

# 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)  $\rho(x, y) = 0$ ,  $\varphi(0, y) = \varphi(L_x, y) = \varphi(x, 0) = 0$ ,  $\varphi(x, L_y) = 1 \text{ V}$ ,  $L_x = 1 \text{ m}$ , and  $L_y = 1.5 \text{ m}$ ;  
(b)  $\frac{\rho(x, y)}{\varepsilon_0} = 1 \text{ V/m}^2$ ,  $\varphi(0, y) = \varphi(L_x, y) = \varphi(x, 0) = \varphi(x, L_y) = 0$ , and  $L_x = L_y = 1 \text{ m}$ .

### 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:

$$\Psi(x, 0) = \sqrt{\frac{1}{\pi}} \exp \left[ ik_0 x - \frac{(x - \xi_0)^2}{2} \right].$$

## 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