

一 等势面

电场中电势相等的点所构成的面。

- ◆ 电荷沿等势面移动时，电场力做功为零。

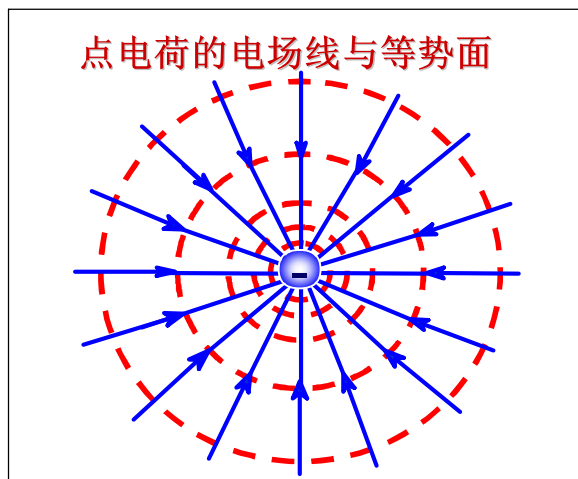
$$W_{AB} = q(V_A - V_B) = \int_a^b q\vec{E} \cdot d\vec{l} = 0$$

$$\therefore \vec{E} \perp d\vec{l}$$

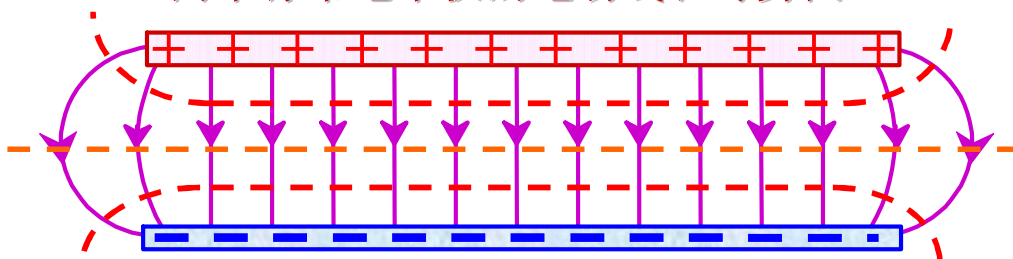
- ◆ 某点的电场强度与通过该点的等势面垂直。



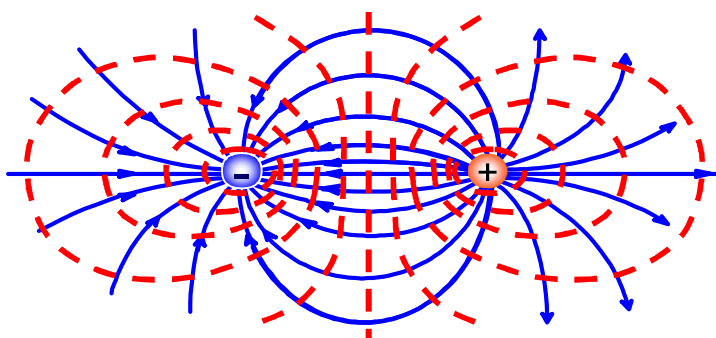
- ◆ 用等势面的**疏密**表示电场的强弱.
任意两**相邻**等势面间的**电势差相等**.
等势面越密的地方, 电场强度越大.



