一 孤立导体的电容

孤立导体的电容为孤立导体所带电荷Q与其电势V的比值.

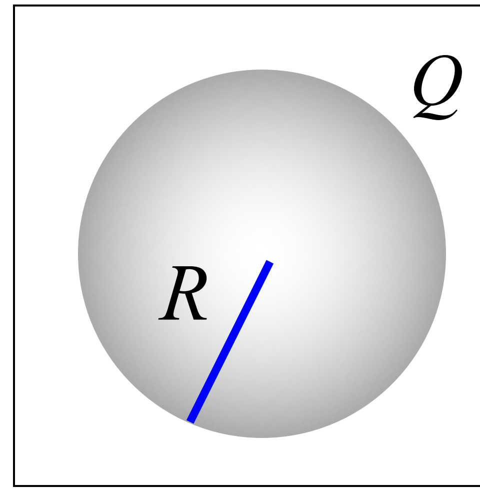
$$\boxed{C = \frac{Q}{V}}$$

单位： $1\,\mathrm{F} = 1\,\mathrm{C}\cdot\mathrm{V}^{-1}$

$$1\,\mathrm{F} = 10^{6}\,\mu\mathrm{F} = 10^{12}\,\mathrm{pF}$$

例 球形孤立导体的电容

$$V=\frac{Q}{4\pi\varepsilon_0 R}$$



$$C=\frac{Q}{V}=4\pi\varepsilon_0 R$$

- 地球 $R_\mathrm{E}=6.4\times10^{6}\ \mathrm{m},\quad C_\mathrm{E}\approx7\times10^{-4}\ \mathrm{F}$

