Computational Astrophysics HW5

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I. EXERCISE 1

(1) The Sun:
with $T \approx 10^7 K$, $n \approx 10^{26} cm^{-3}$, the mean free path $\lambda_{sun} \approx 10^{-6} cm$, compared to the size of system $L \approx 6.96 \times 10^{10} cm$, the result shows that it can be described as a fluid.

(2) Solar wind:
with $T \approx 10^5 K$, $n \approx 10^1 cm^{-3}$, the mean free path $\lambda_{solarwind} \approx 10^{15} cm$, compared to the size of system $L \approx 1.5 \times 10^{15} cm$, the result shows that it can not be described as a fluid.
(By searching the net, I find that solar wind may travel a distance circa 100 AU, still not satisfy the relation $\lambda \ll L$)

(3)Warm ionized interstellar medium:
with $T \approx 10^4 K$, $n \approx 10^1 cm^{-3}$, the mean free path $\lambda_{WIM} \approx 10^{13} cm$, compared to the size of system $L \approx 3.0 \times 10^{19} cm$, the result shows that it can be described as a fluid.
(Scale of WIM is about 1000 pc, from wikipedia.)

(4) Intracluster medium within galaxy clusters:
with $T \approx 3 \times 10^7 K$, $n \approx 10^{-3} cm^{-3}$, the mean free path $\lambda_{IM} \approx 9 \times 10^{23} cm$, compared to the size of system $L \approx 10^{25} cm$, the result shows that it can not be described as a fluid.
(Scale of galaxy cluster is about 1 to 5 pc, from wikipedia.)

II. EXERCISE 2

(1)Implement the LW method, the result is as follow

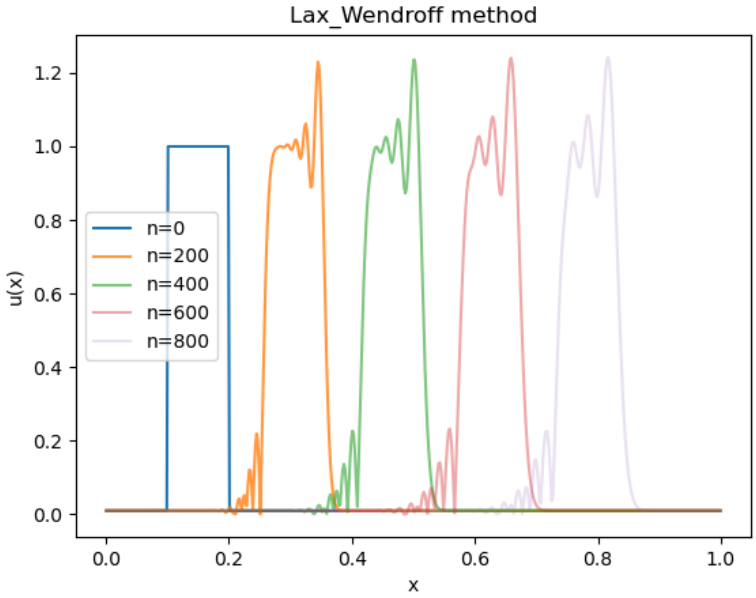
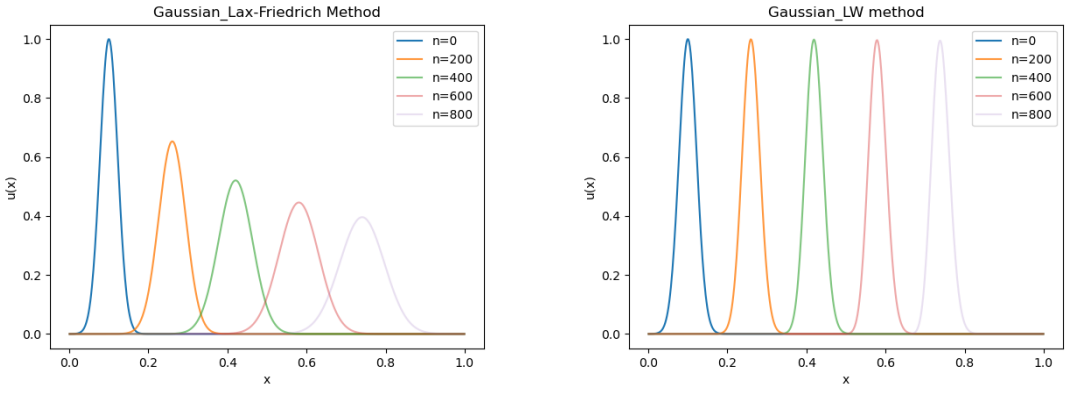


