Timely Information

Abstract: Physics isn't physics, unless it's about the physical. Thus, Wheeler's 'It from Bit' suggests the observed universe from a physically-real first principle. Interval-time coordinates reveal a fundamental bit, leading to the more recent 'It from Qubit' by way of the implied 'Qubit from Bit'.

Coordinated Effort

Previously, interval-time coordinates were developed[1] as a Euclidean lens with which to gain an undistorted perspective on outstanding mysteries in physics. After exploring light, its focus was turned to intrinsic spin[2] and gravity.[3] This time, it examines the foundation of information.

A simultaneity is all *space* at a given time, in a given reference frame. The associated spacelike interval equation[4] is $\Delta \mathbf{d}^2 = \Delta \mathbf{x}^2 - \Delta \mathbf{t}^2$. This conforms to Pythagoras as: $\Delta \mathbf{x}^2 = \Delta \mathbf{d}^2 + \Delta \mathbf{t}^2$, which implies Euclidean geometry with interval-time coordinates. Light quanta are thus seen to transfer via particle-interaction wormhole (pinhole), bypassing space and time of any extent (Fig. 1). Wormholes have different internal (here zero) and external (indefinitely large) spans.

"…to state that the propagation speed of light is invariant is the same as saying that the interval is zero."[5]

Feynman was saying that all observers agree on a *single* point of contact. c is an absolute *speed* limit because contact is an absolute *proximity* limit. It's no accident that both are invariant.

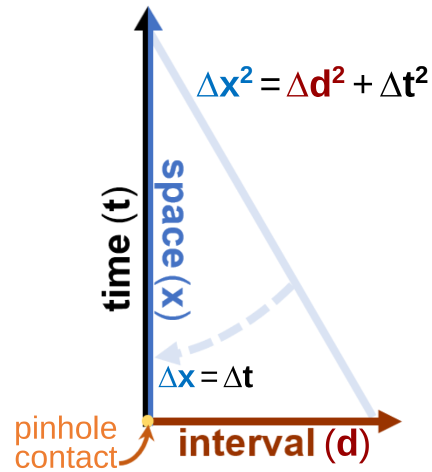

Fig. 1 An undistorted Euclidean map shows light to be interval *contact*, bypassing space & time.

Pinholes supply *hidden locality*, contact which is remote in space and time. It's the incompleteness in quantum theory that Einstein complained of. All contact is interval contact so, why don't we see it? Ironically, we do. Pinholes constitute light, obviating photons. We also feel it, since spinning pinholes generate fields. Lightlike pinholes are velocity dependent, accessible only to energy at speed limit c.

Every Itsy Bit

Wheeler's **It from Bit** doctrine[6] never physically realized the fundamental *bit* to which it refers. It would have to be the *one kind* of object from which all others arise, a *most fundamental* first principle, at the very bottom level of existence. It would be the *simplest* object possible. Pinholes fit this description.

Pinholes are self-existent, a natural consequence of curved-space, radial-time geometry (Fig. 8). In the same way that a sphere has more radii than a circle, there are infinitely more radial contact paths leading to a given center in 4D than there are in 3D. A pinhole is a null vector, pointing its zero magnitude, in a single direction, the implied trajectory of a light quantum. With respect to a light cone (aka "null cone"), which encompasses three dimensions, a pinhole is a single radial element.

The continuum quintessentially provides potential *separation*. Its binary opposite is *NOT separation*, i.e. contact. Pinhole contact can serve as Wheeler's fundamental bit. Nothing is simpler than a hole (Fig. 2).

