一　静电场力所做的功

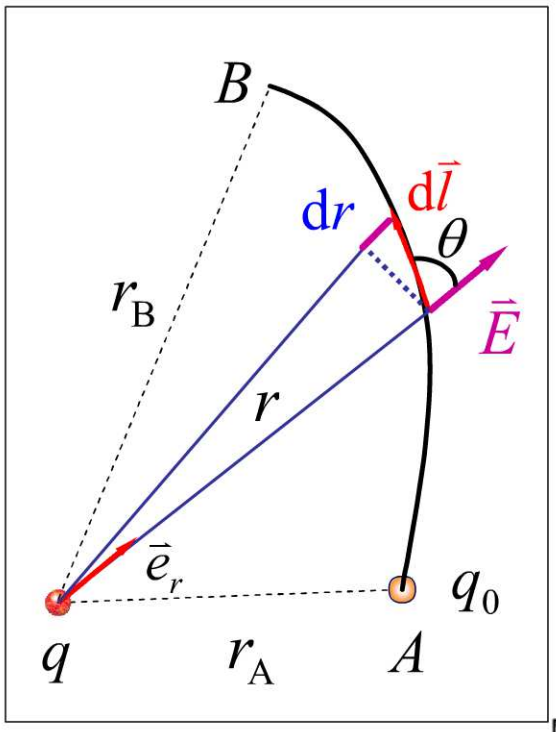
- 点电荷的电场

$$\mathrm{d}W = q_0\vec{E}\cdot\mathrm{d}\vec{l}$$

$$= \frac{qq_0}{4\pi\varepsilon_0 r^2}\vec{e}_r\cdot\mathrm{d}\vec{l}$$

$$\vec{e}_r\cdot\mathrm{d}\vec{l} = \mathrm{d}l\cos\theta = \mathrm{d}r$$

$$\mathrm{d}W = \frac{qq_0}{4\pi\varepsilon_0 r^2}\mathrm{d}r$$

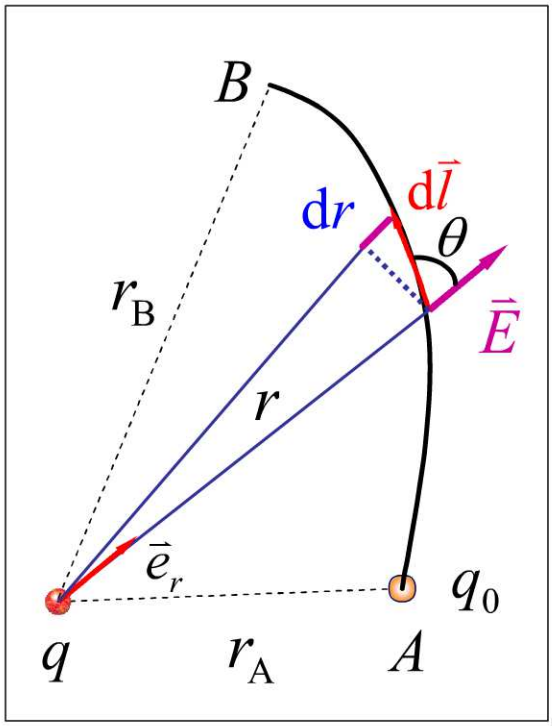


$$\mathrm{d}W = \frac{qq_0}{4\pi\varepsilon_0 r^2}\mathrm{d}r$$

$$W = \frac{qq_0}{4\pi\varepsilon_0}\int_{r_A}^{r_B}\frac{\mathrm{d}r}{r^2}$$

$$= \frac{qq_0}{4\pi\varepsilon_0}\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$$

结论：W仅与q_0的始末位置有关，与路径无关.



