Potential Vector In Biology

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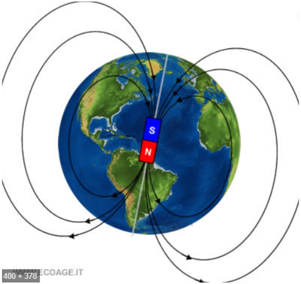
NATURAL PHENOMENA



MAXWELL EQUATIONS

- $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$
- $\vec{\nabla} \cdot \vec{B} = 0$
- $\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
- $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \frac{1}{c^2}\frac{\partial \vec{E}}{\partial t}$

- Espressione dei campi mediante potenziali scalare (ϕ) e vettoriale ($\vec{A}$)
- $\vec{B} = \vec{\nabla} \times \vec{A}$
- $\vec{E} = -\vec{\nabla}\phi - \frac{\partial \vec{A}}{\partial t}$

Electromagnetic waves

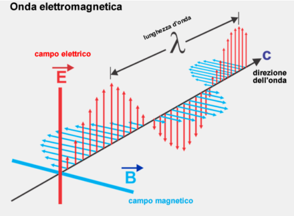


Figure: Plot of an em wave

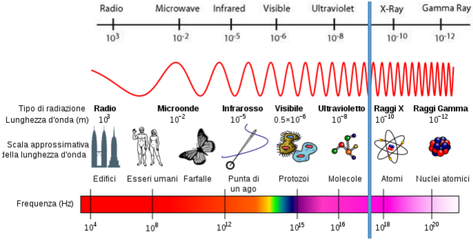


Figure: EM spectrum

- Both classical and quantum mechanical phenomena can be described starting with the determination of the Lagrangian and Hamiltonian function for a specific particle with mass m and charge q.
- Both in Lagrangian and Hamiltonian appear scalar and vector potential.

$$L = T - V = \frac{1}{2} m\dot{\vec{r}}^2 - q\phi + q\vec{A} \cdot \dot{\vec{r}} \tag{1}$$

$$\vec{p} = \frac{\partial L}{\partial \dot{\vec{r}}} = m\dot{\vec{r}} + q\vec{A} \tag{2}$$

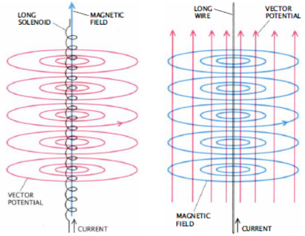
$$H = \vec{p} \cdot \dot{\vec{r}} - L = \frac{1}{2m} |\vec{p} - q\vec{A}|^2 + q\phi \tag{3}$$

So, Hamiltonian, which correspond (almost) to the total energy of the charged particle, doesn't depend on fields, instead it depends on potentials, scalar and vector.

The Bohm-Ahronov effect

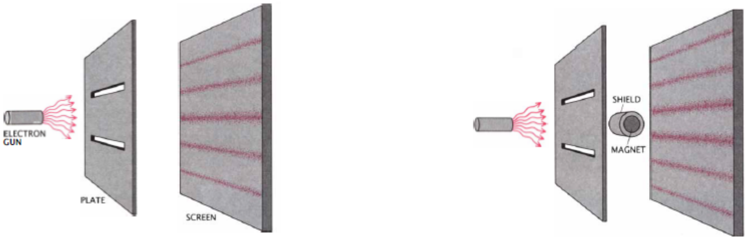
- The Bohm Ahrnov effect is a particular effect in which charges feel potential vector even when electromagnetic field is absent
- Difference of phase observed in an interference pattern of an electron gun going through an external path respect to a solenoid
- We are considering the case which $\phi = 0$. So the difference of phase depends only on potential vector.

$$\delta\theta = \frac{q}{\hbar c} \oint_C \vec{A} \cdot \vec{dr} = \frac{q}{\hbar c} \Phi_B \tag{4}$$



VECTOR POTENTIAL FIELD (*red lines*) is compared with the magnetic field (*blue lines*) for a long solenoid (*left*) and a long wire (*right*). Each line represents its respective field at a given strength. The circulation of the vector potential field around a curve is equal to the magnetic field multiplied by the area bound by that curve.

Figure: Magnetic field and potential vector lines in a solenoid



Difference of interference patterns between cases of absence and presence of magnetic field

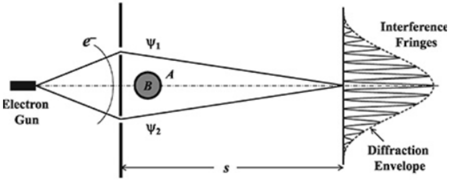


Figure: Interference path of an electron gun moving into two sits. The origin of interference is in the wave nature of electrons, as quantum mechanics states.

- Potential Vector extends to a nearby large area, without transporting energy but just information, exerting a “fine influence”, that alters the phase of the present coherent systems. (Giuliano Preparata and Emilio del Giudice)

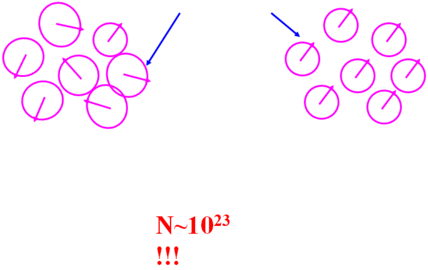


Figure: Difference between coherent and coherent system

Bibliography

- D. Griffiths *Introduction to Electrodynamics*
- Y. Aharonov And D. Bohm *Significance of Electromagnetic potentials in quantum theory*
- Yoseph Imri and Richard Webb *Quantum Interference and the Aharonov-Bohm Effect*

THANKS FOR YOUR ATTENTION