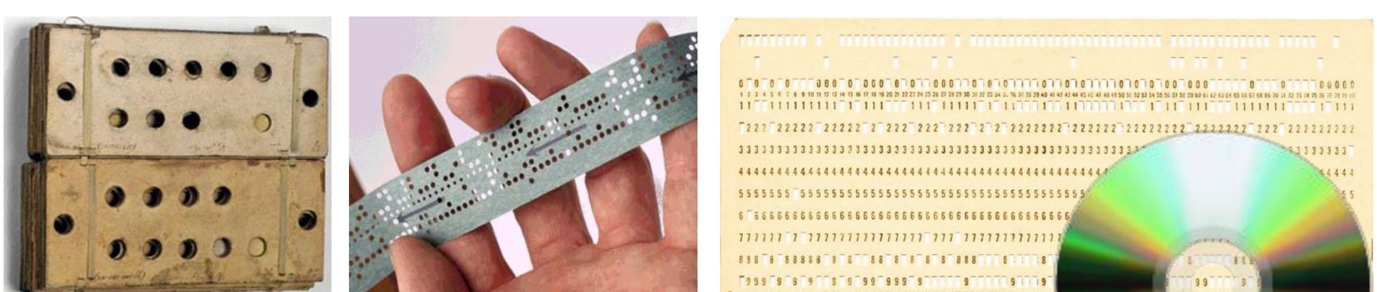

Fig. 2 Holey Moley! Whether in wood, paper, oaktag, plastic, or p-type semiconductors[7-11], holes have been the simplest means of representing binary information. With the continuum for a medium, could nature have done it the same way?

Another Quantum Revolution

Interval-time coordinates view *time* as the primary "intrinsic" spin axis. Such "chronaxial spin" makes no projection on an orthogonal *interval* 3-plane, but it casts equal components on every overarching spatial direction, seen from an observer's timelike perspective. Fermion spin is thus solid-angular, with a range of 4π steradians (Fig. 3). Projections also rotate spatially through 720°. So, for spin½, the Planck constant (h) should be reduced by 4π instead of by 2π, used for classical spin.

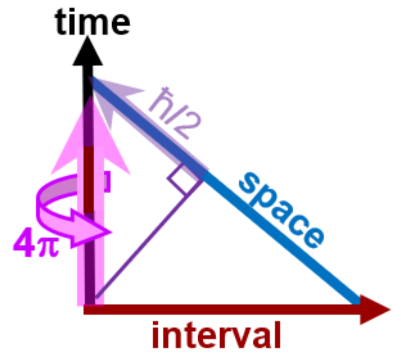

Fig. 3 Solid-angular chronaxial spin makes spatial projections, of equal size in every direction.

Spin about time is inherently *instantaneous*. It is equivalent to say the spinning element is in *superposition*, occupying all radial locations at once. The field element occupies a solid-angular distribution, seen as a classical Gaussian field.

The difference between a cloned object and one in superposition is that clone properties are *duplicated*, while superposition properties are *distributed*, as if oscillating *instantly* between multiple locations (Fig. 4). Clones interact ordinarily, while an object in superposition, exists only probabilistically at each location. For example, with equal probability density at two locations, the odds of detecting an object at either one is 50%.

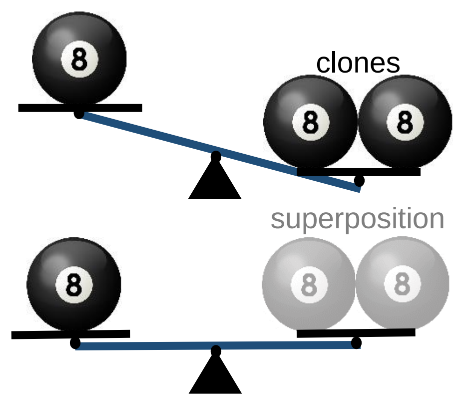

Fig. 4 Clones outweigh a single ball but a ball in superposition does not.

Chronaxial spin points a pinhole probabilistically in all directions at once about a temporal axis. Modeling a pinhole as a fundamental bit, it may be stated: **bit + chronaxial spin = qubit** (a *"solid bit"* or a bit in 3D superposition).

"A pure qubit state is a linear superposition of the basis states. …a linear combination of $|0\rangle$ *and* $|1\rangle$*:* $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$*, where α and β are probability amplitudes …the absolute squares of the amplitudes equate to probabilities…* $|\alpha|^2 + |\beta|^2 = 1$*"*[12]

A qubit is conventionally depicted as a Bloch sphere[13] in an *abstract* Euclidean vector space (a Hilbert space[14]). But qubits are real and interval-time coordinates *realize* a 4D Euclidean space in which to locate them (Fig. 5). Interval coordinates are arguably more "real" than space, since they are invariant (agreed by all observers).