二 电容器

1 电容器的分类

按形状：柱型、球型、平行板电容器

按型式：固定、可变、半可变电容器

按介质：空气、塑料、云母、陶瓷等

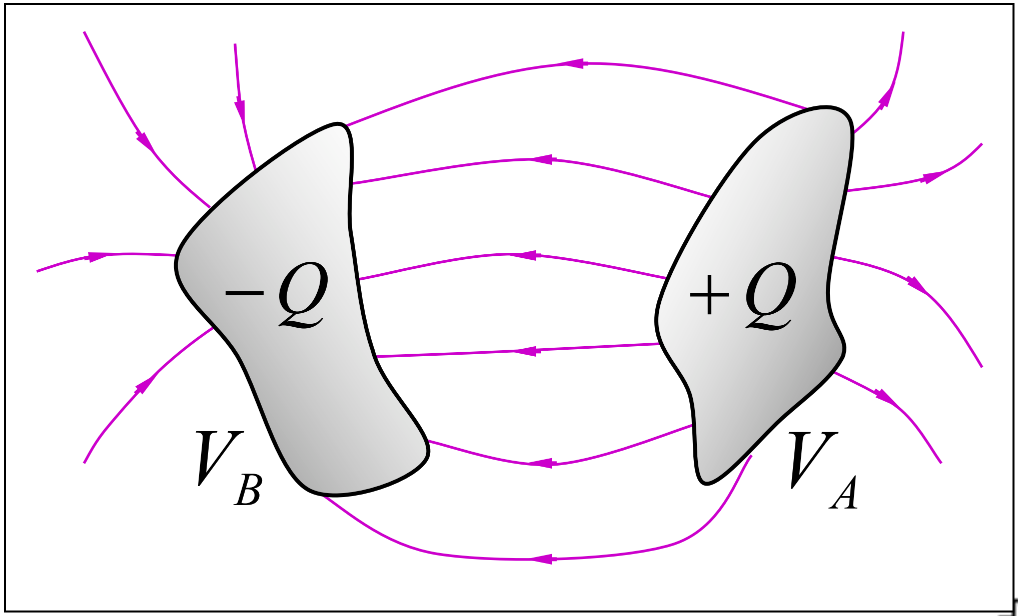
特点：非孤立导体，由两极板组成

2 电容器的电容

电容器的电容为电容器一块极板所带电荷Q与两极板电势差 $V_A - V_B$ 的比值．

$$C = \frac{Q}{V_A - V_B} = \frac{Q}{U}$$

$$U = \int_{AB} \vec{E} \cdot \mathrm{d}\vec{l}$$

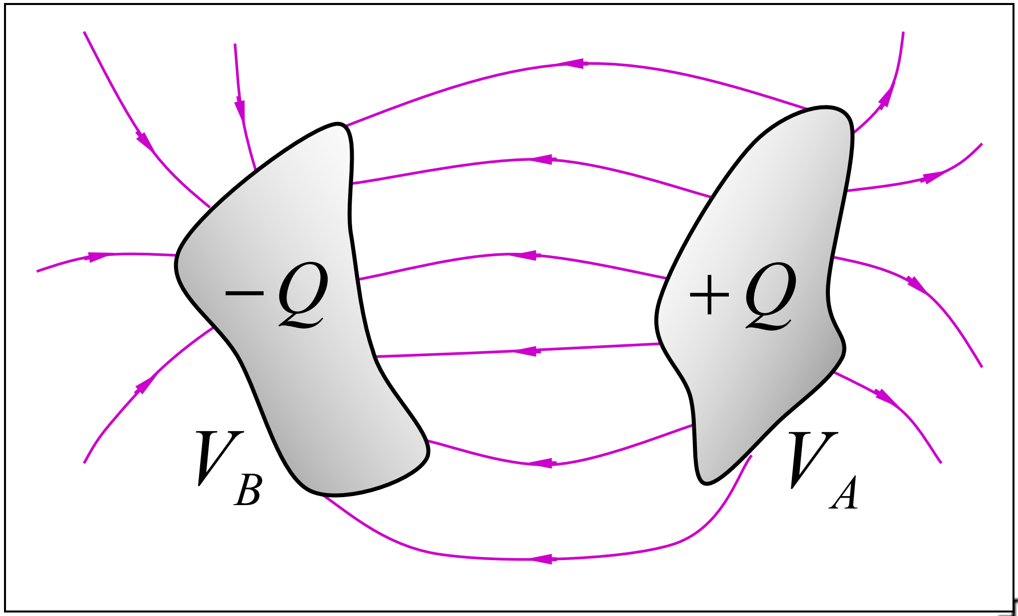


注意

电容的大小仅与导体的形状、相对位置、其间的电介质有关，与所带电荷量无关.

$$C=\frac{Q}{V_A-V_B}=\frac{Q}{U}$$

$$U=\int_{AB}\vec{E}\cdot\mathrm{d}\vec{l}$$



3 电容器电容的计算

步骤

$$C=\frac{Q}{V_A-V_B}=\frac{Q}{U}$$

（1）设两极板分别带电$\pm Q$

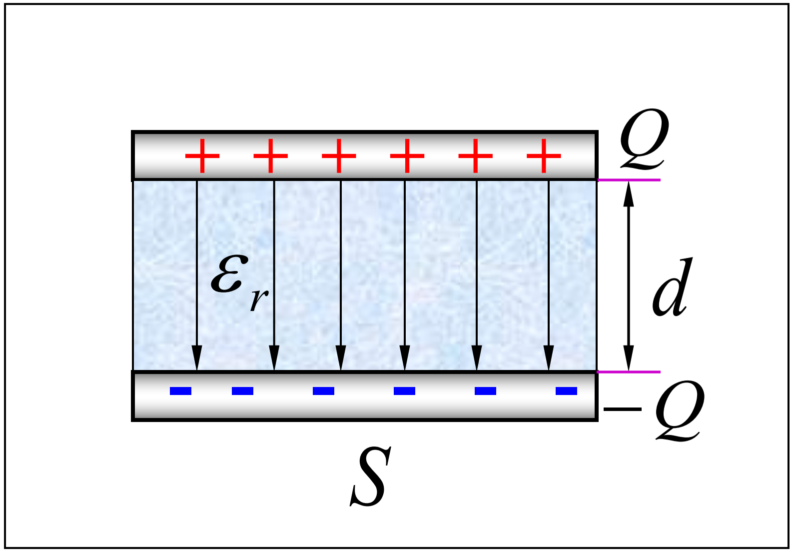
（2）求两极板间的电场强度$\vec{E}$

（3）求两极板间的电势差U

（4）由$C=Q/U$求C

例1 平行平板电容器

解 $$E=\frac{\sigma}{\varepsilon_0\varepsilon_r}=\frac{Q}{\varepsilon_0\varepsilon_r S}$$



