

## The Physical Distinction between the Coulomb and the Lorenz Gauges

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**Abstract.** The mathematical distinction between the Coulomb Gauge and the Lorenz Gauge is well known. Meanwhile, this article will take a look at what the difference means physically.

### The Coulomb Gauge

I. The electromagnetic wave equations don't tell us very much about the deeper physical nature of electromagnetic waves. To obtain more information, we need to look to the equations of Maxwell which are used to derive the wave equations in the first place, and even these feeder equations can only tell us a certain amount. As a starting point, let's begin with the magnetic vector potential,  $\mathbf{A}$ . Maxwell considered  $\mathbf{A}$  to be a momentum, and here it will be treated as the momentum density of the primary electric fluid that fills all space and from which everything is made, [1]. From the equations  $\nabla \times \mathbf{A} = \mathbf{B}$  and  $\mathbf{E}_K = -\partial \mathbf{A} / \partial t$ , where the vorticity  $\mathbf{B}$  is the magnetic flux density, and where  $\mathbf{E}_K$  is the force that arises in connection with time-varying electromagnetic induction, we can deduce that electromagnetic waves must involve the propagation of angular acceleration. After that, we need to guess the rest, as to what structure the wave-carrying medium would need to possess to accommodate such an angular displacement mechanism. Meanwhile, in 1861, Maxwell proposed that space is densely packed with tiny aethereal vortices, [2], [3]. If the aether is the fundamental electric fluid from which everything is made, whereby positive particles are sources in the aether while negative particles are sinks, it will now be suggested that Maxwell's tiny vortices constitute rotating electron-positron dipoles with circumferential speeds equal to and determining the speed of light, [4], [5]. Electromagnetic waves will constitute a swirling of electric fluid from the positron of one vortex into the electron of its immediate neighbour, at an average speed equal to the speed of light, along the line of propagation, [6]. This occurs when a vortex is caused to precess. The transferring of excess electric fluid to its neighbour then causes the neighbour to likewise precess, and the effect is relayed along the line in a wave-like manner.

Meanwhile, the *Coulomb Gauge*, otherwise known as the *Radiation Gauge*, or the *Transverse Gauge*, takes the form,

$$\nabla \cdot \mathbf{A} = 0 \quad (1)$$

Equation (1) is used when deriving the electromagnetic wave equations. While it is commensurate with there being a total balance between the electric fluid flowing into and out of the sinks and sources of the vortex sea, this balance would only be time-averaged in the dynamic state. During part of the cycle of an electromagnetic wave passing through a vortex, the inflow and outflow rates will not be the same. A density pulse will pass through the vortex.

By using the Coulomb gauge in the electromagnetic wave equations, we are therefore ignoring such finer details and approximating the vector field,  $\mathbf{A}$ , to a closed annular ring representing the circumferential momentum of each vortex, and it is treated as though its density doesn't change during the dynamic state when it precesses. As such, the Coulomb gauge should be more accurately referred to as a mathematical condition or a physical circumstance, rather than as a gauge.

## The Lorenz Gauge

II. The *Lorenz Gauge* ascribes the exact same physical meaning to the vector  $\mathbf{A}$  as in the case of the Coulomb gauge, but there is an important difference in the context in which we use it. In the Coulomb gauge, we are looking at a single vortex in conjunction with the wireless radiation propagation mechanism, whereas in the Lorenz gauge, we are looking at a whole region of vortices. The Lorenz gauge takes the form,

$$\nabla \cdot \mathbf{A} = -\mu\epsilon\partial\psi/\partial t \quad (2)$$

where  $\psi$  is electrostatic potential, and where the retarded solution to  $\mathbf{A}$  takes the basic form,

$$\mathbf{A}(\mathbf{r}, t) = (\mu/4\pi)\int_V (\mathbf{J}(\mathbf{r}', t')dV')/r \quad (3)$$

Since an electrostatic potential is not retarded, the only way that we can reconcile this fact with equation (2) is to treat the electrostatic potential at a point in space on the basis of the effect that the electrostatic field strength has on the tiny dipolar aethereal vortex at that point. In the case of each individual vortex, the radial electrostatic field will act differently on the electron (sink) than on the positron (source). This will cause the vortex to precess about an axis parallel to the field lines. The greater the electrostatic field strength, the greater will be the precession rate, and hence the greater the centrifugal pressure in the vortex. Therefore, in the case of the Lorenz gauge, the vector field,  $\mathbf{A}$ , will be a point function for the value of the circumferential momentum density of the vortex at

that point, and where there is an electrostatic field involved, we will treat the electrostatic potential,  $\psi$ , as a measure of the centrifugal pressure in the vortices due to the induced precession.

