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# Predictions and Validations of an Elastic Solid Aether Model


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# Introduction

In the words of Nobel laureate Robert Laughlin,

"The modern concept of the vacuum of space, confirmed by everyday experiment, is a relativistic ether. But we do not call it this because it is taboo." (*A Different Universe, 2005*)

# Introduction

*"The Michelson interferometer is best known for its use in the Michelson-Morley experiment, which disproved the existence of the luminiferous ether."* (web.mit.edu)

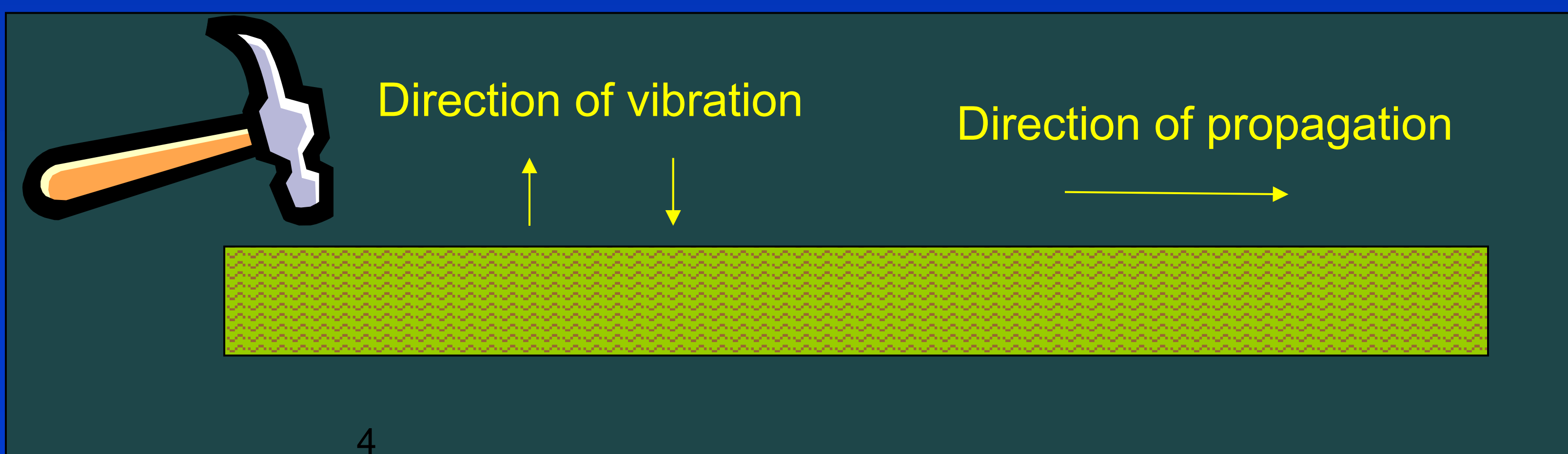
*"…these phenomena involve a quantum degree of freedom called spin, which has no classical counterpart."* *(Shankar, Principles of QM)*

**Both statements are demonstrably false.**

**Let's look at predictions of a solid aether model.**

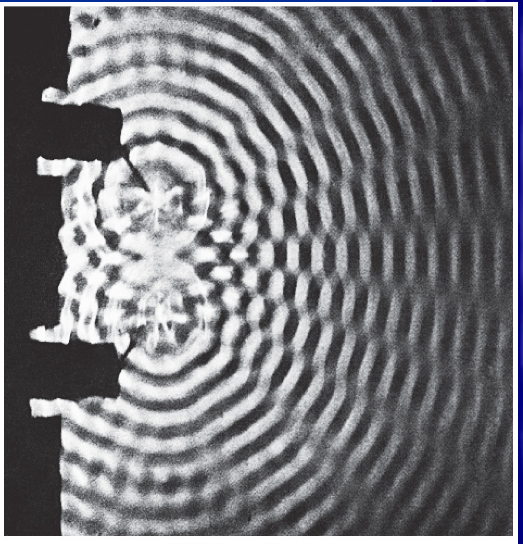
# Aether (1817)

- Young explains polarization and the constant speed of light by proposing that light waves consist of transverse vibrations such as occur in an elastic solid.



