1. Superpositionsprinzip

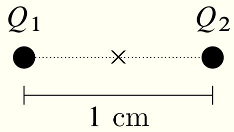
$$q = -1.0 * 10^{-9}\ \mathrm{C};\quad Q = 8.0 * 10^{-6}\ \mathrm{C};\quad k = \frac{1}{4\pi\epsilon_0};\quad \vec{F} = k\,\frac{q_1 q_2}{r^2}\,\vec{r}$$

(a) $d = 0.01\ \mathrm{m};\quad r = \frac{d}{2};\quad Q_1 = Q;\quad Q_2 = -Q$

$$\vec{F}_1 = k\,\frac{qQ_1}{r^2}\begin{pmatrix}-1\\0\end{pmatrix}$$

$$\vec{F}_2 = k\,\frac{qQ_2}{r^2}\begin{pmatrix}1\\0\end{pmatrix}$$

$$\vec{F}_{ges} = \vec{F}_1 + \vec{F}_2 = \underline{\underline{\begin{pmatrix}-5.75\\0\end{pmatrix}\ \mathrm{N}}}$$



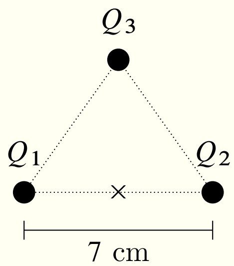
(b) $d = 0.07\ \mathrm{m};\quad r = \frac{d}{2};\quad h = \sqrt{3}r;\quad Q_1 = Q_3 = Q;\quad Q_2 = -Q$

$$\vec{F}_1 = k\,\frac{qQ_1}{r^2}\begin{pmatrix}-1\\0\end{pmatrix}$$

$$\vec{F}_2 = k\,\frac{qQ_2}{r^2}\begin{pmatrix}1\\0\end{pmatrix}$$

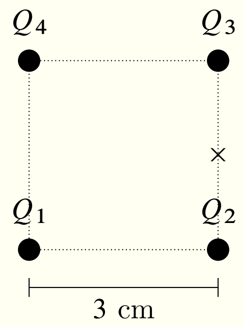
$$\vec{F}_3 = k\,\frac{qQ_3}{h^2}\begin{pmatrix}0\\-1\end{pmatrix}$$

$$\vec{F}_{ges} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \underline{\underline{\begin{pmatrix}-0.12\\0.020\end{pmatrix}\ \mathrm{N}}}$$



(c) $d = 0.03\ \mathrm{m};\quad r = \frac{d}{2};\quad s = \sqrt{5}r;\quad Q_1 = Q_3 = Q;\quad Q_2 = Q_4 = -Q$

$$\vec{F}_1 = k\,\frac{qQ_1}{s^2}\begin{pmatrix} d \\ r \end{pmatrix}\frac{1}{s}$$
$$\vec{F}_2 = k\,\frac{qQ_2}{r^2}\begin{pmatrix} 0 \\ 1 \end{pmatrix}$$
$$\vec{F}_3 = k\,\frac{qQ_3}{r^2}\begin{pmatrix} 0 \\ -1 \end{pmatrix}$$
$$\vec{F}_4 = k\,\frac{qQ_4}{s^2}\begin{pmatrix} d \\ -r \end{pmatrix}\frac{1}{s}$$
$$\vec{F}_{ges} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \underline{\underline{\begin{pmatrix} 0 \\ 0.58 \end{pmatrix}\ \mathrm{N}}}$$

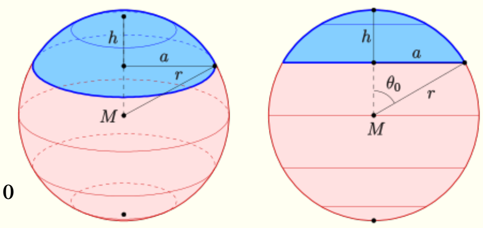


2. Sonnenwind und Ladungsneutralität

$$m = 10^{16}\ \mathrm{kg};\quad k = \frac{1}{4\pi\epsilon_0};\quad \vec{F} = k\,\frac{q_1 q_2}{r^2}\,\vec{r}$$

(a) $d = 1$ AU; $\quad a = r_{Earth}$; $\quad r = \sqrt{d^2 + a^2}$; $\quad \theta_0 = \arctan\left(\frac{a}{d}\right)$

$$A = 4\pi d^2$$
$$O = 2\pi r^2\left(1 - \cos(\theta_0) + \tfrac{1}{2}\sin^2(\theta_0)\right)$$
$$\frac{O}{A} = \frac{r^2\left(1-\cos(\theta_0)+\frac{1}{2}\sin^2(\theta_0)\right)}{2d^2} = 9.1 * 10^{-10}$$
$$M = m\,\frac{O}{A} = \underline{\underline{9.1 * 10^6\ \mathrm{kg}}}$$



(b) $m_P = m_{Proton}$; $\quad q_e = q_{elementary}$; $\quad m_a = m_{Earth}$

$$N = \frac{M}{m_P} \qquad \text{(Amount of Protons)}$$
$$Q = N q_e \qquad \text{(Total Charge of Protons)}$$
$$F_C = k\,\frac{Q^2}{d^2} \qquad \text{(Coulomb Force felt by Earth)}$$
$$a_\perp = \frac{F_C}{m_a} \qquad \text{(Centripetal Accel. felt by Earth)}$$
$$T = 2\pi\sqrt{\frac{d}{a_\perp}} = \underline{\underline{7.03 * 10^7\ \mathrm{s}}}$$

(c) If the solar wind consisted of electrons the observed effect would be the same, only of an entirely different order of magnitude, as the mass of an electron is 10^{10} times smaller than the protons mass. Performing the same calculations outlined above I come to the conclusion that a purely electron-based stream of particles would lead to an orbital period of just over 10 h 30 min. Thank god we have a magnetic field shielding us ...

3. Millikan Versuch

$$r = 1.64 * 10^{-6}\ \mathrm{m}; \quad \rho = 851\ \mathrm{kg/m^3}$$

(a) $V_{Sphere} = \frac{4}{3}\pi r^3; \quad m = V * \rho$

$$m = \frac{4}{3}\pi r^3 \rho = \underline{\underline{1.57 * 10^{-14}\ \mathrm{kg}}}$$

(b) $E_0 = \frac{F_C}{q} = 1.92\ \mathrm{N/C}; \quad F_G = mg$

$$\begin{aligned} F_G &= F_C \\ q &= \frac{mg}{E_0} \\ &= 8.03 * 10^{-14}\ \mathrm{C} = \underline{\underline{5.01 * 10^5 q_e}} \end{aligned}$$