$$U=Ed=\frac{Qd}{\varepsilon_0\varepsilon_r S}$$

$$\boxed{C=\frac{Q}{U}=\frac{\varepsilon_0\varepsilon_r S}{d}}$$

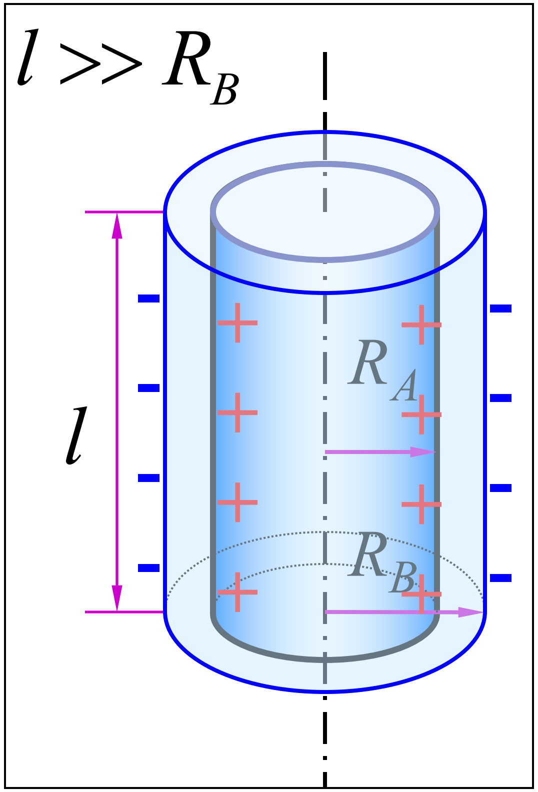
例2 圆柱形电容器

解 设两圆柱面单位长度上分别带电$\pm\lambda$

$$E=\frac{\lambda}{2\pi\varepsilon_0 r}\quad(R_A<r<R_B)$$

$$U=\int_{R_A}^{R_B}\frac{\lambda\mathrm{d}r}{2\pi\varepsilon_0 r}=\frac{Q}{2\pi\varepsilon_0 l}\ln\frac{R_B}{R_A}$$