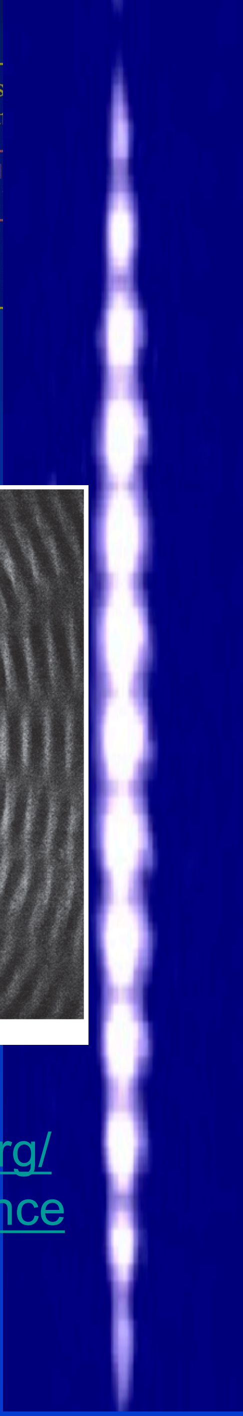
# Aether (1773-1829)

- Young validated his wave hypothesis by demonstrating that light shining between two slits generates an interference pattern (far right) similar to that observed from two wave sources.

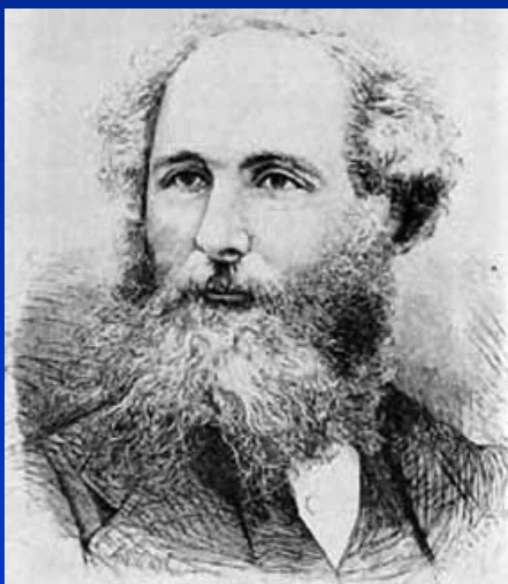




Link: http://en.wikipedia.org/wiki/Wave_interference



# Electromagnetism (1871)

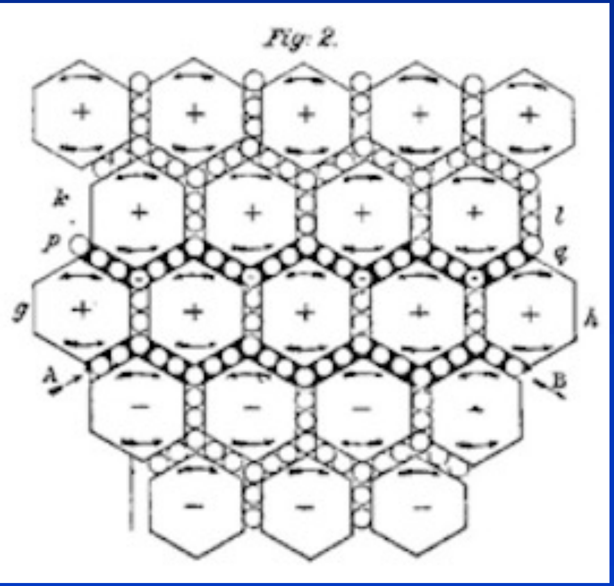


James Maxwell suggests that matter itself consists of waves:

"But what if these molecules, indestructible as they are, turn out to be not substances themselves, but mere affections of some other substance?"
(Introductory Lecture on Experimental Physics, 1871)