- 任意带电体的电场（点电荷的组合）

$$\vec{E}=\sum_i \vec{E}_i$$

$$W=q_0\int\vec{E}\cdot\mathrm{d}\vec{l}=\sum_i q_0\int\vec{E}_i\cdot\mathrm{d}\vec{l}$$

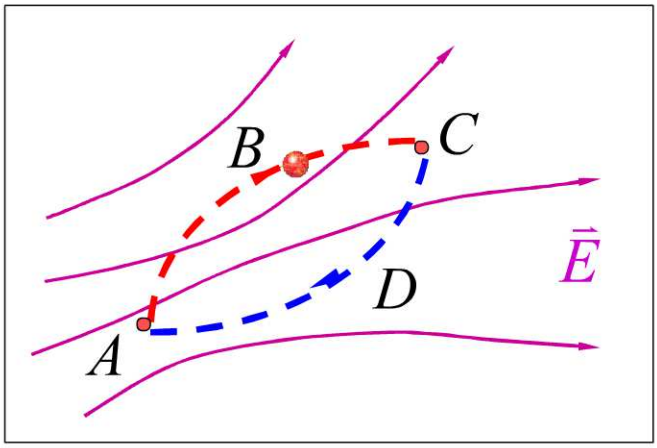
结论：静电场力做功，与路径无关.

二 静电场的环路定理

$$q_0\int_{ABC}\vec{E}\cdot d\vec{l}=q_0\int_{ADC}\vec{E}\cdot d\vec{l}$$

$$q_0\left(\int_{ABC}\vec{E}\cdot d\vec{l}+\int_{CDA}\vec{E}\cdot d\vec{l}\right)=0$$

$$\oint_l \vec{E}\cdot d\vec{l}=0$$

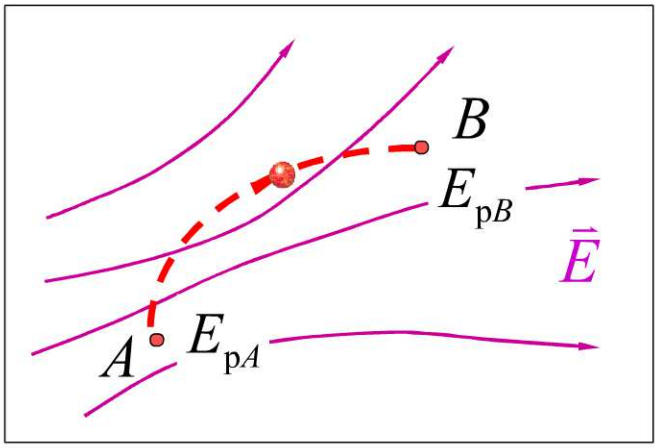


结论： 沿闭合路径一周，电场力作功为零.

静电场是保守场

三　电势能

静电场是保守场，静电场力是保守力. 静电场力所做的功就等于电荷电势能增量的负值.



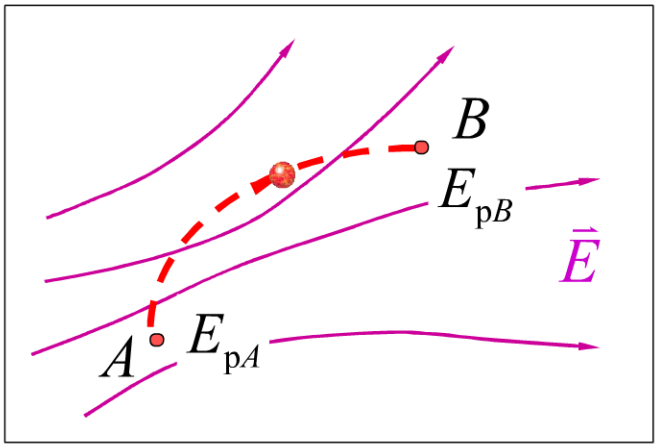
$$W_{AB} = E_{pA} - E_{pB} = -(E_{pB} - E_{pA})$$

电场力做正功，电势能减少.

$$\int_{AB} q_0 \vec{E} \cdot \mathrm{d}\vec{l} = E_{pA} - E_{pB} = -(E_{pB} - E_{pA})$$

令 $E_{pB} = 0$

$$E_{pA} = \int_{AB} q_0 \vec{E} \cdot \mathrm{d}\vec{l}$$



试验电荷q_0在电场中某点的电势能，在数值上等于把它从该点移到零势能处静电场力所作的功.