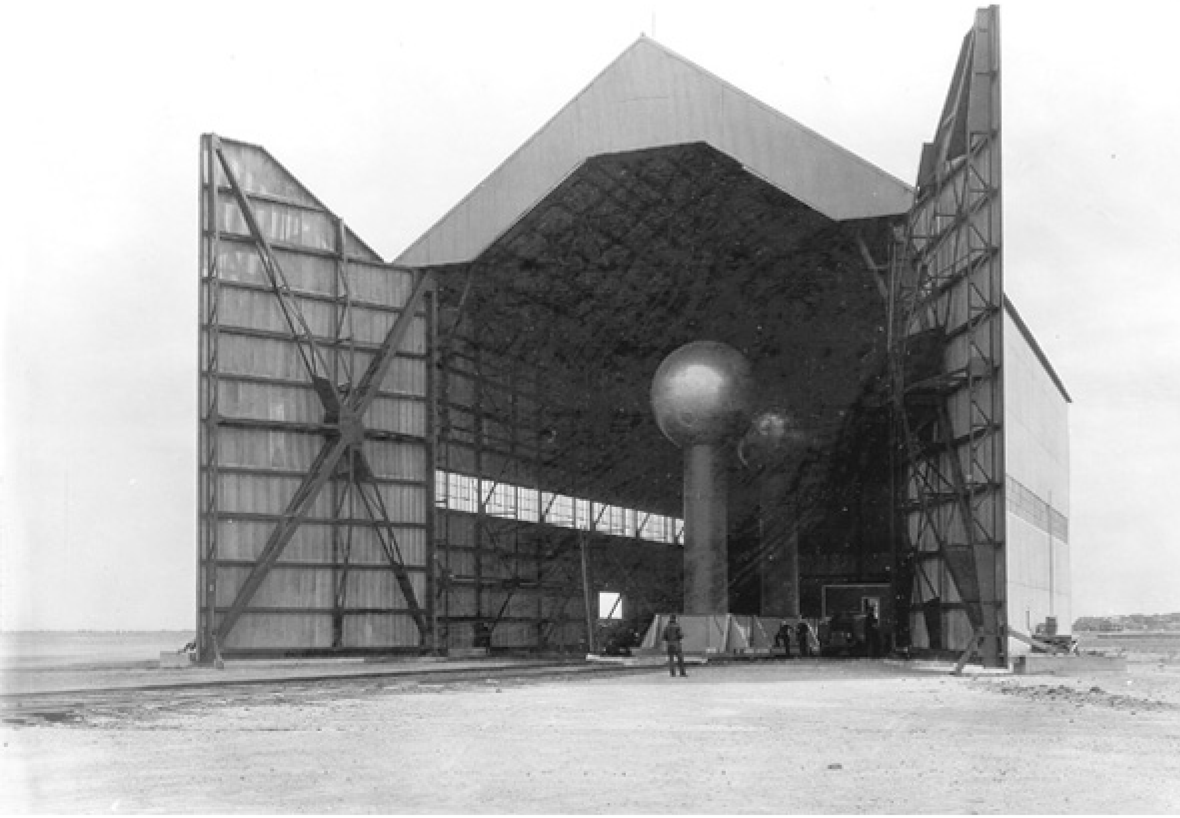
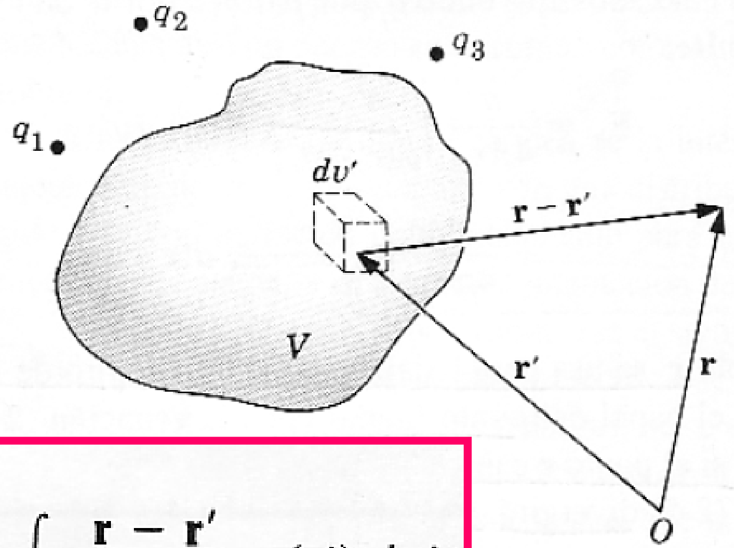
Electricidad



