



第 3 次作业

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摘要: 使用有限差分法, 数值求解了一个具有解析解的一维对流(平流, 输运)方程. 对于时间偏导项, 采取两层显式差分平流方案. 对于空间偏导项, 分别采取前(右)向和后(左)向差分作近似. 选取两个不同的时间与空间步长之比 τ , 分别执行计算. 在四个求解尝试中, 仅有当 τ 取 0.9 时的两层显式前向差分平流方案可接近解析解. 在另外三个求解尝试中, 当 τ 取 2.0 时的两层显式前向差分平流方案能体现特征线的方向(物理意义为平流方向), 但其数值结果显示出不稳定的外观; 两个两层显式后向差分平流方案的尝试均不能正确体现特征线的方向, 且数值结果显示出不稳定的外观. 由数值实验可以看出, 即使要求解的问题相对简单, 采取前向和后向差分格式得到的数值结果可能大不相同, 且数值格式的稳定性可能对网格剖分方式高度敏感. 本文所使用的计算机程序和文档发布于 https://github.com/grwei/SJTU_2021-2022-2-MATH6008.

关键词: 有限差分法, 输运方程, 两层格式, 显式格式

Homework 3

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Abstract: Using the finite difference method, a one-dimensional advection (convection, transport) equation with an analytical solution is numerically solved. For the temporal partial derivatives, a two-layer explicit differential advection scheme is adopted. For the spatial partial derivatives, forward (rightward) and backward (leftward) is approximated to the difference. Two different ratios of time and space steps, τ , are selected to perform the calculation separately. Among the four solution attempts, only the two-layer explicit forward differential advection scheme when τ is 0.9 can be approximated. Analytical solution. In the other three solution attempts, the two-layer explicit forward differential advection scheme when τ takes 2.0 can reflect the direction of the characteristic line (the physical meaning is the direction of advection), but its numerical results show an unstable appearance; both attempts at the two-layer explicit backward differential advection scheme fail to correctly reflect the orientation of the feature lines, and the numerical results show an unstable appearance. It can be seen from the numerical experiments that even if the solution required The problem is relatively simple, the numerical results obtained with the forward and backward differencing schemes can be quite different, and the stability of the numerical scheme can be highly sensitive to the meshing method. The computer programs and documents used in this article are published at https://github.com/grwei/SJTU_2021-2022-2-MATH6008.

Keywords: finite difference method, advection equation, two-level scheme, explicit scheme



目 录

摘要	i
Abstract.....	i
1 讨论	1
References	2



1 讨论



References