$$\boxed{C=\frac{Q}{U}=\frac{2\pi\varepsilon_0 l}{\ln\dfrac{R_B}{R_A}}}$$

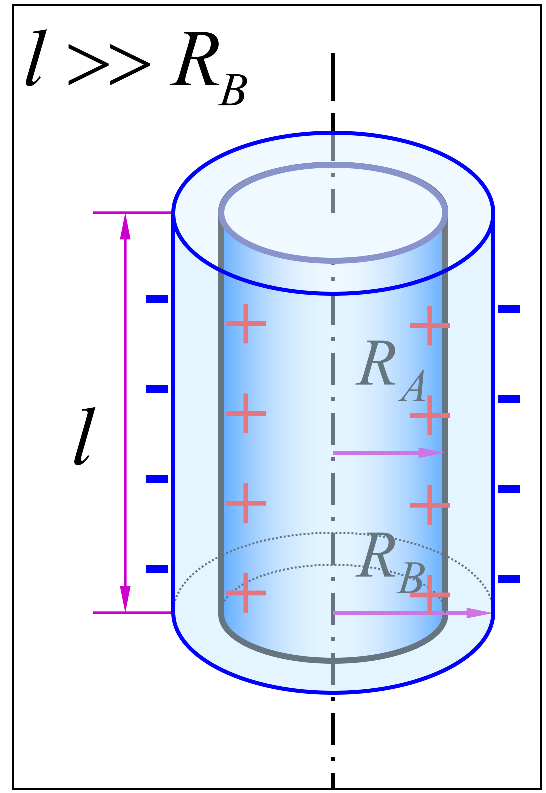


$$C=\frac{Q}{U}=\frac{2\pi\varepsilon_0 l}{\ln\dfrac{R_B}{R_A}}$$

$$d=R_B-R_A\ll R_A$$

$$C\approx\frac{2\pi\varepsilon_0 lR_A}{d}=\frac{\varepsilon_0 S}{d}$$

平行板电容器电容



例3 球形电容器的电容

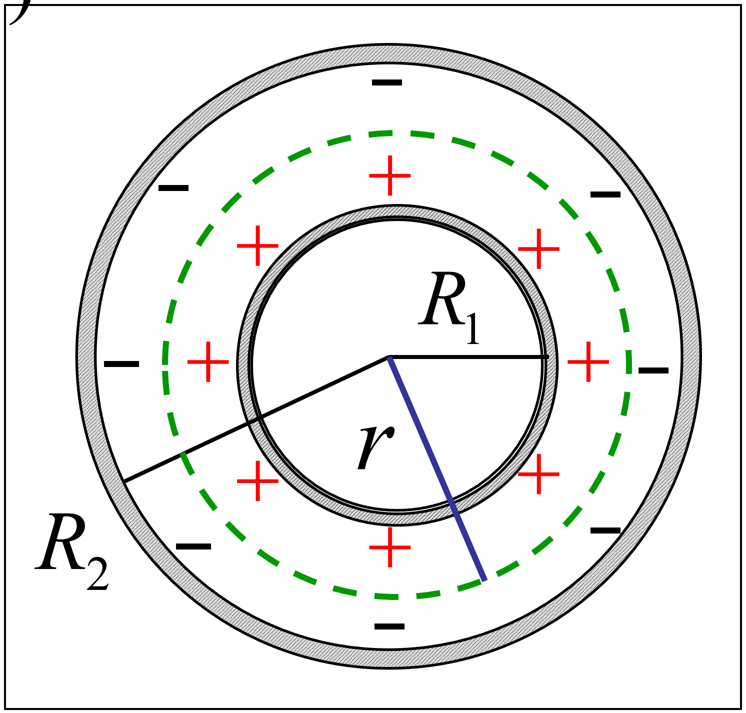
解 设内外球带分别带电$\pm Q$

$$E=\frac{Q}{4\pi\varepsilon_0 r^2}\ (R_1<r<R_2)$$

$$U=\int_l \vec{E}\cdot\mathrm{d}\vec{l}$$

$$=\frac{Q}{4\pi\varepsilon_0}\int_{R_1}^{R_2}\frac{\mathrm{d}r}{r^2}$$

$$=\frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$



6-4 电容 电容器

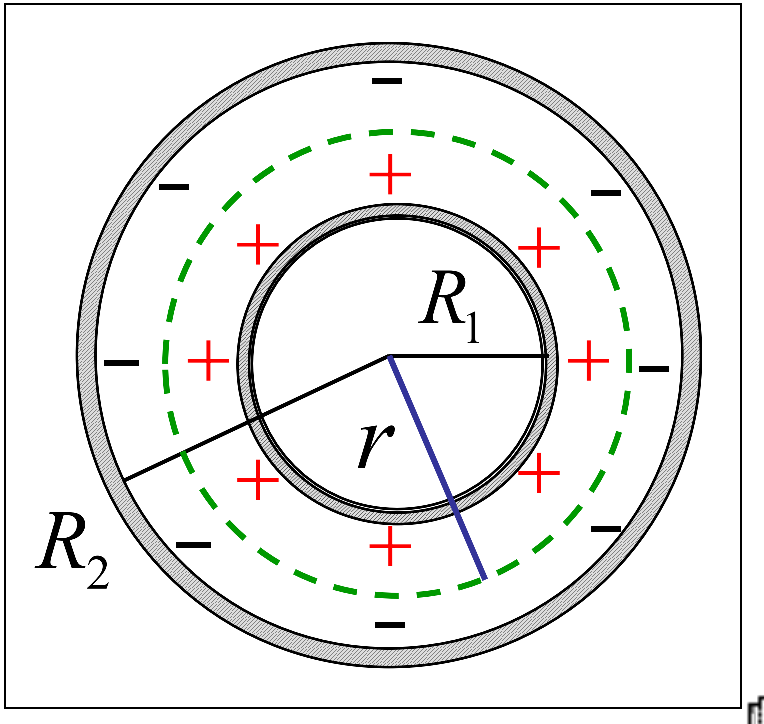
$$U=\frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$C=\frac{Q}{U}=4\pi\varepsilon_0\frac{R_1R_2}{R_2-R_1}$$

