If we take the angular frequency of the carrier for the same $\omega_{c,\mathrm{A}} = \omega_{c,\mathrm{B}}$,[139] hence the reference for space and time is the same, therefore, the extension is given by the time it takes for the ***subton*** to exist multiplied by the velocity of ***subtons***. The time is to count the angular phase.[140]
We must ascertain that the information about the clock's value $\{t_c\}$ is driven *FORWARD* at the speed of light c.
An intuit existence of a *NOW*-state-mode of ***subtons*** is that they transmit one phase angle value

(3.266) $$\phi_{c,\mathrm{AB}} = \phi_{c,\mathrm{A}} = \phi_{c,\mathrm{B}} = \omega_c t_{c,\mathrm{AB}} = \omega_c t_{c,\mathrm{A}} = \omega_c t_{c,\mathrm{B}}$$

This is called the instantaneous *NOW* value of the quantum phase angle information.
The quantum phase angle as the ***subton*** produce is in this way the past through the extension

(3.267) $$\phi_3 = \omega_c t_3 .$$

Expressed in an ironic daily manner; the past is light-years away (or just light-seconds away).
This is the classical paradox of relativity with a light like *null line* path, $(c\Delta t_3)^2 - (\Delta x_3)^2 = 0$.[141]

3.5.2.2. Macroscopic Coherent Amplitude Modulation

We saw at (3.260)-(3.262) that a carrier can be amplitude modulated, if this is done phase angle coherent, without affecting the eternal constant angular frequency ω_c of the carrier.

3.5.2.3. Phase Modulation

Phase modulation is a relative concept. – I.e., the phase angle ϕ is varied relative to a reference phase angle ϕ_c of a phantom carrier with an angular frequency ω_c as a reference.
This ω_c is also a reference clock that generates development parameter t_c for that carrier. The macro-modulating phase difference is called $\Delta\phi$, hence the modulated variable phase angle gets

(3.268) $$\phi = \phi_c + \Delta\phi \quad = \quad \omega_c t_c + \Delta\phi \quad = \quad \omega_c t_c + \Delta\omega{\cdot}t_c + \omega_c \Delta t$$

Such a phase modulation can then be regarded as frequency modulation FM $\omega = \omega_c + \Delta\omega$, or time modulation TM: $t_{\mathrm{TM}} = t_c + \Delta t$, where the creation of ***subtons*** is controlled relative to the carrier clock. Here we shall not elaborate further on direct time modulation, because with $\phi = \omega_c t_{\mathrm{TM}} = \omega_c(t_c + \Delta t)$ it ends up in phase modulation or particular cases synchronous amplitude modulation.

For frequency modulation, the phase angle is given by $\phi_{\mathrm{FM}} = (\omega_c + \Delta\omega)t_c = \omega_{\mathrm{FM}} t_c = \omega t_\omega + \theta$.
Here it is thus possible to create ***subtons*** with different angular frequencies ω_{FM}, but these must all be related to the carrier ω_c as too t_c to make internal sense for a ***spectrum.***
(Those can assumingly be related to one external reference $|\widehat{\omega}| \equiv 1\ [\widehat{\omega}]$).
The signal in our intuition has one ***direction*** as a transversal plane wave, it is $\forall \vec{\omega}_{\mathrm{FM}} \| \vec{\omega}_c$.
If we look at each $\vec{\omega} = \vec{\omega}_{\mathrm{FM}}$, each ***subton*** $|\psi_{\pm\vec{\omega}}(\phi_{\vec{\omega}})\rangle$ generates its own individual development parameter $t_{\vec{\omega}}$ or angular phase angle $\phi_{\vec{\omega}} = \omega t_{\vec{\omega}}$, that will be indefinite in terms of ϕ_c, in that $\phi_\omega = \omega t_c + \theta$. Since this ***subton*** individual concept of time does not help us in our intuition, we adhere to the carrier clock $\{t_c\}$ as the reference for the signal giving the development parameter t_c, where $\Delta t \equiv 0$ in (3.268).
This time reference t_c is linked to the carrier circle oscillator $\vec{\omega}_c$. (Ideal From the first ***subton***.)

