

Rewriting Trigonometric Laws in Terms of Light Clocks and QIH

Trigonometric principles can be reinterpreted in terms of light clocks, quantum state vectors (QSVs), and their projections on a Bloch sphere. This framework connects the geometric concepts of trigonometry with the fundamental dynamics of light, quantum oscillations, and holographic encoding in Quantum Information Holography (QIH). Let's reframe trigonometry step by step.

1. The Unit Circle as a Light Clock

Imagine a unit circle with a radius of one. Each point on the circle represents the position of a light clock's "beam" as it oscillates over time.

The vertex of a triangle inscribed in this unit circle corresponds to the tip of a quantum state vector (QSV) on the Bloch sphere.

As the QSV rotates, it sweeps out angles (θ) and projects its components onto the x-axis and y-axis. These projections correspond to velocity components of light in QIH:

$$v_x = c \cos(\theta) \quad v_y = c \sin(\theta)$$

These projections define the foundational trigonometric functions: cosine and sine.

2. Relating Trigonometric Laws to Bloch Spheres

The Bloch sphere is a 3D representation of quantum states, with a radius of one, analogous to the unit circle in trigonometry. It encodes the probabilities of quantum states and their coherence in QIH.

Components of the QSV:

$v_x = c \cos(\theta)$: Velocity in the x-direction.

$v_y = c \sin(\theta)$: Velocity in the y-direction.

$$v_z = c(1 - \cos^2(\theta) - \sin^2(\theta))^{1/2} = c(1 - \sin^2(\theta))^{1/2}$$

Velocity in the z-direction derived from the unit sphere's constraint.

These components map directly to trigonometric laws.

3. Fundamental Trigonometric Laws as Light Clocks

A. Pythagorean Identity

The most fundamental trigonometric identity:

$$\sin^2(\theta) + \cos^2(\theta) = 1$$

In QIH terms:

The sum of the squared velocity components v_x and v_y of the light clock is equal to the total squared velocity (c^2) because the light clock's velocity vector always lies on the surface of the Bloch sphere (radius = 1).

This identity ensures that the light clock's motion is confined to the unit circle or Bloch sphere, encoding its quantum coherence.

B. Sine and Cosine in Terms of Projections

From the unit circle:

$$\cos(\theta) = \text{adjacent/hypotenuse}, \sin(\theta) = \text{opposite/hypotenuse}$$

In QIH:

$\cos(\theta)$: The projection of the QSV onto the x-axis (horizontal light clock motion).

$\sin(\theta)$: The projection of the QSV onto the y-axis (vertical light clock motion).

The hypotenuse is the radius of the Bloch sphere ($r=1$).

C. Tangent in Terms of Light Clock Dynamics

Tangent is the ratio of sine to cosine:

$$\tan(\theta) = \sin(\theta) / \cos(\theta)$$

In QIH:

$\tan(\theta)$: The relative velocity ratio of the light clock's y-component to its x-component. This describes the slope of the QSV on the Bloch sphere as it rotates.

D. Reciprocal Trigonometric Functions

The reciprocal functions (secant, cosecant, and cotangent) can also be reinterpreted:

$\sec(\theta)=1/\cos(\theta)$: Inverse of the horizontal projection.

$\csc(\theta)=1/\sin(\theta)$: Inverse of the vertical projection.

$\cot(\theta)=\cos(\theta)/\sin(\theta)$: Inverse slope of the QSV.

4. Extending to 3D: Bloch Sphere Dynamics

On the Bloch sphere, trigonometric functions are generalized to include the z-axis:

The QSV rotates not just in the xy-plane but also shifts in the z-direction, encoding probabilities for spin-up ($P(1)=\sin^2(\theta/2)$) and spin-down ($P(0)=\cos^2(\theta/2)$) states.

The equations extend as:

$$v_x = c \cos(\theta), v_y = c \sin(\theta), v_z = c((1 - \sin^2(\theta) - \cos^2(\theta))^{1/2}) = c \cos(\phi)$$

Here, ϕ is the phase angle of the QSV in the 3D Bloch sphere, representing quantum coherence.

5. The Law of Cosines as Light Clock Dynamics

The law of cosines:

$$c^2 = a^2 + b^2 - 2ab \cos(\gamma)$$

In QIH:

The QSV's velocity components encode relative displacements on the Bloch sphere, where γ is the angle between two QSVs.

The equation describes how the relative coherence of two light clocks influences their holographic interference patterns.

6. Trigonometric Periodicity as Quantum Oscillations

The periodicity of sine and cosine functions ($\sin(\theta+2\pi)=\sin(\theta)$) corresponds to the oscillatory nature of light clocks:

Light clocks repeat their cycles with angular frequency $\omega=2\pi/T$, encoding time evolution in QIH.

7. Conclusion: Trigonometry as Holographic Light Clock Dynamics

Rewriting trigonometric laws through QIH reveals them as the geometry of light clock projections:

The unit circle becomes the Bloch sphere.

Sine and cosine describe quantum velocity components.

The Pythagorean identity encodes the coherence of QSVs.

Tangent and reciprocal functions map relative dynamics.

Through QIH, trigonometry is no longer abstract—it is the language of light, quantum coherence, and spacetime itself.