Therefore, if we have a charged sphere, the precessional axes of the tiny dipolar vortices in the field will be tracing out the radial electrostatic field lines, and if the sphere begins to move translationally, there will be a tendency for these same vortices to re-align into a magnetic field configuration, whereby their rotation axes form solenoidal rings around the line of motion. This is all predicted by the Lorentz transformation of fields, with the idea being, that as the sphere approaches the speed of light, the radial electrostatic alignment, marked out by the precessional axes of the vortices, will have totally given way to a disc-like magnetic alignment, [7].

This is the context for the Lorenz gauge, and the conversion of the electrostatic alignment into the magnetic alignment as the source sphere accelerates, will propagate outwards in a wave-like manner, through the sea of vortices at the speed of light. The Lorenz gauge might be better referred to as the *retarded circumstance*.

## Conclusion

**III.** The *Coulomb Gauge*, also known as the *Transverse Gauge*, or the *Radiation Gauge*, is the divergence formula for the magnetic vector potential,  $\mathbf{A}$ , as is used in the derivation of the electromagnetic wave equations, and which helps us to determine the deeper physical nature of wireless radiation in space. While space is densely packed with tiny dipolar vortices in an all-pervading electric fluid, the Coulomb gauge is defined through a single vortex. It is based on treating the magnetic vector potential as the momentum of the transverse perimeter circulation of the electric fluid within this vortex. Ignoring density variations in the dynamic state when electromagnetic waves are passing through, the divergence of  $\mathbf{A}$  will therefore be zero.

In the case of the *Lorenz Gauge* however, the vector field,  $\mathbf{A}$ , is a point function for the value of  $\mathbf{A}$  at each vortex in a whole region of vortices, and the formula is time-retarded. Meanwhile, an electrostatic field is not time-retarded, but it can entrain a region of such vortices. In doing so it causes the vortices to precess about an axis parallel to the radial electrostatic field lines. This precession increases the intrinsic centrifugal pressure of each vortex according to the field strength at that point, and it is this centrifugal pressure in the electric fluid of the vortices which defines the electrostatic potential term,  $\psi$ , for the purposes of the Lorenz gauge. When a charged body begins to linearly accelerate, the precessing vortices in the electrostatic field start to realign into a solenoidal magnetic field and this realignment propagates outwards at the speed of light in the form of electromagnetic radiation. This is what the Lorenz transformations are all about, [7].

## References

- [1] O'Neill, John J., "**PRODIGAL GENIUS, Biography of Nikola Tesla**", Long Island, New York, 15th July 1944, Fourth Part, paragraph 23, quoting Tesla from his 1907 paper "**Man's Greatest Achievement**" which was published in 1930 in the Milwaukee Sentinel, "*Long ago he (mankind) recognized that all perceptible matter comes from a primary substance, of a tenuity beyond conception and filling all space - the Akasha or luminiferous ether - which is acted upon by the life-giving Prana or creative force, calling into existence, in never ending cycles, all things and phenomena. The primary substance, thrown into infinitesimal whirls of prodigious velocity, becomes gross matter; the force subsiding, the motion ceases and matter disappears, reverting to the primary substance*".  
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[http://vacuum-physics.com/Maxwell/maxwell\\_oplf.pdf](http://vacuum-physics.com/Maxwell/maxwell_oplf.pdf)
- [3] Whittaker, E.T., "**A History of the Theories of Aether and Electricity**", Chapter 4, pages 100-102, (1910)  
*"All space, according to the younger (John) Bernoulli, is permeated by a fluid aether, containing an immense number of excessively small whirlpools. The elasticity which the aether appears to possess, and in virtue of which it is able to transmit vibrations, is really due to the presence of these whirlpools; for, owing to centrifugal force, each whirlpool is continually striving to dilate, and so presses against the neighbouring whirlpools."*
- [4] Tombe, F.D., "**The Double Helix Theory of the Magnetic Field**", (2006)  
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- [6] Lodge, Sir Oliver, "**Ether (in physics)**", Encyclopaedia Britannica, Fourteenth Edition, vol. 8, pp. 751-755, (1937)  
See pp. 6-7 in the pdf file in the link below, beginning at the paragraph that starts with, **Possible Structure**. –, and note that while the quote suggests that the ether is incompressible, this is almost certainly not the case. The quote in question, in relation to the speed of light, reads, "*The most probable surmise or guess at present is that the ether is a perfectly incompressible continuous fluid, in a state of fine-grained vortex motion, circulating with that same enormous speed. For it has been partly, though as yet incompletely, shown that such a vortex fluid would transmit waves of the same general nature as light waves— i.e., periodic disturbances across the line of propagation—and would transmit them at a rate of the same order of magnitude as the vortex or circulation speed*"  
<http://gsjournal.net/Science-Journals/Historical%20PapersMechanics%20/%20Electrodynamics/Download/4105>
- [7] Tombe, F.D., "**The Lorentz Aether Theory**", (2020)  
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