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The decrease in the received oscillating frequency energy dilates the chronometric count along the locally defined development parameter relative to the local equivalent identical ***entity*** $\Psi_R$, $[\omega_0^{-1}]$.

**5.7.4.5. The Space-Time Algebra STA from a 4-dimensional 1-vector basis**

Often the Minkowski $\mathcal{B}$-plane is called the Lorentz plane because it is the hyperbolic plane for the Lorentz rotation. What happens externally outside this plane? The tradition is to make a time dimension and three space dimensions with opposite signatures, we use in this book $(+,-,-,-)$ for a Clifford algebra $\mathcal{G}_{1,3}(\mathbb{R})$ the Minkowski metric space foundation basis $\{\gamma_0,\gamma_1,\gamma_2,\gamma_3\}$.

The ***direction*** $\gamma_0$ is the unit cyclic measure of development, which is an isometric measure for the three-dimensional ***directions*** units $\gamma_1,\gamma_2,\gamma_3$ of Descartes extension: *length*, *breadth*, *depth* in the so-called natural space. The STA basis $\{\gamma_0,\gamma_1,\gamma_2,\gamma_3\}$ we define as orthonormal, from (5.300)-(5.304) we have

(5.377) $\gamma_0\cdot\gamma_1 = \gamma_0\cdot\gamma_2 = \gamma_0\cdot\gamma_3 = 0,\quad |\gamma_0| = |\gamma_1| = |\gamma_2| = |\gamma_3| = 1,$
$\gamma_1\cdot\gamma_2 = \gamma_2\cdot\gamma_3 = \gamma_3\cdot\gamma_1 = 0.$ ← Orthogonal extensions, therefor $\perp$.

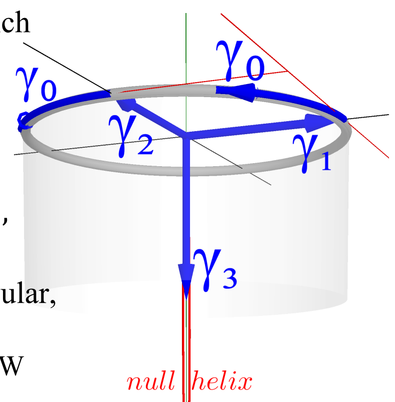


Figure 5.56 The STA basis $\{\gamma_0,\gamma_1,\gamma_2,\gamma_3\}$ displayed as perpendicular ***directions*** in all four dimensions. We chose the $\gamma_3$ ***direction*** for the relativistic velocity that causes the Lorentz rotation $e^{\gamma_3\gamma_0\zeta}$ in a Minkowski $\mathcal{B}_3$-plane ***direction*** $\mathcal{B}_3 \equiv \gamma_3\gamma_0$ that is not displayed. The Euler oscillating rotation $e^{\gamma_2\gamma_1\omega t}$ by the arc ***direction*** $\gamma_0$ in the extension plane supported by $\gamma_1\gamma_2 = \boldsymbol{i}_3$. The *null* ***direction*** is shown as *null helixes* collapsed around the $\gamma_3$ extension ***direction***. Undecided orientation $-\mathcal{B}_k=\gamma_0\gamma_k$ or $\mathcal{B}_k=\gamma_k\gamma_0$