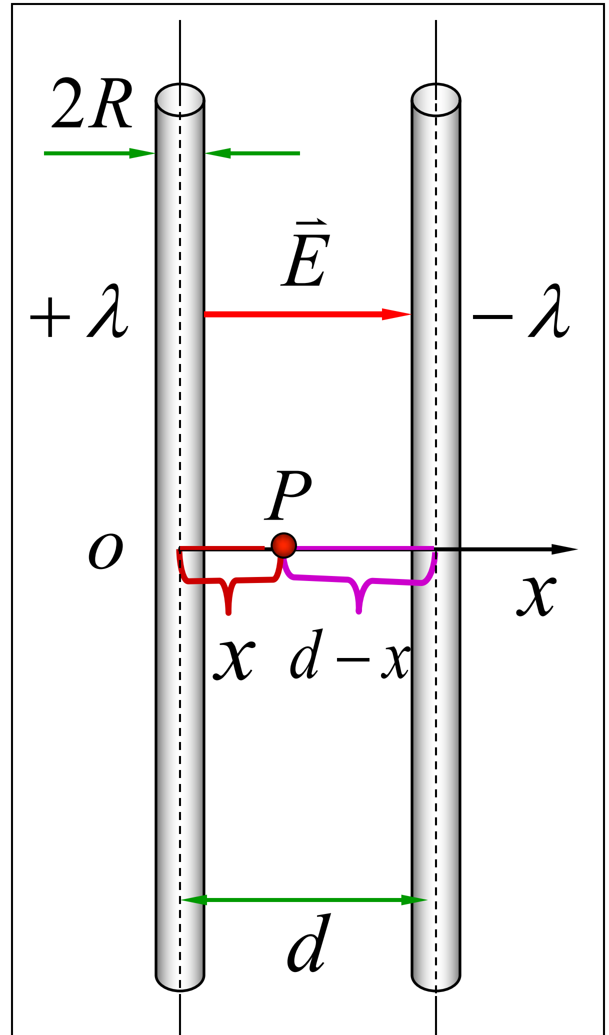
$$R_2\to\infty$$

$$C=4\pi\varepsilon_0R_1$$

孤立导体球电容



例4 两半径为R的平行长直导线，中心间距为d，且$d>>R$，求单位长度的电容.



解 设两金属线的电荷线密度为$\pm\lambda$

$$E = E_{+} + E_{-}$$

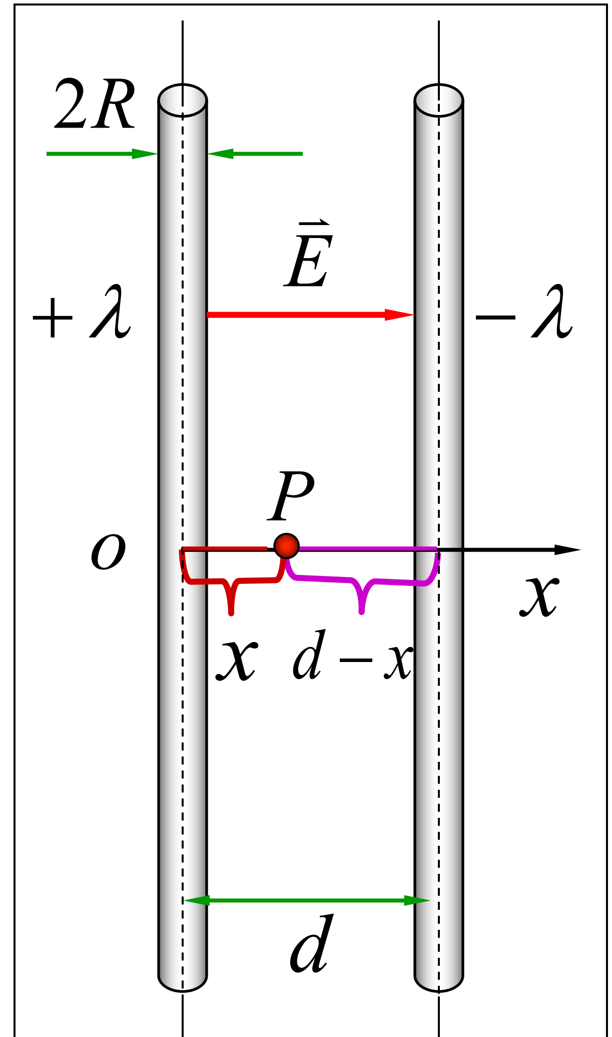
$$= \frac{\lambda}{2\pi\varepsilon_0 x} + \frac{\lambda}{2\pi\varepsilon_0 (d-x)}$$

