计算物理作业 8

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正面迎击 *ddl* 军团!

1　题目 1：松弛法求解泊松方程

1.1　题目描述

Consider the Poisson equation:

$$\nabla^2\varphi(x,y) = -\frac{\rho(x,y)}{\varepsilon_0}$$

from electrostatics on a rectangular geometry with $x \in [0, L_x]$ and $y \in [0, L_y]$. Write a program that solves this equation using the relaxation method and test your program with the following cases:
(a) $\rho(x,y) = 0$, $\varphi(0,y) = \varphi(L_x,y) = \varphi(x,0) = 0$, $\varphi(x,L_y) = 1\,\mathrm{V}$, $L_x = 1\,\mathrm{m}$, and $L_y = 1.5\,\mathrm{m}$;
(b) $\frac{\rho(x,y)}{\varepsilon_0} = 1\,\mathrm{V/m^2}$, $\varphi(0,y) = \varphi(L_x,y) = \varphi(x,0) = \varphi(x,L_y) = 0$, and $L_x = L_y = 1\,\mathrm{m}$.

1.2　程序描述

1.3　伪代码

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1.4　结果示例

2　题目 2：含时薛定谔方程求解

2.1　题目描述

Solve the time-dependent Schrödinger equation using both the Crank–Nicolson scheme and a stable explicit scheme. Consider the one-dimensional case and test it by applying it to the problem of a square well with a Gaussian initial state coming in from the left.
Hint: The Gaussian initial state could be expressed as:

$$\Psi(x,0) = \sqrt{\frac{1}{\pi}}\exp\left[ik_0x - \frac{(x-\xi_0)^2}{2}\right].$$

2.2 程序描述

2.3 伪代码

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2.4 结果示例

3 题目 3：波动方程显式求解稳定条件

3.1 题目描述

Prove the stability condition of the explicit scheme of the 1D wave equation by performing Von Neumann stability analysis:

$$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}.$$

If $c\Delta t/\Delta x \leq 1$, the explicit scheme is stable.

3.2 程序描述

3.3 伪代码

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3.4 结果示例