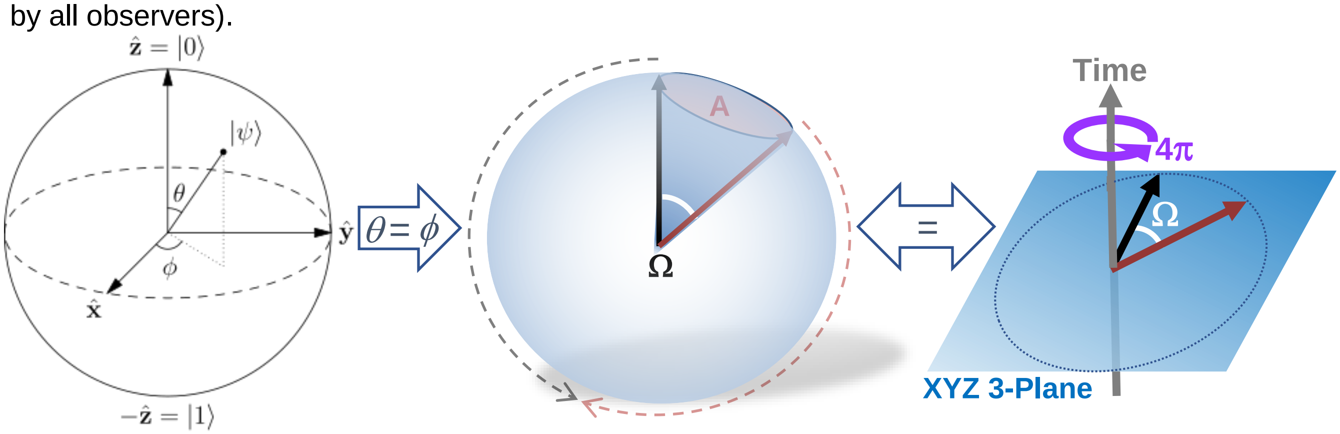

Fig. 5 Left: A Bloch sphere represents a qubit. Center: If $\theta = \phi$, solid angle **Ω** of an inscribed cone replaces both. Cone height (probability amplitude) cycles over 720° (4π) as the angle everts. Right: In an interval 3-plane, solid-angular *area* appears as an *arc*, about a temporal axis. A qubit may thus be modeled as a fundamental bit (i.e. a pinhole) with essentially-instantaneous chronaxial spin.

"…probability amplitude…Nobody knows any machinery… there is probability all the way back"[15]

Probability amplitude (a) may also be physically realized as the altitude of a solid angle. Consider opposed spin components, making plane angle θ. Fig. 6 shows that a is the projection of 100% (i.e. **1**) self-correlation on the altitude (i.e. a = **1**$\cos(\theta/2)$). The opposed spin component then correlates as the projection of a on its own location or **1**$\cos(\theta/2)\cos(\theta/2) = \cos^2(\theta/2)$.

The Gravity of the Situation

"*[Rolf] Landauer said that information is physical." and [John] Wheeler said that physics is informational."*[16]

We are reminded that information cannot exist unembodied. It always manifests physically as mass-energy. So, information exhibits gravity. Contact is the opposite of separation. A pinhole with chronaxial spin reduces the separational capacity (i.e. potential for objects to remain separate) of the surrounding continuum.[3] This generates an inward acceleration field for which intensity follows the inverse square law. Thus, *qubits exhibit gravity.*

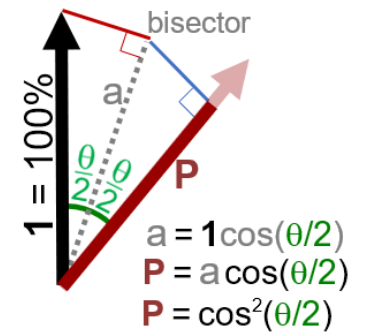

Fig. 6 A prepared spin has 100% self-correlation. The probability **P** that a subsequently-measured spin component will correlate relates to projection a on their unmeasured bisector (altitude).

"Energy" is the term distinguishing relative chronaxial spin rates ($\boldsymbol{\omega}_3$). The uncertainty: $\Delta\mathbf{E}\,\Delta\mathbf{t} > \hbar/2$ reveals that at a given moment ($\Delta t = 0$), ΔE is infinite. That is, chronaxial spin is instantaneous. Yet field frequency (**f**) is quantized in: $\boldsymbol{\omega}_3 = 4\pi\mathbf{f}$. Each solid-angular turn sweeps out a single field instance (a "quantum" of spin), seen as one "light cone" and expressed as $\hbar/2 = h/4\pi$. $\mathbf{E} = h\mathbf{f} = h\boldsymbol{\omega}_3/4\pi$.

Completing each turn, a pinhole runs into itself. To proceed, it rises on its unidirectional axis (time) to generate a new field instance. This answers Wheeler's *"How come the quantum?"*[17] A muon exerts more gravity than an electron because its field frequency is that much greater.

