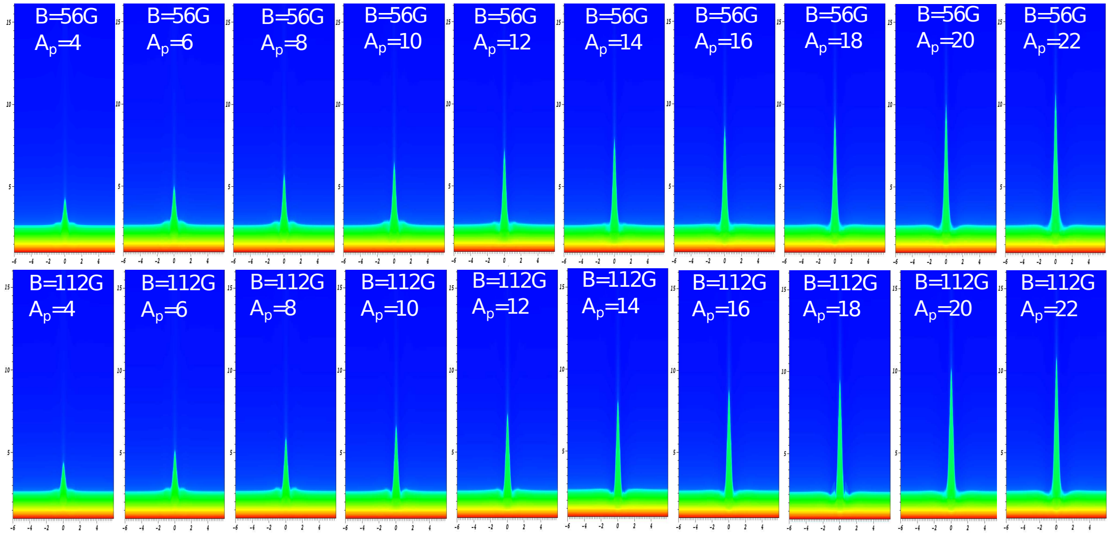

Fig. 9. Evolution of the plasma jets at different pressure pulse and two different configurations of magnetc fields B=56 Gauss and B=112 Gauss. The Mosaic diagram shows the maximum height of the evolved jets

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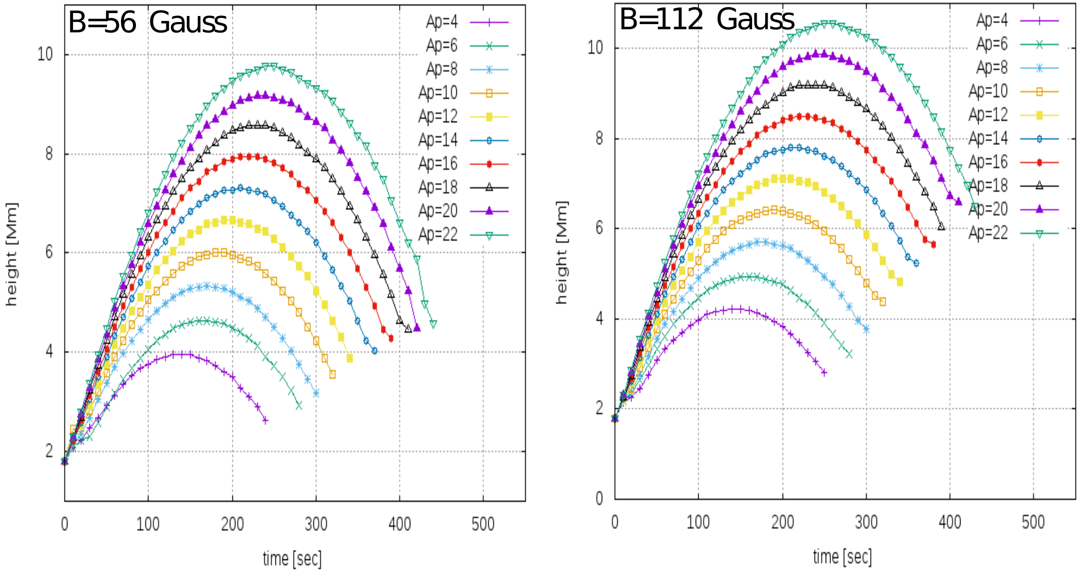

Fig. 10. Height of the jets and their evolution w.r.t. the time.