Generador de Van der Graff

Repaso

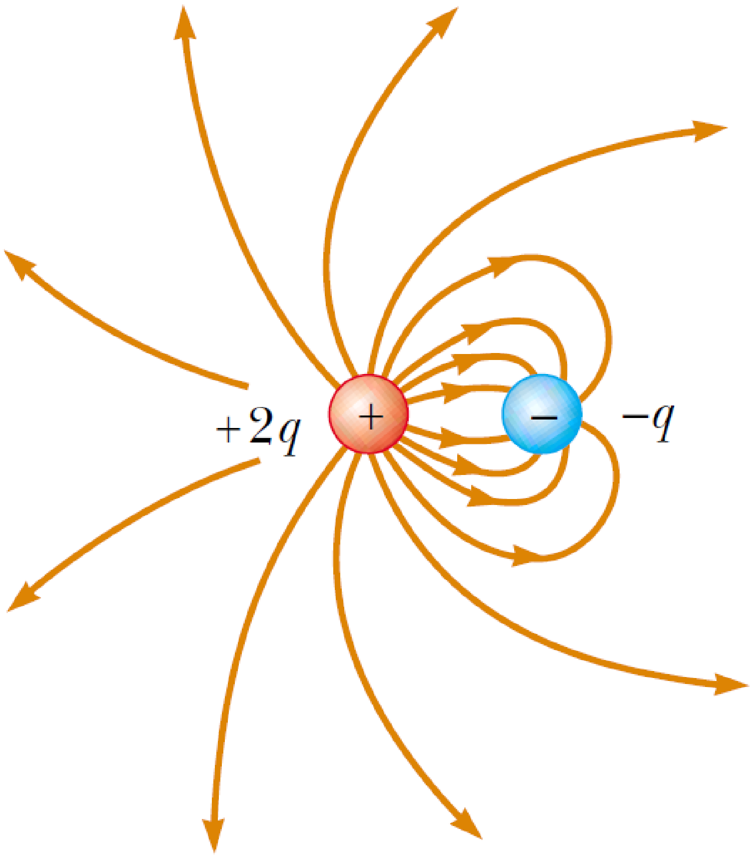
$$\mathbf{E} = \lim_{q \to 0} \frac{\mathbf{F}_q}{q}$$



$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0} \sum_{i=1}^{N} q_i \frac{\mathbf{r} - \mathbf{r}_i}{|\mathbf{r} - \mathbf{r}_i|^3} + \frac{1}{4\pi\epsilon_0} \int_V \frac{\mathbf{r} - \mathbf{r}'}{|\mathbf{r} - \mathbf{r}'|^3} \rho(\mathbf{r}')\, dv' + \frac{1}{4\pi\epsilon_0} \int_S \frac{\mathbf{r} - \mathbf{r}'}{|\mathbf{r} - \mathbf{r}'|^3} \sigma(\mathbf{r}')\, da'.$$

El campo eléctrico es una propiedad de la distribución de carga y no representa una "interacción".