The modulation as a concept can only become meaningful when it varied over time.
The time-dependent modulated frequency $\omega_{\mathrm{FM}}(t_c) = |\vec{\omega}(t_c)|$ provides phase modulation

(3.269) $$\phi_{\mathrm{M}}(t_c) = \omega_c t_c + \Delta\phi(t_c) \;=\; \omega_{\mathrm{FM}}(t_c) t_c = \big(\omega_c + \Delta\omega_{\mathrm{FM}}(t_c)\big) t_c \;=\; \phi_{\vec{\omega}}(t_c).$$

[139] $\omega_{c,\mathrm{A}} \neq \omega_{c,\mathrm{B}}$ by the Doppler effect when two events A and B are in relativistic different velocity references. (cooling of the background radiation by expansion).
[140] Here I ask the reader; what is the speed of times? Is it the angular frequency of the carrier ω_c? Or is it c ?
[141] Look at chapter II. 5.7 for the relativistic issue of different ***directions*** in a Minkowski space metric $(c\Delta t_3 \gamma_0)^2 + (\Delta x_3 \gamma_3)^2 = 0$

When the signal contain myriads of simultaneous ***subtons*** at one specified frequency $\omega_{\mathrm{FM}}(t_c)$, the angular phase modulation between them can never be read (demodulated) because they are individually indistinguishable. Therefore simultaneously only one phase angle value $\phi_{\mathrm{M}}(t_c)$ for one $\omega_{\mathrm{FM}}(t_c)$ at one development stamp t_c is a possibility in a macroscopic modulated signal.

What we control in the signal, when we modulate the phase angle $\Delta\phi(t_c)$ after the reference clock $\{t_c\}$ from the carrier, is the angular frequency energy of the created ***subtons***

(3.270) $$\omega_{\mathrm{FM}}(t_c) = \omega_c + \Delta\phi(t_c)/t_c \qquad \Leftrightarrow \qquad \Delta\omega_{\mathrm{FM}}(t_c) = \Delta\phi(t_c)/t_c$$

Here it is very important to remember that individual ***subtons*** $|\psi_{\pm\vec{\omega}}(t_c, \Delta\phi_{\vec{\omega}})\rangle$ only carrier the instantaneous *NOW*-values of the phase angle difference $\Delta\phi_{\vec{\omega},\mathrm{A}} = \Delta\phi_{\vec{\omega},\mathrm{B}} = \Delta\phi_{\mathrm{M}}(t_{c,\mathrm{AB}})$ or the modulated phase angle $\phi_{\vec{\omega},\mathrm{A}} = \phi_{\vec{\omega},\mathrm{B}} = \phi_{\mathrm{M}}(t_{c,\mathrm{AB}})$, as $t_{c,\mathrm{A}} = t_{c,\mathrm{B}}$. This is conveyed by all ***subtons*** $|\psi_{\pm\vec{\omega}}(t_c, \Delta\phi_{\vec{\omega}})\rangle_{\mathrm{AB}}$ just like the reference parameter $\{t_c\}$ for all carrier ***subtons*** $|\psi_{\pm\vec{\omega}_c\perp\odot}(t_c)\rangle_{\mathrm{AB}}$. – That is the signal information from A to B

The ***subton*** not only retains $\vec{\omega}_{\mathrm{FM,A}} = \vec{\omega}_{\mathrm{FM,B}}$, but also the phase angle $\phi_{\mathrm{M,A}} = \phi_{\mathrm{M,B}}$ relative to the carrier phase angle $\phi_{c,\mathrm{A}} = \phi_{c,\mathrm{B}}$, which too is retained from A to B.
All this is here based on the carrier $\vec{\omega}_{c,\mathrm{A}} = \vec{\omega}_{c,\mathrm{B}}$ is substantial for the described ideology for the carrier ***subtons***. This implies that a relative ratio from A to B is unchanged (preserved).[142]
We have omitted the effect that the signal and carrier ***subtons*** can interact with the environment.[143] We accept the loss of part of the ***subtons*** in the channel is acceptable.
The conclusion is that the development-dependent phase modulation PM is pseudonym with a varied frequency FM modulation, that is $\Delta\phi(t_c) = \Delta\phi_{\mathrm{PM}}(t_c) = \Delta\omega_{\mathrm{FM}}(t_c) t_c$, when we view by intuition from a chronometer time $\{t_c\}$ given by a transmitter carrier phase angle $\phi_c = \omega_c t_c$.
For this we consider the carrier wave described from the transmitter

(3.271) $$^{\mathrm{A}}\Big|\psi^{\mathrm{macro}}_{\Sigma\pm\vec{\omega}_c\perp\odot}(t_c)\Big\rangle \rightrightarrows W^{\mathrm{helix}}_{\pm\vec{\omega}_c}(t_c, x_3) = \boldsymbol{A}_{\mathrm{A}} \boldsymbol{A}_{loss}(x_3)\big(e^{\pm i(\omega_c t_c - k_{c,3} x_3)}\big)_{\perp\vec{\omega}_c}, \quad \text{where } k_{c,3} = \omega_c / c\,.$$