Intanglement

Entanglement is central to quantum information theory. The instant correlation of properties *between* separate particles is so fascinating that correlations *within* a single fermion are sometimes overshadowed. Fig. 6 relates spin correlation resulting from such **in**ternal en**tanglement**. That separate "extangled" particles demonstrably imitate intanglement is what makes them so fascinating.

Classical *planar* rotation is the superposition of *two* orthogonal *linear* oscillations about a shared central axis. Knowing one such "intangled" component informs of the other. If $\mathbf{x} = \mathbf{r}\cos\theta$, then $\mathbf{y} = \mathbf{r}\sin\theta$. But this relies on a *conventional* rotation direction. Without that, the sign (± spin direction) of **y** is indeterminate.

One dimension up, chronaxial spin makes *three* orthogonal *planar* projections, which are intangled. Again, measuring one informs only partly of the others. Spin on the Z axis occurs in an XY-plane. That provides the linear X component of the XZ projection and the linear Y component of the ZY projection. It's enough to know the magnitude of each but not their spin directions. In fact, measuring one projection means *not knowing* the spin direction of others, forming a basis for complementarity.

"To him [Bohr] the 'indivisibility of the quantum of action', which was his way of describing the uncertainty principle, implied that not all aspects of a system can be viewed simultaneously."[18]

The probability that the signs (±) of two spin components will agree at 90° is $\mathbf{P} = \cos^2(90°/2)$ or 50%, which may be expressed as a superposition[19] of an orthogonal one: **|spin up⟩ = √½|spin right⟩ + √½|spin left⟩**, where √½ is the probability amplitude: a = cos(90°/2).

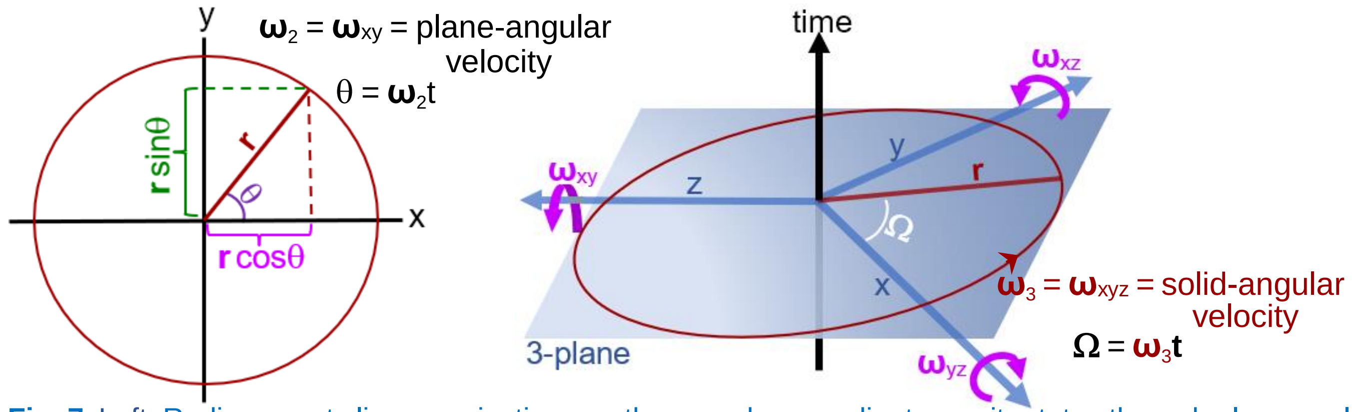

Fig. 7 Left: Radius **r** casts linear projections on the x- and y- coordinates as it rotates through plane angle θ with velocity $\boldsymbol{\omega}_2$. Right: Three orthogonal spin projections are cast by **r** as it rotates through **Ω** (about time) with solid-angular velocity $\boldsymbol{\omega}_3$. The maroon loop indicates a compacted sphere in a 3-plane. Measuring $\boldsymbol{\omega}_{xy}$ is not enough to know spin directions of $\boldsymbol{\omega}_{xz}$ or $\boldsymbol{\omega}_{yz}$.

Extanglement

Einstein asserted that quantum mechanics incomplete, particularly as it lacks an explanation for by remote correlation of entangled particles. Yet his Relativity is able to supply a physical basis for such a link.