FIG. 1. Lax-Wendroff method

(2)Substituting the top hat function by Gaussian function, implement LW and LF method, the result:



(a) Lax-Friedrich method (b) Lax-Wendroff method

FIG. 2. Gaussian function

(3)

III. EXERCISE 3

(1) Implemented the piecewise-linear method (PLM) for the advection test, the result figure:

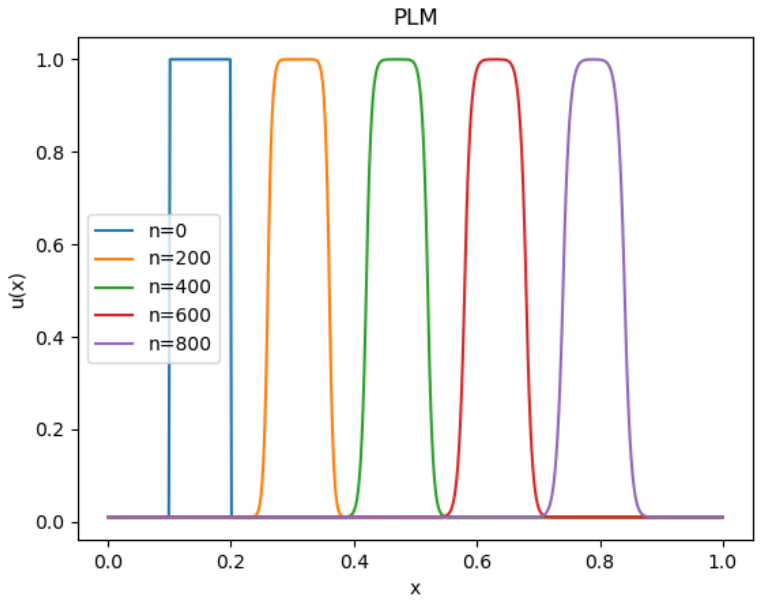
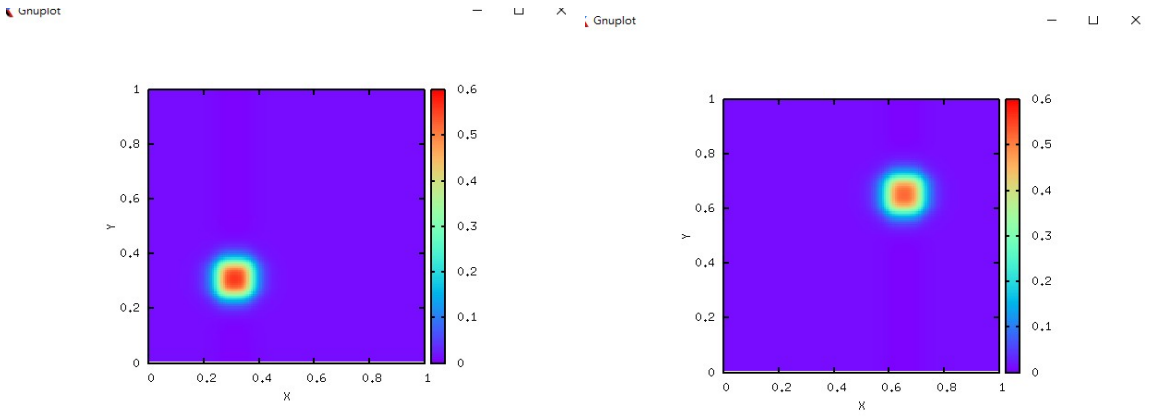


FIG. 3. Piecewise-linear method

(2)Change 1-dimensional to 2-dimensional finite volume method, using PLM method to see how 2D advection go. Since the result animation can not be put here, I choose some screen shot as my result:



(a) Square function going up-right (1)

(b) Square function going up-right (2)

FIG. 4. 2D advection simulation

IV. EXERCISE 4

V. CODE LINK

Exercise2

Exercise3-1 Exercise3-2