# Electromagnetism (1862-1873)

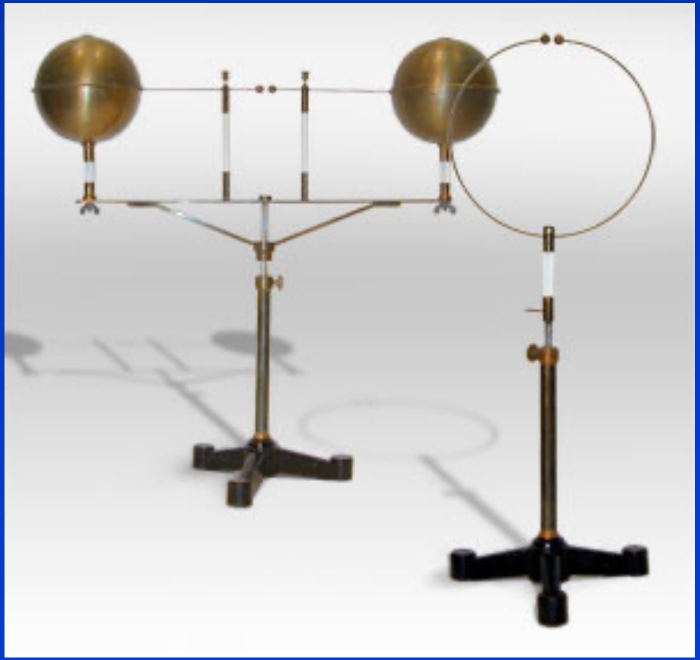
- Maxwell models the aether as a lattice of rotating elastic cells separated by rolling particles whose excess or deficiency represents electric charge. He concludes that light is electromagnetic radiation.




(*On Physical Lines of Force 1862, A Treatise on Electricity and Magnetism 1873*)

# Electromagnetism (1887)

- Heinrich Hertz confirms Maxwell's predictions experimentally, demonstrating propagation of electromagnetic energy through space.



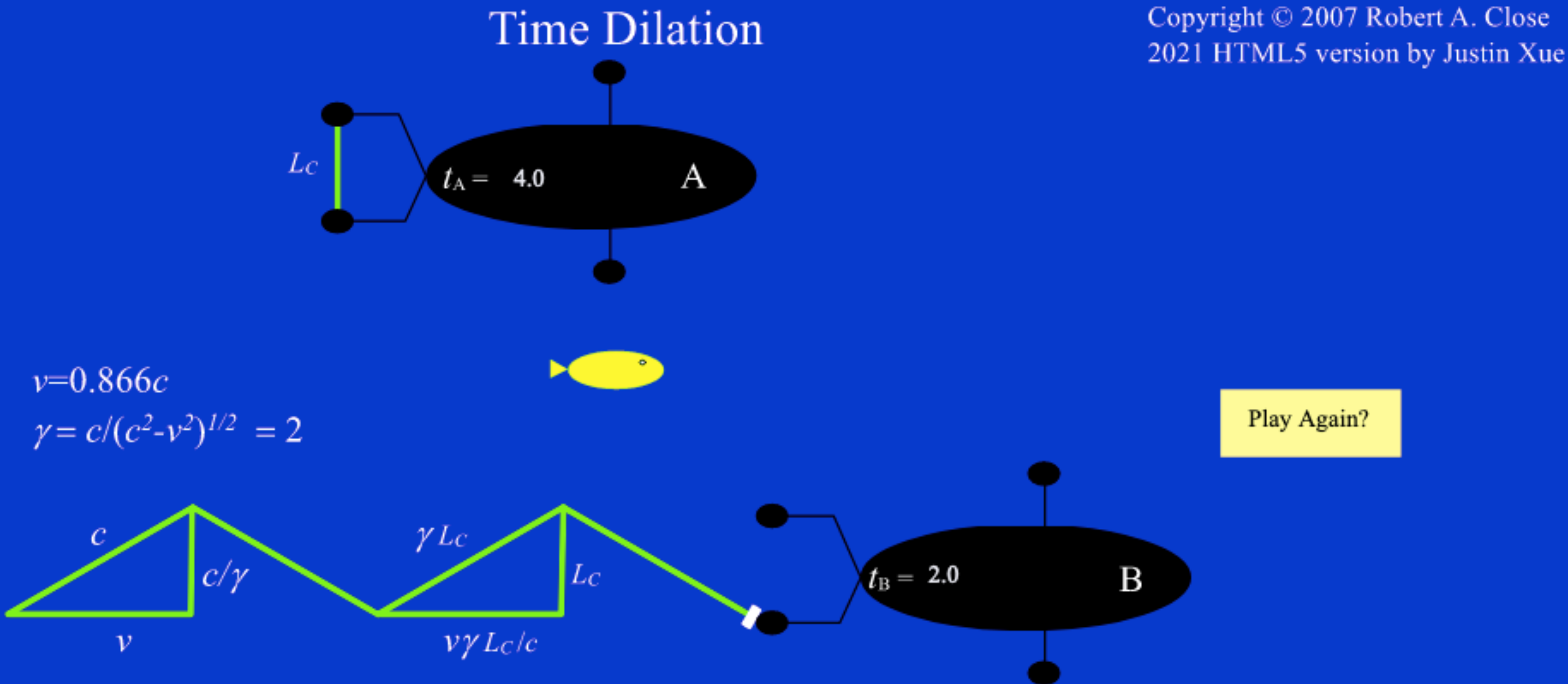
http://www.sparkmuseum.com/BOOK_HERTZ.HTM