A fermion pair entangled in a "total-spin-zero" or "singlet" state exhibits spin correlations *between* particles as strong as those *within* a *single* particle (Fig 6).[20] But, being spatially separate, they can't share the same temporal spin axis. To see their common axis, a Euclidean lens is again required.

Interval-time coordinates are naturally available at every location in a curved-space, radial-time model of the expanding cosmos (Fig. 8). The temporal coordinate is normal to space and the interval coordinate is tangent to it. Any 3-sphere enclosing the central Big Bang is a spatial simultaneity in the cosmic rest frame. But relativistic length contraction flattens the 3-sphere in the direction of any motion. In the limit as speed approaches ***c***, space and time *coincide* as light bypasses both on the way to the future.

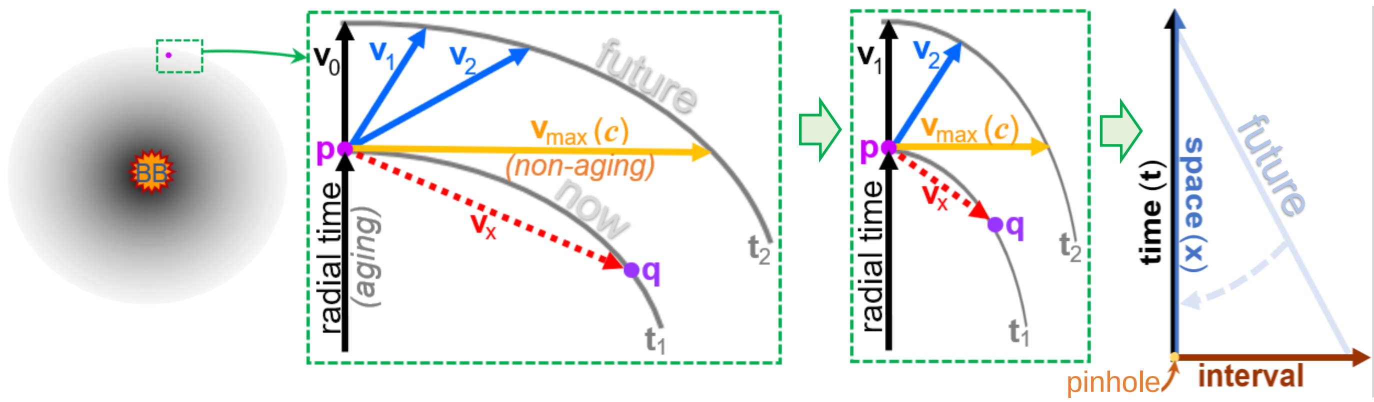

Fig. 8 From Left: A 4D temporal field emanates from the Big Bang event (BB) with concentric spatial 3-spheres (t_1, t_2) enclosing it at every radius. Any point (p) has interval-time coordinates: tangent (***c***) and normal (v_0) to space respectively. In the rest frame of v_1, moving with respect to background radiation, the cosmos is shorter in the direction of motion. At speed limit ***c*** interval contact occurs with the future, bypassing time and space. Energy communicates via this ***c***-dependent *hidden locality* (a "pinhole").

Thus, a speed ***c***-dependent pinhole (the object of chronaxial spin) effectively has *dual* spin axes, both temporal and spatial (Fig. 9). The spatial axis varies with pinhole direction. Instantaneous spin makes it a shared state of all spatial directions, which is absolutely indeterminant. Chronaxial spin is the fundamental engine of *quantum indeterminism*.

However, two particles, emerging from an event governed by conservation of angular momentum, may synchronize their spins to share the spatial axis defining their separation, a basis for entanglement.