Here we keep the transmitter amplitude constant $\boldsymbol{A}_{\mathrm{A}} = \boldsymbol{A}(t_c) = \boldsymbol{A}(0_c)$ for $\forall t_c \geq 0$
When (3.271) is modulated, the transmitter phase angle $\phi(t_c) = \omega_c t_c + \Delta\phi = \big(\omega_c + \Delta\omega_{\mathrm{FM}}(t_c)\big)t_c$.
This can also be formulated as FM modulation $\omega_{\mathrm{FM}}(t_c) = (\omega_c t_c + \Delta\phi)/t_c = \omega_c + \Delta\omega_{\mathrm{FM}}(t_c)$.
The wave ***direction*** $\mathbf{e}_3$ is conceived to define the ***direction*** of all the circle oscillators $\vec{\omega}_{\mathrm{FM}} = \omega_{\mathrm{FM}}\mathbf{e}_3$. The modulated wave around an imaginary reference carrier is then

(3.272) $$^{A}\Big|\psi^{\mathrm{macro}}_{\Sigma\pm\vec{\omega}_{\mathrm{FM}}\perp\odot}(\phi_{\mathrm{PM}})\Big\rangle \rightrightarrows W^{\mathrm{helix}}_{\pm\vec{\omega}_{\mathrm{FM}}}(\phi(t_c), x_3)$$
$$= \boldsymbol{A}_{\mathrm{A}} \boldsymbol{A}_{\mathrm{loss}}(x_3)\big(e^{\pm i(\omega_c t_c + \Delta\phi(t_c) - k_{c,3} x_3)}\big)_{\perp\mathbf{e}_3} = \boldsymbol{A}_{\mathrm{A}} \boldsymbol{A}_{\mathrm{loss}}(x_3)\big(e^{\pm i(\omega_{\mathrm{FM}}(t_c) t_c - k_{c,3} x_3)}\big)_{\perp\mathbf{e}_3}.$$

This term expresses a circularly polarized modulated wave with helicity $+1$ or -1 .
For a linearly polarized wave from a transmitter dipole, we can rewrite the wave as

(3.273) $$W^{\mathrm{helix}}_{+\vec{\omega}_{\mathrm{FM}}}(\phi(t_c), x_3, \theta_d) + W^{\mathrm{helix}}_{-\vec{\omega}_{\mathrm{FM}}}(\phi(t_c), x_3, \theta_d)$$
$$= \boldsymbol{A}_{\mathrm{A}} \boldsymbol{A}_{\mathrm{loss}}(x_3)\big(e^{+i(\omega_c t_c + \Delta\phi(t_c) + \theta_d - k_{c,3} x_3)} + e^{-i(\omega_c t_c + \Delta\phi(t_c) + \theta_d - k_{c,3} x_3)}\big)$$
$$= \boldsymbol{A}_{\mathrm{A}} \boldsymbol{A}_{\mathrm{loss}}(x_3)\, 2\cos\big(\omega_c t_c + \Delta\phi(t_c) + \theta_d - k_{c,3} x_3\big)$$
$$= \boldsymbol{A}_{\mathrm{A}} \boldsymbol{A}_{\mathrm{loss}}(x_3)\, 2\cos\big(\omega_{\mathrm{FM}}(t_c) t_c + \theta_d - k_{c,3} x_3\big).$$

[142] Here the Doppler effect is excluded from consideration, since speeds of events are not yet included in this concept. Anyway, in the case of Doppler-displacement, the mutual multiplicative ratios between the different frequencies are conserved.
[143] Whether it is sufficient with the conditions $|\vec{\omega}_{\mathrm{FM,A}}| = |\vec{\omega}_{\mathrm{FM,B}}|$ and $|\vec{\omega}_{c,\mathrm{A}}| = |\vec{\omega}_{c,\mathrm{B}}|$ under mutual changing in ***direction*** in interaction as an annihilation B with recreation in B towards a new event C for ***subtons*** $^{\mathrm{ABC}}\Psi_\omega$, like multi-interaction in a transmission conductor (optical fibres, waveguides and coaxial cables) ***Subtons*** $^{\mathrm{AB\ldots C}}\Psi_\omega$ will not be discussed here, but it seems to be the case of the success we already have experienced in the 20th century.