Líneas de Fuerza

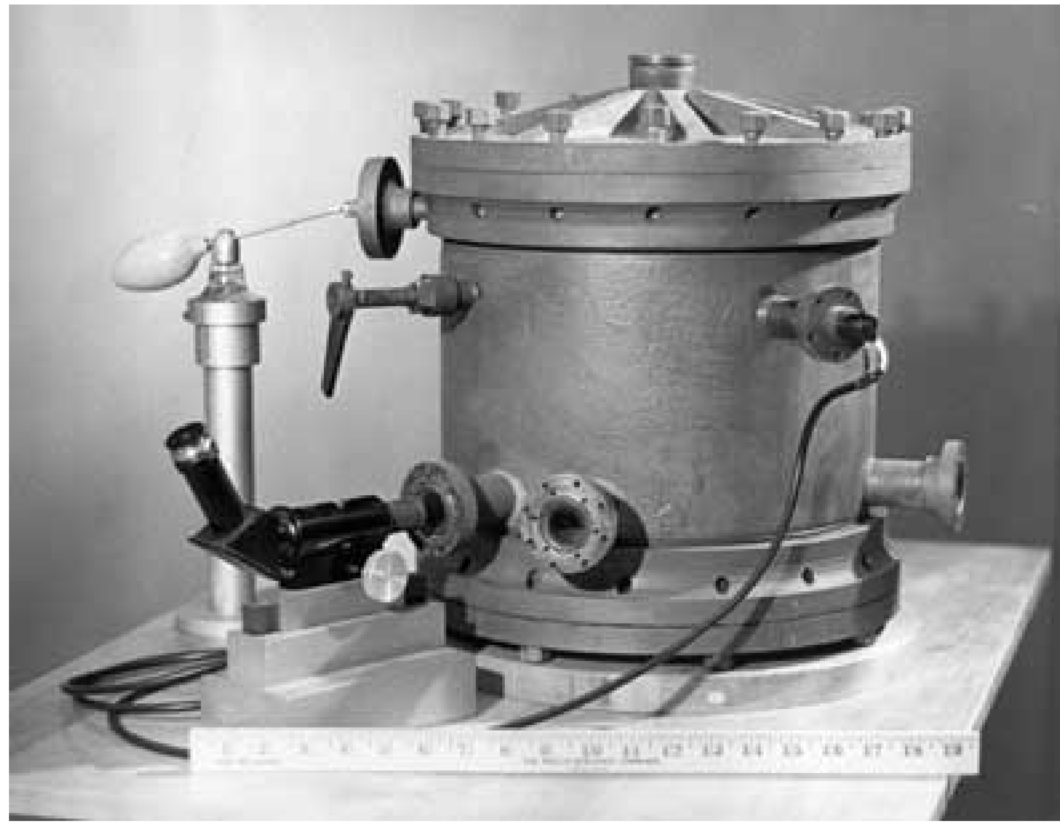


Las líneas de fuerza NO REPRESENTAN TRAYECTORIAS

Las líneas de fuerza NO PUEDEN CRUZARSE

Experimento de Millikan (1909-1913)

(1868-1953)



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THE

PHYSICAL REVIEW

THE ISOLATION OF AN ION, A PRECISION MEASUREMENT OF ITS CHARGE, AND THE CORRECTION OF STOKES'S LAW.[1]

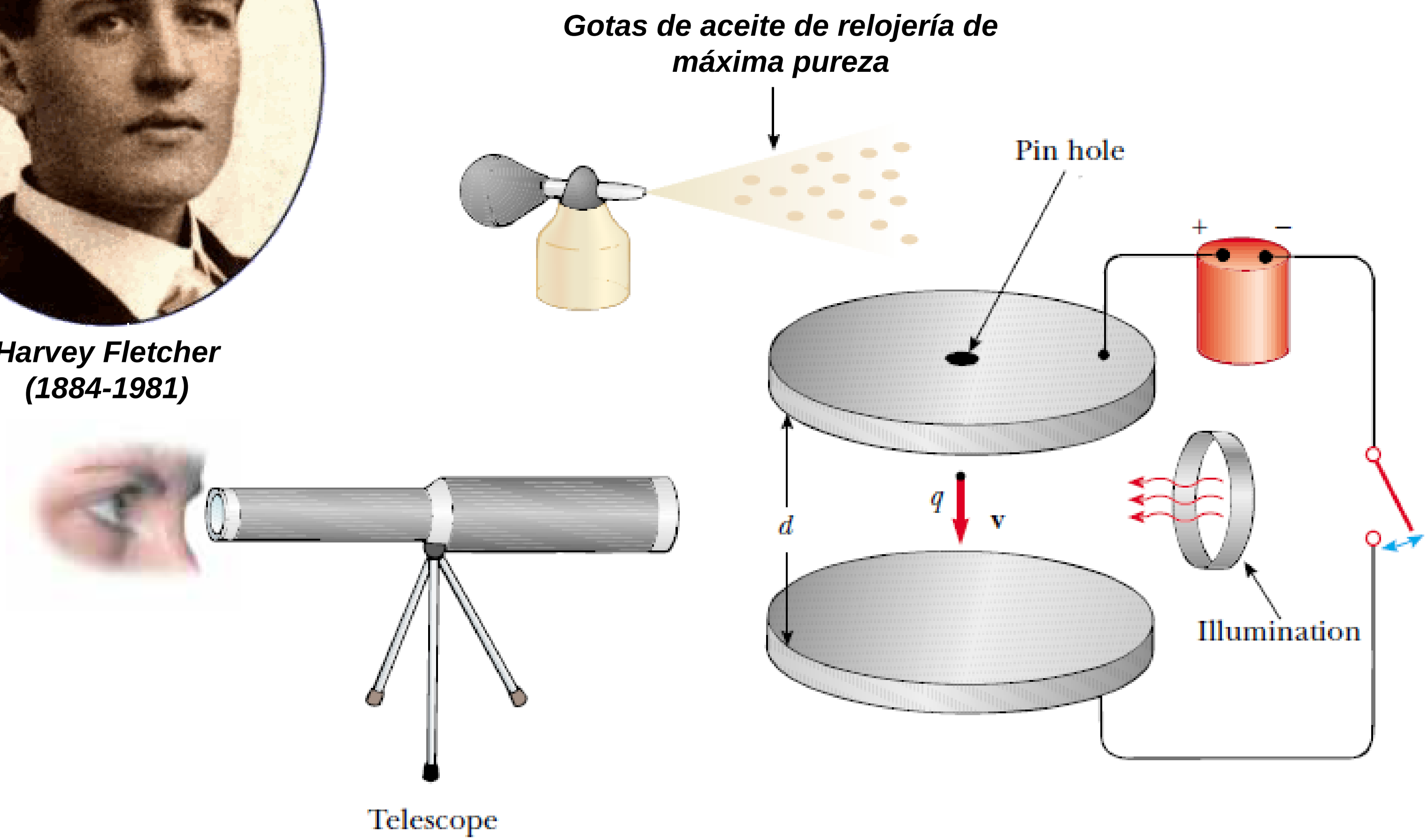
BY R. A. MILLIKAN.