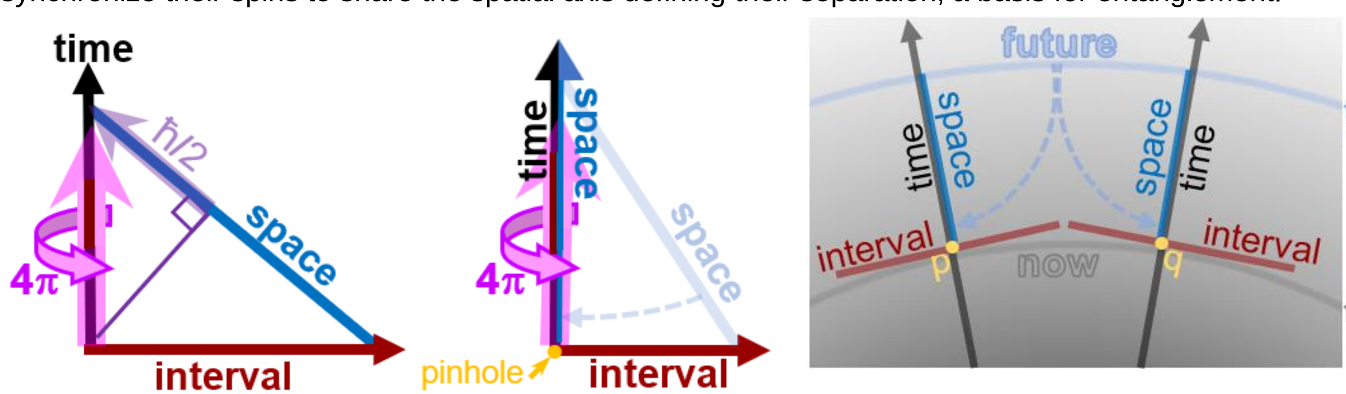

Fig. 9 Left: From the rest frame of a real (subluminal) observer, intrinsic spin is seen as purely chronaxial. Center: But, a ***c***-dependent pinhole experiences quantum spin as *biaxial*, about coinciding space and time. Right: Thus, two particles (p & q) with *different* temporal axes may share a spatial axis, thereby instantly correlating their spin projections. Such a pair is physically entangled, regardless of separation.

Four Your Information

"To uncover the deep and hidden connection between time and existence ... is a task for the future."[6]

Wheeler's "hidden connection" is physically realized as *interval contact*, seen in Euclidean coordinates. A speed ***c***-dependent pinhole is his fundamental **bit**. Unlike an Einstein-Rosen bridge, a pinhole is modeled as the *source* of gravity rather than the *result* of it. It is contact in ***four*** dimensions rather than three.

"Wheeler…has novel geometries…One such geometry consists of a space full of 'wormholes'. Such holes are ultra-tiny."[21]

Time occupies a central role as axis. Spin is instantaneous, but *existence is persistence*. Each turn advances the pinhole futureward to form the next quantum field instance. Intrinsic spin, qubit and gravity are merely different aspects of the same superposition, over which the pinhole is distributed. Thus, chronaxial spin provides both continuity and indeterminism.

"In a classical system, a bit would have to be in one state or the other. However, quantum mechanics allows the qubit to be in a coherent superposition of both states at the same time, a property that is fundamental to quantum mechanics and thus quantum computing."[12]

A field instance is a state neither entirely of contact nor of separation. Gravity is the resulting separational insufficiency. Relative spin rates are expressible as field frequency but more commonly as energy or mass. Since de Broglie gave us matter *waves*, it is only reasonable, in the case of fundamental particles, to also ascribe a *frequency*. Relative field frequency fits. Two line segments comprised by infinite points, have a finite ratio of lengths. The same for field frequency and energy.

It from Qubit[22] includes an ongoing attempt to derive gravity from entanglement.[23] If that is possible at all, it will be complicated by the reality that entanglement is spacelike and gravity is lightlike. It has been far more productive to proceed from a lightlike field element, the pinhole. For the same reason, the pinhole, as scrutinized by a Euclidean lens will provide the simplest path to unification of gravity with electromagnetism in a subsequent writing.

Fig. 10 God doesn't play dice! He uses a chronaxial spinner (spinor,[24] if you prefer).

"…there is probability all the way back…in the fundamental laws of physics there are odds."[15] p145

"…in the end the machinery will be revealed, and the laws will turn out to be simple"[25]

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8] data on paper tape (photo)
9] oaktag punch card (photo)
10] CD - compact disk (photo)
11] integrated circuit (photo)
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Related Animations - by the author (as "Faradave"), in sequence

Getting Coordinated (the world via Euclidean Lens)
Contact Sport (*c*-ing the light)
The "Hole" Shebang (fishing for wormholes)
Applying a Light Touch (unmasking photons)
What Time Is It? (leaving Lorentz transforms)
3-Ring Circus (dark energy and speed c):
Spin½ "Plane" & Simple (classically modeled)
Riding a Bi-Cycle (720° rotation)
Probable Cause (probability amplitude)
A Noether Round (new symmetry)
Field Goal (making one)
Massive Undertaking (gravity mechanism)
Instant Energy (physically realized)
Gaining Momentum (relative mass-energy)
Native Uprising (simultaneous fields)
Timely Information (Qubit from Bit)