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Corrigendum to “Spurious behavior of shock-capturing methods by the fractional step approach: Problems containing stiff source terms and discontinuities” [J. Comput. Phys. 241 (2013) 266–291]

Helen C. Yee

NASA Ames Research Center, yee@nas.nasa.gov

Dmitry V. Kotov

Center for Turbulence Research, dkotov@stanford.edu

Wei Wang

Florida International University, weiwang1@fiu.edu

Chi-Wang Shu

Brown University, shu@dam.brown.edu

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Corrigendum

Corrigendum to “Spurious behavior of shock-capturing methods by the fractional step approach: Problems containing stiff source terms and discontinuities” [J. Comput. Phys. 241 (2013) 266–291]

H.C. Yee^{a,*}, D.V. Kotov^b, Wei Wang^c, Chi-Wang Shu^d^a NASA Ames Research Center, Moffett Field, CA 94035, USA^b Stanford Center for Turbulence Research, Stanford, CA 94305-3035, USA^c Department of Mathematics & Statistics, Florida International University, Miami, FL 33199, USA^d Division of Applied Mathematics, Brown University, Providence, RI 02912, USA

This corrigendum contains a correction to some of the figures in the article “Spurious behavior of shock-capturing methods by the fractional step approach: Problems containing stiff source terms and discontinuities” [J. Comput. Phys. 241 (2013) 266–291]. There was a computer coding error in the computer code that generates the results. The coding error consists of failing to update the temperature from the final solution of the RK4 convection step time evolution before the reaction step using the Strang splitting in Eq. (29). In addition, if $N_r > 1$, the error includes no update to the temperature for each sub-iteration on the reaction step in Eq. (29). The error affects Figs. 5–12, 14–17, 19–22.

By fixing the bug in the computer code, there are minor difference in the solution behavior by the studied numerical methods with the majority of the conclusion remains the same. There is however an improvement (reduction) in the spurious behavior by WENO5/SR. The correction to the text portion are:

- Page 277, line 5 from bottom should be replaced by “Fig. 8 indicates that as we increase the stiffness coefficient further, WENO5/SR still produces the correct shock speed for the $1000K_0$ stiffness, whereas WENO5fi/SR + split exhibit oscillatory solutions for the same grid and CFL = 0.05.”
- Page 278, second line below Section 4.1.3 should be replaced by “Fig. 9 shows the effect of the time steps for five CFL values that are under the CFL limit (left sub-figure), using 50 grid points and WENO5. The right sub-figure shows the error in terms of the number of grid points away from the reference shock location (Err) for three stiffness coefficients $100K_0$, $1000K_0$ and $10000K_0$ ”
- Page 287, the last five lines should be replaced by “Again, WENO5/SR, WENO5fi and WENO5fi + split are able to obtain the correct shock speed with similar accuracy.”

The followings are the corrected Figs. 5–12, 14–17, 19–22.

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* Corresponding author. Tel.: +1 415 604 4769.

E-mail address: Helen.M.Yee@nasa.gov (H.C. Yee).

Fig. 5. 1D C-J detonation problem, Arrhenius case for the original stiffness K_0 at $t = 1.8$: pressure and density comparison among three standard shock-capturing methods (TVD, WENO5, WENO7) using 50 uniform grid points with CFL = 0.05.

Fig. 6. 1D C-J detonation problem, Arrhenius case for the original stiffness K_0 at $t = 1.8$: temperature and density comparison among standard high order shock-capturing methods and low dissipative methods (WENO5, WENO5/SR, WENO5fi and WENO5fi + split) using 50 uniform grid points with CFL = 0.05.

Fig. 7. 1D C-J detonation problem, Arrhenius case at $t = 1.8$: pressure comparison between the original stiffness K_0 (left) and $4K_0$ (right) of the source term computed by WENO5 using 50 uniform grid points. All the CFL values for the inviscid simulations are based on the convection part of the PDEs.

Fig. 8. C-J detonation problem, Arrhenius case at $t = 1.8$: density comparison between WENO5/SR and WENO5fi/SR + split for $100K_0$ (left) and $1000K_0$ (right) using 50 uniform grid points with CFL = 0.05.

Fig. 9. 1D C-J detonation problem, Arrhenius case using 50 uniform grid points: density comparison for five CFL numbers by WENO5 (left). Number of grid point away from the reference solution (Err) as a function of the CFL number (128 CFL values with $6.316455696 \times 10^{-3}$ equal increment) for three stiffness coefficients ($100K_0$, $1000K_0$, $10000K_0$) by WENO5. A negative “Err” value indicates the number of grid points behind the reference shock solution. All the CFL values for the inviscid simulations are based on the convection part of the PDEs.