§ 1. INTRODUCTION.

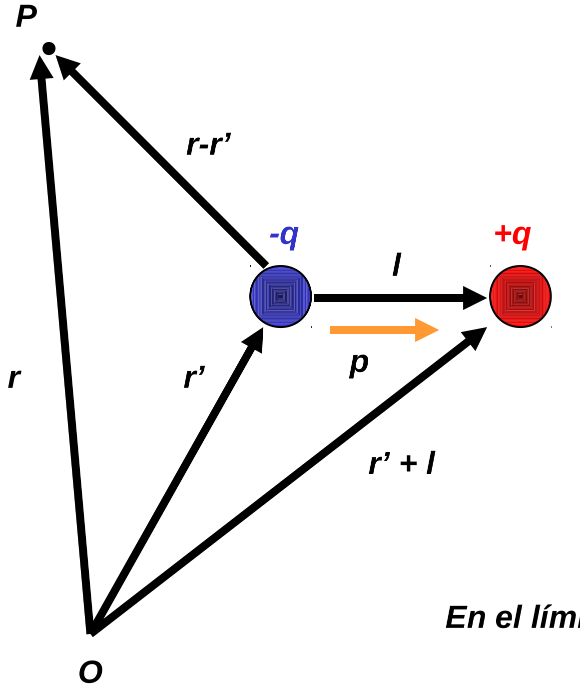
IN a preceding paper[2] a method of measuring the elementary electrical charge was presented which differed essentially from methods which had been used by earlier observers only in that all

Experimento de Millikan

***Harvey Fletcher* (1884-1981)**



Dipolo Eléctrico



$$\mathbf{E}(\mathbf{r}) = \frac{q}{4\pi\epsilon_0}\left\{\frac{\mathbf{r}-\mathbf{r}'-\boldsymbol{l}}{|\mathbf{r}-\mathbf{r}'-\boldsymbol{l}|^3} - \frac{\mathbf{r}-\mathbf{r}'}{|\mathbf{r}-\mathbf{r}'|^3}\right\}$$

$$|\mathbf{r}-\mathbf{r}'-\boldsymbol{l}|^{-3} = [(\mathbf{r}-\mathbf{r}')^2 - 2(\mathbf{r}-\mathbf{r}')\cdot\boldsymbol{l} + \boldsymbol{l}^2]^{-3/2}$$
$$= |\mathbf{r}-\mathbf{r}'|^{-3}\left[1 - \frac{2(\mathbf{r}-\mathbf{r}')\cdot\boldsymbol{l}}{|\mathbf{r}-\mathbf{r}'|^2} + \frac{\boldsymbol{l}^2}{|\mathbf{r}-\mathbf{r}'|^2}\right]^{-3/2}$$

En el límite l/r <<1

$$|\mathbf{r}-\mathbf{r}'-\boldsymbol{l}|^{-3} = |\mathbf{r}-\mathbf{r}'|^{-3}\left\{1 + \frac{3(\mathbf{r}-\mathbf{r}')\cdot\boldsymbol{l}}{|\mathbf{r}-\mathbf{r}'|^2} + \cdots\right\}$$