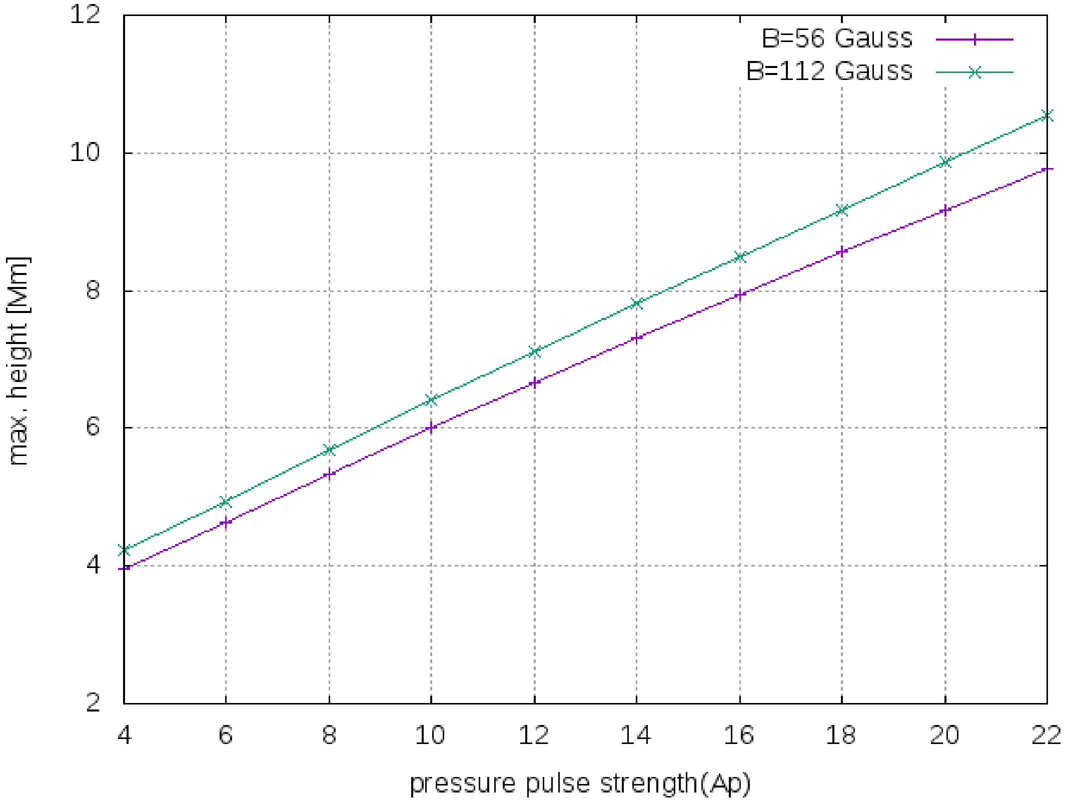

Fig. 11. Maximum height of the model jets vs. pressure pulse strength(Ap).

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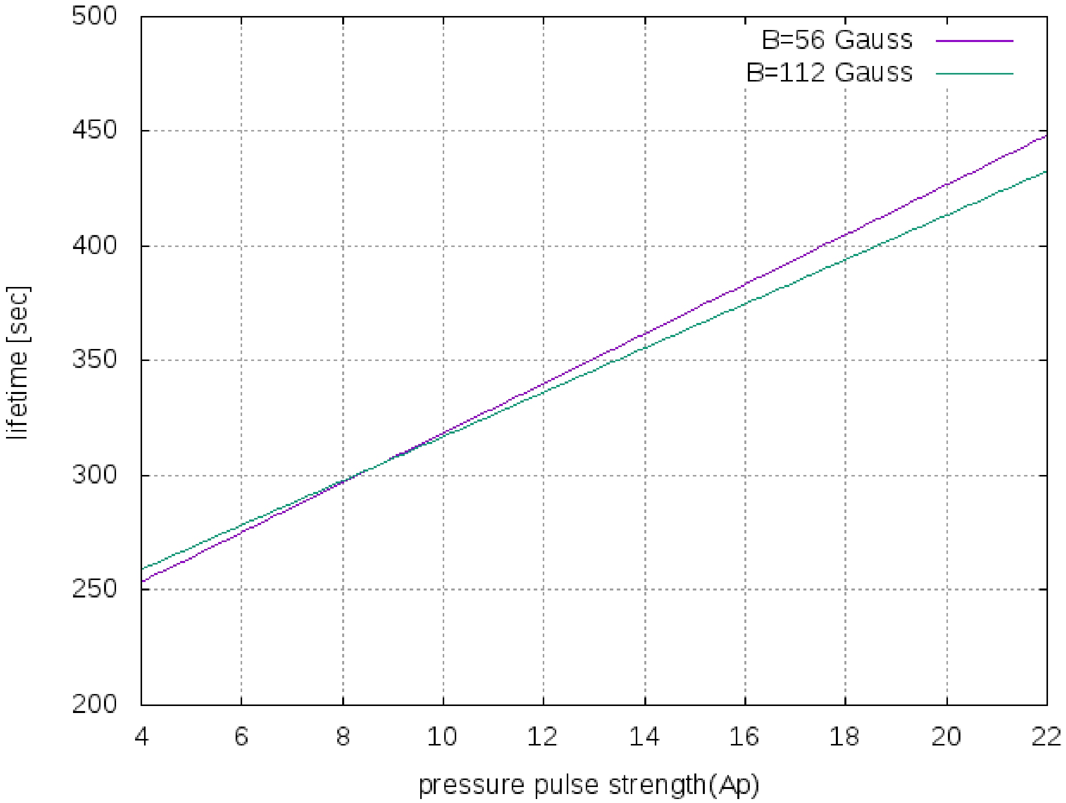