Fig. 10. 1D C-J detonation problem, Arrhenius case at $t = 1.8$: number of grid points away from the reference shock solution (Err) as a function of the CFL number (128 discrete CFL values with $6.316455696 \times 10^{-3}$ equal increment) for three standard shock-capturing methods using 50, 150, 300 uniform grid points (across) and for stiffness K_0 , $100K_0$, $1000K_0$ (top to bottom). See Fig. 9 for additional captions.

Fig. 11. 1D C-J detonation problem, Arrhenius case at $t = 1.8$: number of grid point away from the reference shock solution (Err) as a function of the CFL number (128 discrete CFL values with $6.316455696 \times 10^{-3}$ equal increment) for three low dissipative shock-capturing methods using 50, 150, 300 uniform grid points (across) and for stiffness K_0 , $100K_0$, $1000K_0$ (top to bottom). See Fig. 9 for additional captions

Fig. 12. 1D C-J detonation problem, Arrhenius case at $t = 1.8$: comparison of the same spatial discretization with RK4 and RK3 temporal discretization for three low dissipative shock-capturing methods using 150, 300 uniform grid points and for stiffness K_0 .

Fig. 14. $N_r = 1, 5, 10, 100$ (top to bottom) study using Strang splitting by improved schemes for the 1D C-J detonation problem, Arrhenius case at $t = 1.8$. Number of grid points away from the reference shock solution (Err) as a function of the CFL number (128 discrete CFL values with $6.316455696 \times 10^{-3}$ equal increments) using 50, 150, 300 uniform grid points (across) and for stiffness K_0 : WENO5, WENO5/SR, WENO5fi, WENO5fi + split and WENO5fi/SR + split. All of the computations use RK4.

Fig. 15. No Strang splitting results for the 1D C-J detonation problem, Arrhenius case at $t = 1.8$: number of grid point away from the reference shock solution (Err) as a function of the CFL number (128 discrete CFL values with $6.316455696 \times 10^{-3}$ equal increment) for three low dissipative shock-capturing methods using 50, 150, 300 uniform grid points (across) and for stiffness K_0 .

Fig. 16. No cutoff safeguard procedure and Strang splitting results for the 1D C-J detonation problem, Arrhenius case at $t = 1.8$: number of grid point away from the reference shock solution (Err) as a function of the CFL number (128 discrete CFL values with $6.316455696 \times 10^{-3}$ equal increment) for three low dissipative shock-capturing methods using 50, 150, 300 uniform grid points (across) and for stiffness K_0 .

Fig. 17. Strang splitting and no safeguard schemes based on Hu et al. positivity-preserving method (top) and Zhang and Shu positivity-preserving method (bottom) for the 1D C-J detonation problem, Arrhenius case at $t = 1.8$. Number of grid points away from the reference shock solution (Err) as a function of the CFL number (128 discrete CFL values with $6.316455696 \times 10^{-3}$ equal increments) using 50, 150, 300 uniform grid points (across) and for stiffness K_0 : WENO5, WENO5/SR, WENO5fi, WENO5fi + split and WENO5fi/SR + split. All of the computations use RK3, Strang splitting with $N_r = 10$.

Fig. 19. 2D detonation problem at $t = 0.3 \times 10^{-7}$ and $K_0 = 0.5825 \times 10^{10}$: density computed by different methods. From left to right: reference solution by the standard WENO5 method using 4000×800 uniform grid points, WENO5, WENO5/SR and WENO5fi + split using 500×100 uniform grid points with CFL = 0.05

Fig. 20. 2D detonation problem at $t = 1.7 \times 10^{-7}$ and $K_0 = 0.5825 \times 10^{10}$: density computed by different methods. From left to right: reference solution by the standard WENO5 method using 4000×800 uniform grid points, WENO5, WENO5/SR and WENO5fi + split using 500×100 uniform grid points with CFL = 0.05.

Fig. 21. 1D cross-section of density at $t = 1.7 \times 10^{-7}$ by four high order shock-capturing methods for the 2D detonation problem using 200×40 uniform grid points, CFL = 0.05 and $K_0 = 0.5825 \times 10^{10}$. The left figure zoomed in the vicinity of the discontinuity. Note that there is an enlargement of the x domain using the same fixed δx in order to illustrate the wrong shock location.

Fig. 22. 2D detonation problem at $t = 1.7 \times 10^{-7}$ and $K_0 = 0.5825 \times 10^{10}$; number of grid point away from the reference shock solution as a function of the CFL number (128 discrete CFL values with $6.22047244094488 \times 10^{-3}$ equal increment) for three low dissipative shock-capturing methods using 200×40 and 500×100 uniform grid points (across) and for stiffness K_0 , $100K_0$, $1000K_0$ (top to bottom). See Fig. 9 for additional captions.