两平行带电平板的电场线和等势面



一对等量异号点电荷的电场线和等势面



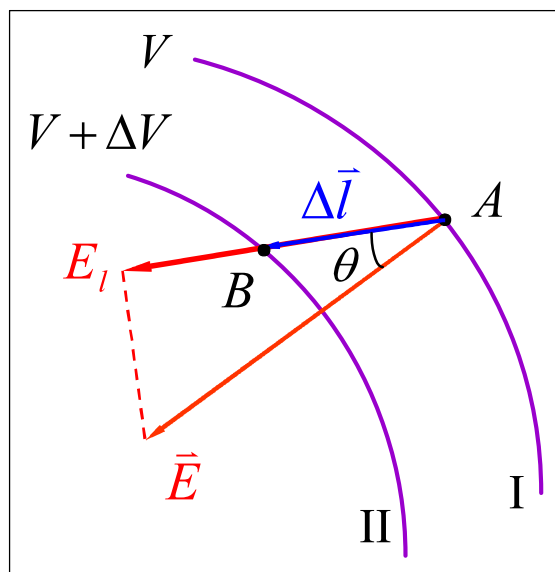
二 电场强度与电势梯度

$$\begin{aligned} -\Delta V &= \vec{E} \cdot \Delta \vec{l} \\ &= E \Delta l \cos \theta \end{aligned}$$

$$E \cos \theta = E_l$$

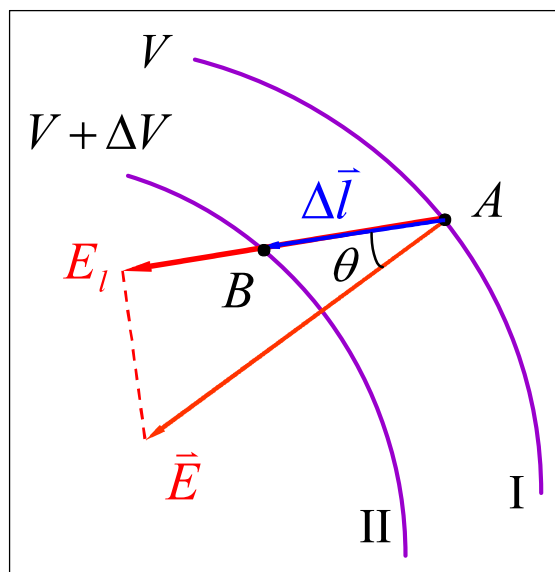
$$E_l = -\frac{\Delta V}{\Delta l}$$

$$E_l = -\lim_{\Delta l \rightarrow 0} \frac{\Delta V}{\Delta l} = -\frac{dV}{dl}$$



$$E_l = -\frac{dV}{dl}$$

电场中某一点的电场强度沿任一方向的分量，等于这一点的电势沿该方向单位长度上电势变化率的负值。

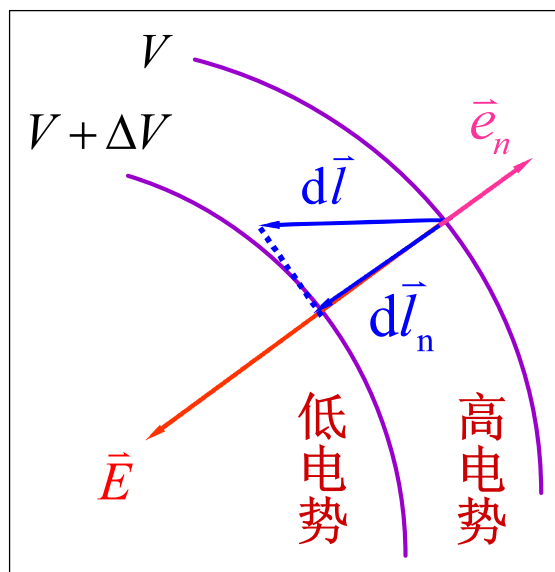


$$E_l = -\frac{dV}{dl} \quad E_n = -\frac{dV}{dl_n}$$

$$\because dl > dl_n \quad \therefore E_n > E_l$$

$$\vec{E} = -\frac{dV}{dl_n} \vec{e}_n$$

大小 $|\vec{E}| = \left| \frac{dV}{dl_n} \right|$
 方向 由高电势处指向低电势处



电场强度等于电势梯度的负值

$$\vec{E} = -\left(\frac{\partial V}{\partial x}\vec{i} + \frac{\partial V}{\partial y}\vec{j} + \frac{\partial V}{\partial z}\vec{k}\right) = -\text{grad}V = -\nabla V$$