# Matter Waves (1924)

- Louis Victor de Broglie explains the hydrogen spectrum by proposing that electrons have a wave-like character with energy proportional to frequency and momentum proportional to wave vector.

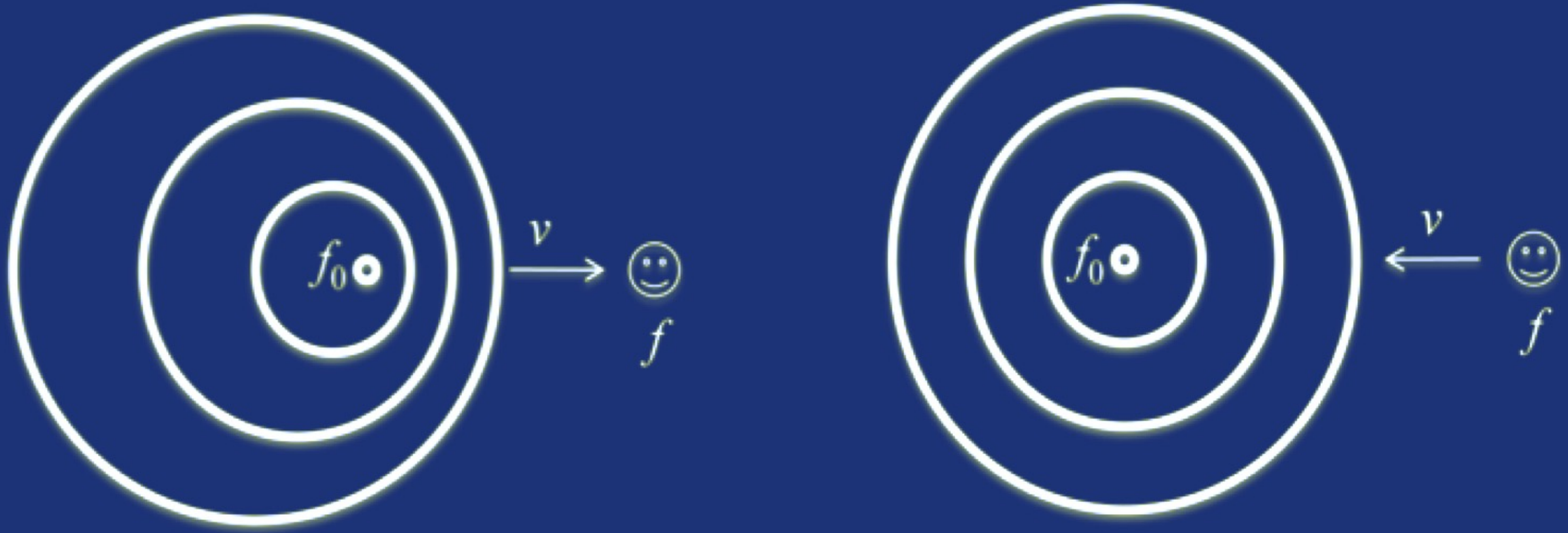
# Relativity (2007)