As we have seen above $\gamma_0\cdot\gamma_k=0$ are in substance not perpendicular, in that their ***directions*** can be changed by a Lorentz rotation.
Anyway, we display the $\gamma_0$ ***direction*** as perpendicular to all NOW lines in Figure 5.56the NOW plane $\gamma_1\gamma_2$ of , where $\gamma_0 \| (\gamma_1\gamma_2)$.
The three extension ***direction*** unit 1-vectors $\gamma_k$ display a three dimensional Cartesian basis, that local is both perpendicular and orthonormal. The development dimension is not spatial, and therefore we display the ***direction*** unit $\gamma_0$ as cyclic oscillating around in a unit circle following the arc of its circumference repeating itself periodically for every $2\pi\gamma_0$
The founding unit $\gamma_0$ reference is then the radian measure of the unit circle performing an oscillation with an autonomous *frequency energy* $\omega$ of the local ***entity***. The oscillating rotation is then performed by $e^{\gamma_2\gamma_1\omega t}$, traditional prescribed $e^{-i\omega t}\in\mathbb{C}$, where $t$ is the development chronometer. The reader is encouraged to compare this chronometric timing concept with Figure 1.2 in chapter I. 1.6.2.3. When it comes to the impact on extension space compare it with the idea of Figure 3.13 in chapter I. 3.4.1.
Interpreted as a tangent 1-vector, $\gamma_0$ support a classical (Augustinian) timeline going from the first beginning to the final end (A→Ω). Herein this book we (similar to the ancient Greeks) like to wrap this concept into an oscillating circular rotation for each local autonomous defining ***entity***.
When it comes to two ***entities*** $\Psi_A$ and $\Psi_B$ separated in the extension ***direction*** $\gamma_3$ where $\Psi_B$ gets information about $\Psi_A$, we need a third signal ***entity*** $\Psi$ bringing the information about $\Psi_A$ to $\Psi_B$. We set the speed of this subton $\Psi$ to one unit $\beta=1$ (e.g., speed of light $c=1$) observed from both $\Psi_A$ and $\Psi_B$. Seen from $\Psi_B$ the transmission ***direction*** of the signal $\Psi$ will fall in the *null* ***direction*** of the receiving ***entity*** $\Psi_B$ that is the interpreting observer.
In principle Figure 5.55 show the same situation as Figure 5.56 for a subton $\Psi$ intuits from external for the receiving situation at B, the difference are in the interpretations of the displays.







### 5.7.5. The planes of Space-Time Algebra and the Euclidean Cartesian plane

**5.7.5.1. Founding Summary of Minkowski Space with Euler and Lorentz Rotations**

In this section 5.7 we have introduced the Minkowski metric space as a Clifford algebra with mixed signatures, $(+)$ for development and $(-)$ for extensions, by defining a Minkowski $\mathcal{B}$-plane bivector in § 5.7.1 with signatures $(+,-)$ for the algebra $\mathcal{G}_{1,1}(\mathbb{R})$
and introducing *null* ***directions*** for information, and in § 5.7.1.3, the development count $\gamma_0$ as an isometric measure. The traditional Minkowski display is interpreted in section 5.7.2, first for the plane display $(+,-)$ in Figure 5.53, then in § 5.7.2.2 this plane display is Euler rotated around in a two-dimensional extension plane $\gamma_1\gamma_2$ ***direction*** resulting in a Minkowski space algebra $\mathcal{G}_{1,2}(\mathbb{R})$ with signature $(+,-,-)$ displayed in Figure 5.54, with a *null* cone. In §5.7.2.3 this is supplemented with a third dimension of extension $\gamma_3$, forming the full STA Minkowski signature $(+,-,-,-)$.
From the paravector concept $\wp$ in section 5.7.3 we get from the development count $\gamma_0$ the STA Clifford algebra $\mathcal{G}_{1,3}(\mathbb{R})$ with its 1-vector concept $p=\wp\gamma_0$ (5.345). The Lorentz rotation is discussed in section 5.7.4 as a hyperbolic rotation in a $\mathcal{B}$-bivector-plane, then as a Lorentz transformation § 5.7.4.2 of the paravector, and the STA Lorentz boost in § 5.7.4.3 with the relativistic speed $\beta$, and invariant quantities of information with a hyperbolic same folding of development to a helix extension ***directions*** approaching the *null* ***direction*** for $\beta\to 1$.