Fig. 12. Life-time of the model jets vs. pressure pulse strength (Ap)

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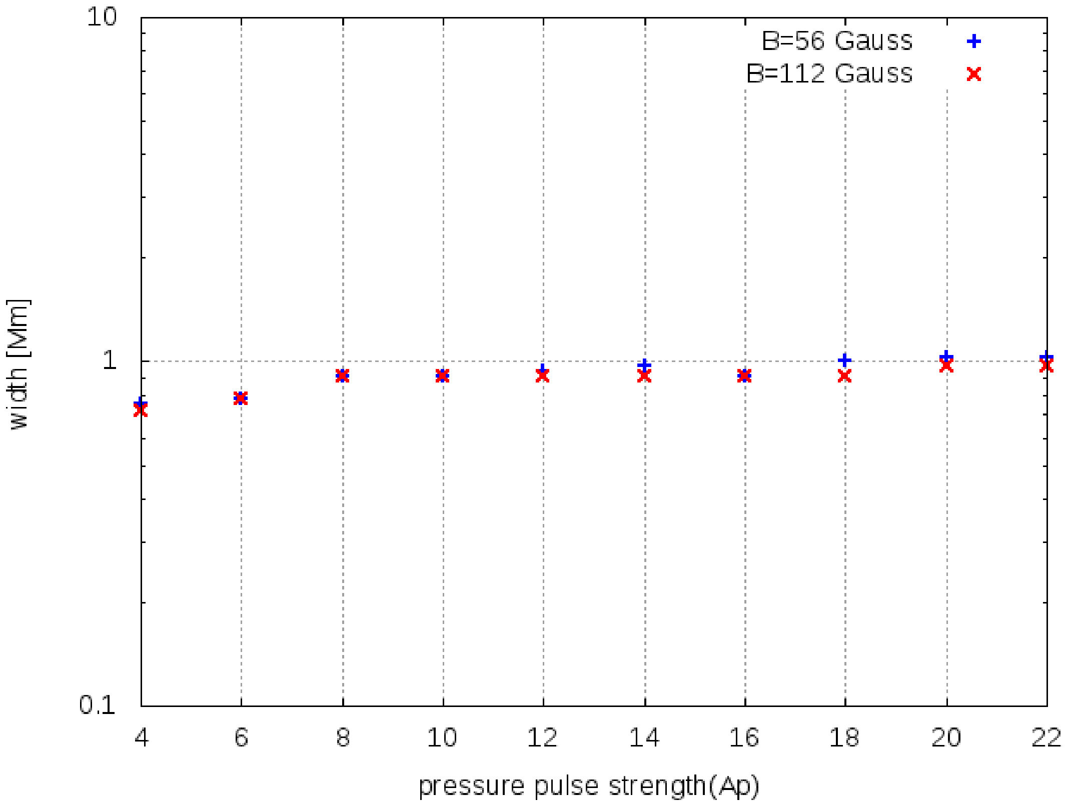

Fig. 13. Width of the jets vs. pressure pulse strength(Ap) in the solar atmosphere for two different configuration of magnetic field (B= 56 Gauss and B=112 Gauss).

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