Wave measurements are related by Lorentz transforms.




https://www.classicalmatter.org/UnderwaterRelativity.htm

# Doppler Shifts




$$f = \frac{c}{\lambda} = \frac{c}{\left(\frac{c-v}{f_0}\right)} = f_0\left(\frac{1}{1-\beta}\right)$$

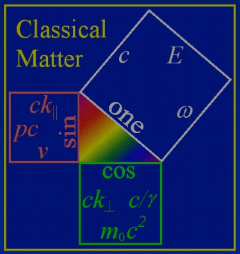
$$f = \frac{c+v}{\lambda} = \frac{c+v}{\left(\frac{c}{f_0}\right)} = f_0(1+\beta)$$

Because clocks and Doppler shifts depend on who is moving, it is impossible to determine absolute velocity. But it is possible to determine absolute acceleration.

# Relativity

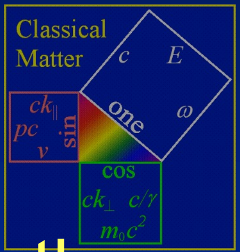
- *Physical* space is Galilean.
- *Measurement* space is Minkowski.
- Lorentz invariance is just a mathematical property of the wave equation.
- Length contraction and time dilation are real for an accelerated object, illusory for an accelerated observer.

# Relativity

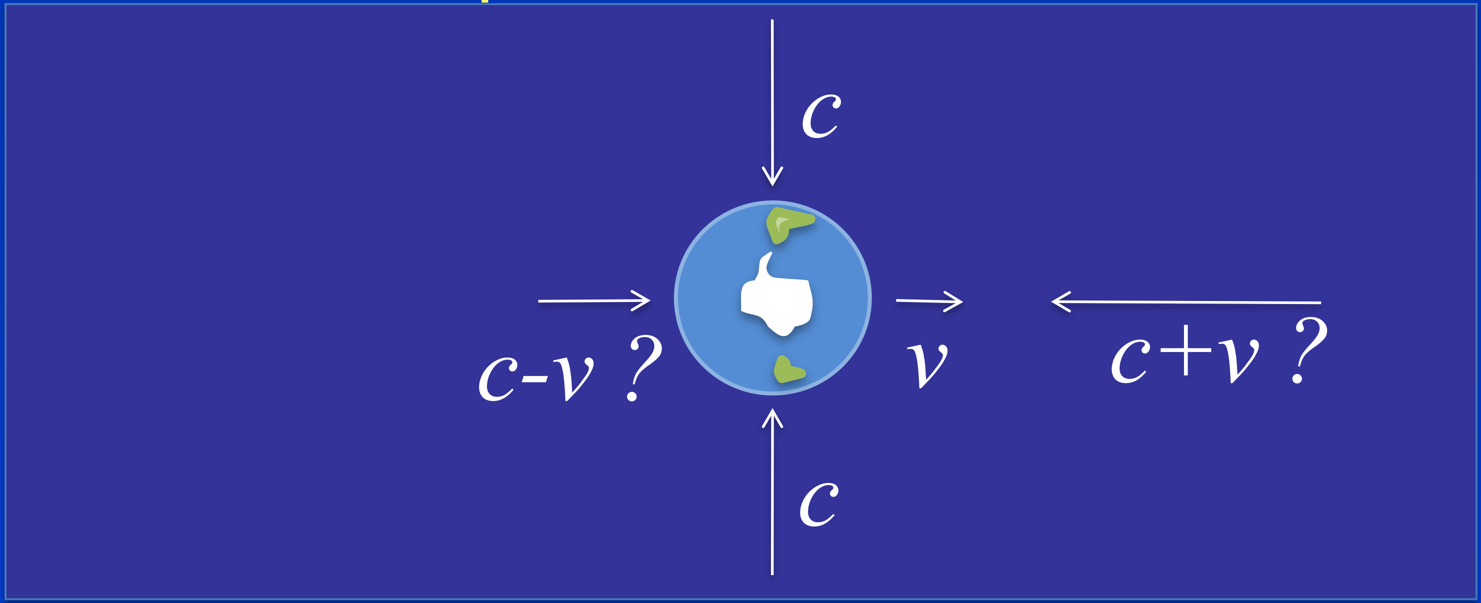



- Distance and time cannot be defined independently.
- Length is proportional to the round-trip light propagation time between two points, either as a traveling wave (photons) or as a standing wave (material ruler).
- Any clock made of matter will behave like a “light clock”.