**5.7.5.2. Mapping Operation Between STA planes and the Euclidean Cartesian plane**

As the ideological foundation for the plane concept, we choose to use the Euclidean approach by the Cartesian orthonormal basis $\{\boldsymbol{\sigma}_1,\boldsymbol{\sigma}_2\}$ that we immediately expand to the standard basis (5.198) $\{1,\boldsymbol{\sigma}_1,\boldsymbol{\sigma}_2,\boldsymbol{i}\coloneqq\boldsymbol{\sigma}_2\boldsymbol{\sigma}_1\}$ for the Euclidean plane algebra. Our experience has taught us, that is an oversimplified static view, where nothing happens, and no information is transmitted. Any knowledge of the physical situation in this is a priori transcendental to our intuition, as Immanuel Kant told us. We must endow the situation with a measuring concept, which makes something happens. We need a reference for this, and this is a cyclic oscillator with a stable reliable angular frequency energy $\omega$, which makes the ***one quantum*** count for us.
This oscillator possesses an information development ***direction*** unit $\gamma_0$.
We expand the sequential order of counts to a real number continuous monotone growing parameter span of development ***direction*** $\{\lambda_0\gamma_0|\forall\lambda_0\in\vec{\mathbb{R}},\ \gamma_0^2\coloneqq 1\in\vec{\mathbb{R}}\}$ as a linear Euclidean algebra $\mathcal{G}_1(\mathbb{R})$ of one dimension for a continuous 1-vector concept $\lambda_0\gamma_0$ of a *development* ***direction***, a ***primary quality of first grade*** (***pqg***-1), that indeed not possess any Descartes extension in space.
We choose this continuous count to be the measure for the Euclidean plane *object* defined by the Cartesian orthonormal basis $\{\boldsymbol{\sigma}_1^2=\boldsymbol{\sigma}_2^2=1,\ \boldsymbol{\sigma}_1,\boldsymbol{\sigma}_2\}$. Measure $\gamma_0^2\coloneqq 1$ is the measure for these two $\boldsymbol{\sigma}_1^2=\boldsymbol{\sigma}_2^2=1$. The information signal generated from the oscillating generator for $\gamma_0$ must be isometric for both $\boldsymbol{\sigma}_1$ and $\boldsymbol{\sigma}_2$ transmitted from their common bottom to their tips; vice versa.
The measurement mapping is established by the multiplication operation (5.328): $\{1,\boldsymbol{\sigma}_1,\boldsymbol{\sigma}_2\}\gamma_0$

(5.378) $\{1\gamma_0,\boldsymbol{\sigma}_1\gamma_0,\boldsymbol{\sigma}_2\gamma_0\}=\{\gamma_0,\gamma_1,\gamma_2\}$.

Then we have an autonomous isometric orthonormal basis for a plane in STA.
We remember the negative signature for $\gamma_1^2=\gamma_2^2=-1$, confirmed by $\boldsymbol{\sigma}_k\gamma_0\boldsymbol{\sigma}_k\gamma_0=-\boldsymbol{\sigma}_k\boldsymbol{\sigma}_k=-\boldsymbol{\sigma}_k^2$.
The Euclidean plane unit bivector $\boldsymbol{i}\coloneqq\boldsymbol{\sigma}_2\boldsymbol{\sigma}_1$ is mapped by $\gamma_0^2=1$

(5.379) $\boldsymbol{i}=\boldsymbol{i}\gamma_0^2=-\boldsymbol{\sigma}_2\gamma_0\boldsymbol{\sigma}_1\gamma_0=-\gamma_2\gamma_1=\gamma_1\gamma_2$.

Now we have done the map for the Euclidean plane concept represented by their standard bases

(5.380) $\{1,\boldsymbol{\sigma}_1,\boldsymbol{\sigma}_2,\boldsymbol{i}\coloneqq\boldsymbol{\sigma}_2\boldsymbol{\sigma}_1\}\ \leftrightarrow\ \{\gamma_0,\ \gamma_1,\gamma_2,\ \gamma_1\gamma_2\}$

and connected the extension in the Cartesian plane with an oscillating reference measure $\gamma_0$.
Then we have the isometric measure in what David Hestenes call Space-Time-Algebra (STA) [6]



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