求电场强度的三种方法

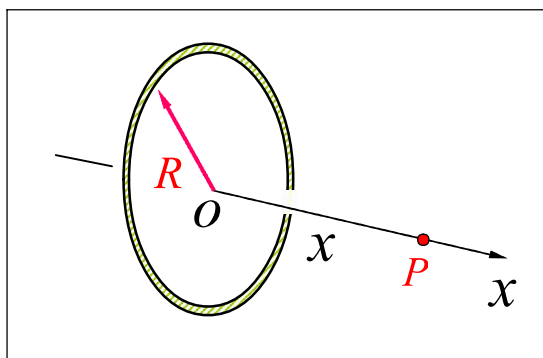
- 利用电场强度叠加原理
- 利用高斯定理
- 利用电势与电场强度的关系



例1 用电场强度与电势的关系，求均匀带电细圆环轴线上一点的电场强度。

解

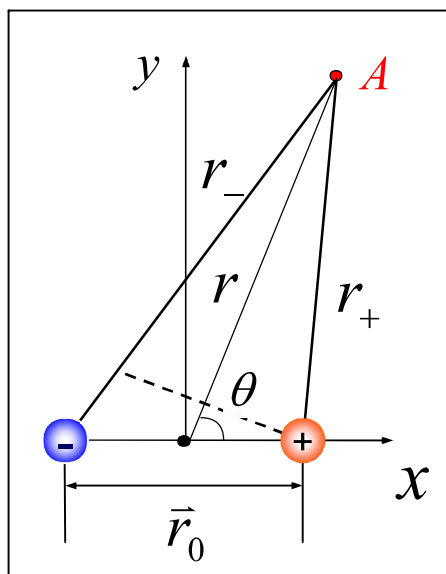
$$V = \frac{q}{4\pi\epsilon_0(x^2 + R^2)^{1/2}}$$
$$E = E_x = -\frac{\partial V}{\partial x}$$
$$= -\frac{\partial}{\partial x} \left[\frac{q}{4\pi\epsilon_0(x^2 + R^2)^{1/2}} \right]$$
$$= \frac{qx}{4\pi\epsilon_0(x^2 + R^2)^{3/2}}$$



例2 求电偶极子电场中任意一点A的电势和电场强度.

$$\text{解} \quad \left\{ \begin{array}{l} V_+ = \frac{1}{4\pi\epsilon_0} \frac{q}{r_+} \\ V_- = -\frac{1}{4\pi\epsilon_0} \frac{q}{r_-} \end{array} \right.$$

$$V = V_+ + V_- = \frac{q}{4\pi\epsilon_0} \frac{r_- - r_+}{r_+ r_-}$$

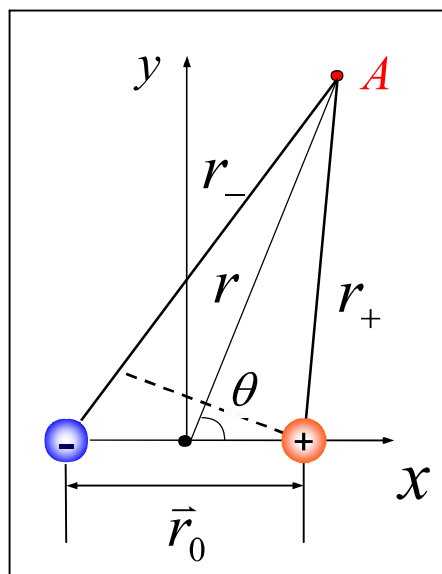


$$\because r_0 \ll r \quad \therefore r_- - r_+ \approx r_0 \cos \theta \quad r_- r_+ \approx r^2$$