$$U=\int_{R}^{d-R}E\mathrm{d}x$$

$$=\frac{\lambda}{2\pi\varepsilon_0}\int_{R}^{d-R}\left(\frac{1}{x}+\frac{1}{d-x}\right)\mathrm{d}x$$

$$=\frac{\lambda}{\pi\varepsilon_0}\ln\frac{d-R}{R}\approx\frac{\lambda}{\pi\varepsilon_0}\ln\frac{d}{R}$$

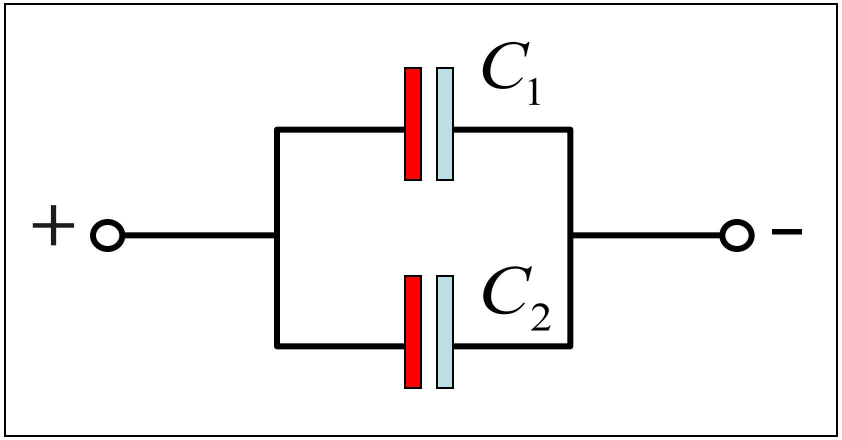
$$C=\frac{\lambda}{U}=\frac{\pi\varepsilon_0}{\ln\frac{d}{R}}$$



三 电容器的并联和串联

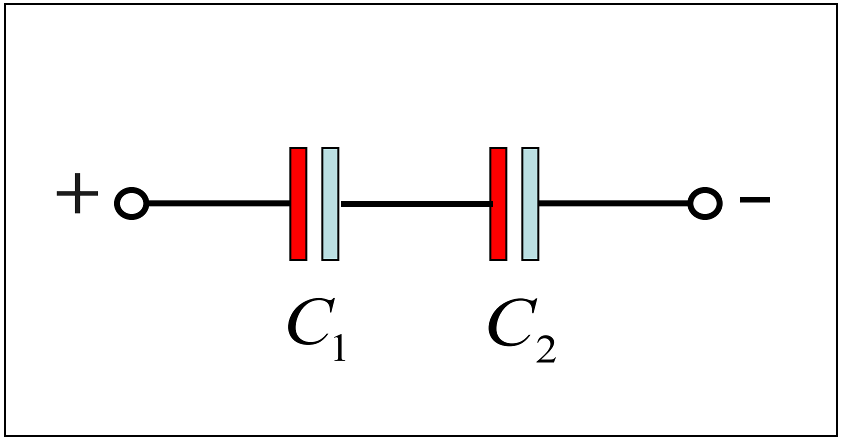
1 电容器的并联

$$C = C_1 + C_2$$



2 电容器的串联

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$



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