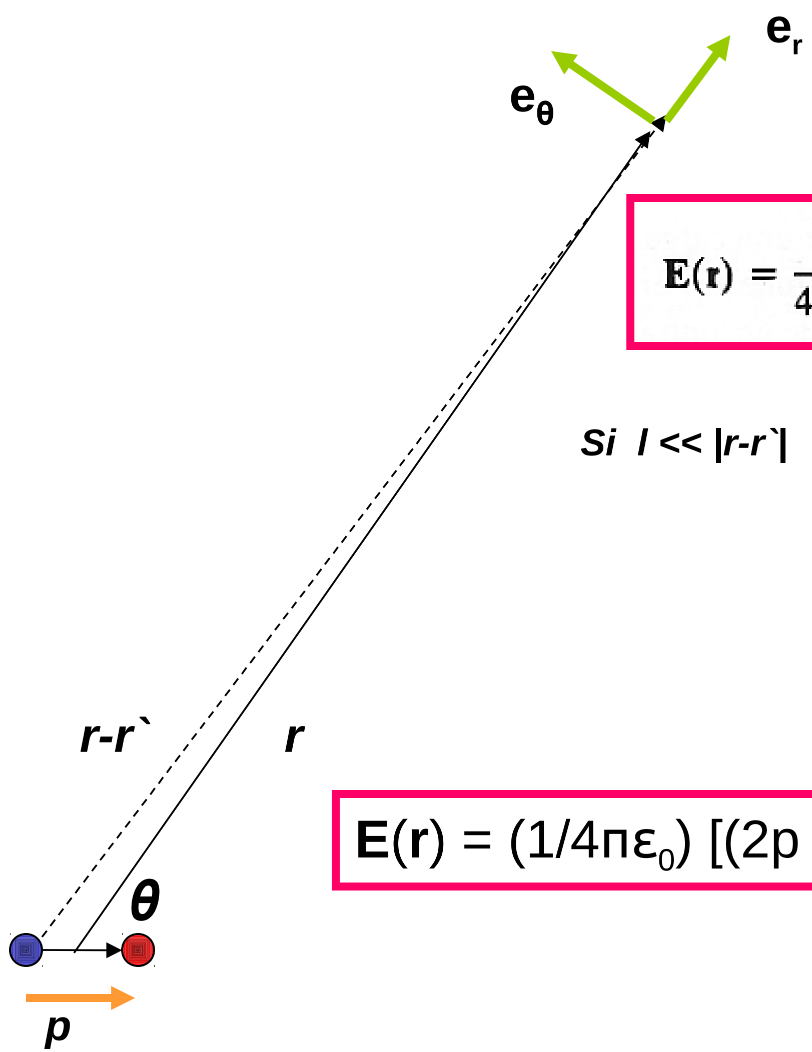
$$\mathbf{E}(\mathbf{r}) = \frac{q}{4\pi\epsilon_0}\left\{\frac{3(\mathbf{r}-\mathbf{r}')\cdot\boldsymbol{l}}{|\mathbf{r}-\mathbf{r}'|^5}(\mathbf{r}-\mathbf{r}') - \frac{\boldsymbol{l}}{|\mathbf{r}-\mathbf{r}'|^3} + \cdots\right\}$$

Se define el Momento Dipolar Eléctrico $\mathbf{p} = q\boldsymbol{l}$

$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\left\{\frac{3(\mathbf{r}-\mathbf{r}')\cdot\mathbf{p}}{|\mathbf{r}-\mathbf{r}'|^5}(\mathbf{r}-\mathbf{r}') - \frac{\mathbf{p}}{|\mathbf{r}-\mathbf{r}'|^3}\right\}$$

El campo eléctrico del dipolo varía como $1/r^3$

Dipolo Eléctrico



$$\mathbf{E}(\mathbf{r}) = \frac{1}{4\pi\epsilon_0}\left\{\frac{3(\mathbf{r}-\mathbf{r}')\cdot\mathbf{p}}{|\mathbf{r}-\mathbf{r}'|^5}(\mathbf{r}-\mathbf{r}') - \frac{\mathbf{p}}{|\mathbf{r}-\mathbf{r}'|^3}\right\}$$

Si l << |r-r`| **(r-r')/|r-r'| ~ er**

$$\mathbf{E}(\mathbf{r}) = (1/4\pi\varepsilon_0)\,[(2p\cos(\theta)/r^3)\,\mathbf{e}_r + (p\,\mathrm{sen}(\theta)/r^3)\,\mathbf{e}_\theta]$$

Potencial Eléctrico

$$\mathbf{E} = -\nabla V$$

$$\nabla \times \mathbf{E} = 0$$

CAMPO CONSERVATIVO

$$\mathbf{F} = -\nabla U$$

Fuerza conservativa — ***Energía potencial***

Es fácil verificar esto para carga puntual y coord. cartesianas

$$\int \mathbf{E} \cdot d\mathbf{l} = -\int \nabla V \cdot d\mathbf{l}$$

$$V(\mathbf{r}) = -\int_{\mathrm{ref}}^{\mathbf{r}} \mathbf{E} \cdot d\mathbf{l}$$