$$V = V_+ + V_- = \frac{q}{4\pi\epsilon_0} \frac{r_- - r_+}{r_+ r_-}$$

$$\approx \frac{q}{4\pi\epsilon_0} \frac{r_0 \cos \theta}{r^2} = \frac{1}{4\pi\epsilon_0} \frac{p \cos \theta}{r^2}$$

$$\left. \begin{array}{l} \theta = 0 \\ \theta = \pi \\ \theta = \frac{\pi}{2} \end{array} \right\} \begin{array}{l} V \approx \frac{1}{4\pi\epsilon_0} \frac{p}{r^2} \\ V \approx -\frac{1}{4\pi\epsilon_0} \frac{p}{r^2} \\ V = 0 \end{array}$$

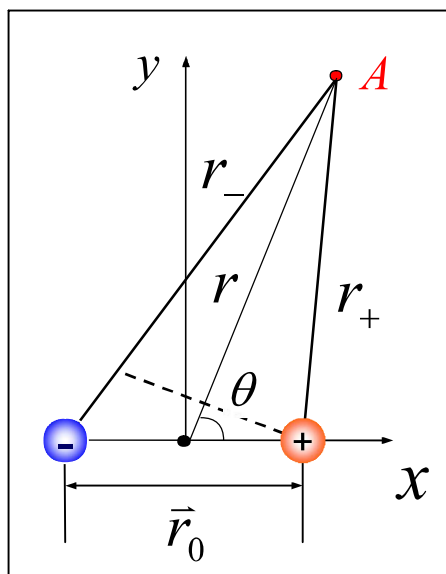


$$V = \frac{1}{4\pi\epsilon_0} \frac{p \cos\theta}{r^2} = \frac{p}{4\pi\epsilon_0} \frac{x}{(x^2 + y^2)^{3/2}}$$

$$E_x = -\frac{\partial V}{\partial x} = -\frac{p}{4\pi\epsilon_0} \frac{y^2 - 2x^2}{(x^2 + y^2)^{5/2}}$$

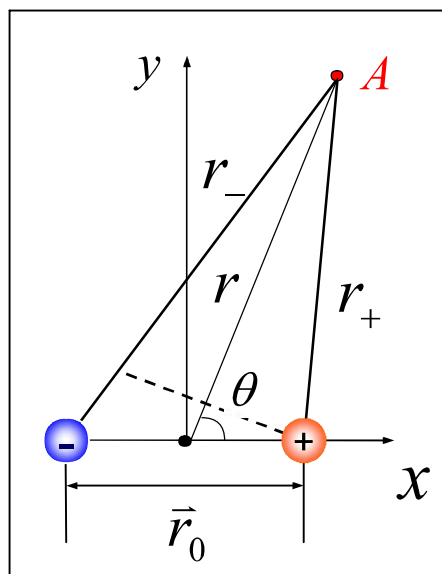
$$E_y = -\frac{\partial V}{\partial y} = \frac{p}{4\pi\epsilon_0} \frac{3xy}{(x^2 + y^2)^{5/2}}$$

$$E = \sqrt{E_x^2 + E_y^2}$$
$$= \frac{p}{4\pi\epsilon_0} \frac{(4x^2 + y^2)^{1/2}}{(x^2 + y^2)^2}$$



$$E = \frac{p}{4\pi\epsilon_0} \frac{(4x^2 + y^2)^{1/2}}{(x^2 + y^2)^2}$$

$$\left. \begin{array}{l} y = 0 \\ x = 0 \end{array} \right\} \begin{array}{l} E = \frac{2p}{4\pi\epsilon_0} \frac{1}{x^3} \\ E = \frac{p}{4\pi\epsilon_0} \frac{1}{y^3} \end{array}$$



选择进入下一节:

- 5-0 教学基本要求
- 5-1 电荷量子化 电荷守恒定律
- 5-2 库仑定律
- 5-3 电场强度
- 5-4 电场强度通量 高斯定理
- *5-5 密立根测定电子电荷的实验