# Relativity




- If matter moves rigidly through space, then the measured speed of light would depend on direction.
- If matter consists of waves propagating through a solid aether, then the measured speed of light would NOT depend on direction.

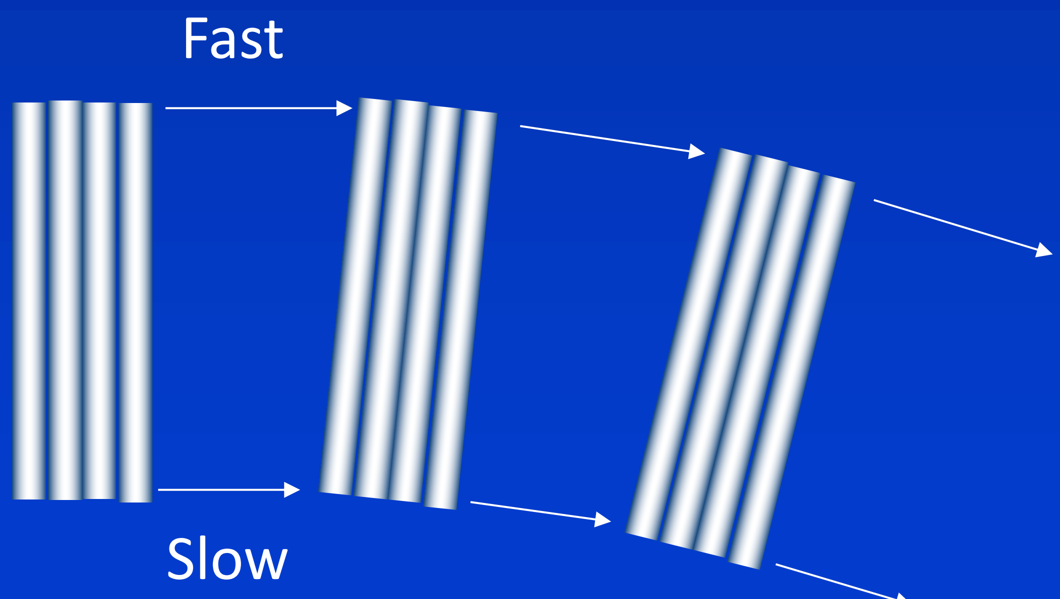


# Relativity (1887)

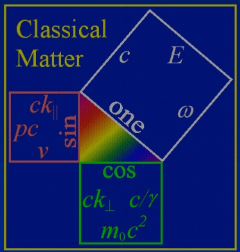
- The inability to detect differences in relative light speed is demonstrated by Albert Michelson (pictured) & Edward Morley.
- **<u>This confirms the wave nature of matter consistent with the solid aether model.</u>**

# Gravity

- Distortions of a solid increase density, decrease elasticity, and reduce wave speed (compare a twisted rubber band under constant tension). Waves bend toward slower speed. Analyze scalar waves for simplicity.



# Gravity




Wave Equation ($c = \sqrt{\mu/\rho} = c_1/n$):

$$\frac{\rho}{\rho_1}\partial_t^2 Q - \frac{\mu}{\mu_1}c_1^2\nabla^2 Q = 0$$

Rest mass $\sim\kappa/c$ $(-c^2\nabla^2 R = c^2\kappa^2 R = \omega^2 R)$:

$$Q = R(\kappa r)e^{i\omega t} \qquad \left(\text{e.g. } R = \frac{\sin\kappa r}{r}\right)$$

Traveling: $(\omega = \gamma_1\omega_1;\ c = c_1 \Longrightarrow \kappa = \kappa_1)$:

$$R(\kappa\gamma(x - vt), \kappa y, \kappa z)e^{i\left(\gamma_1\omega_1 t - \frac{n^2\gamma_1\omega_1}{c_1^2}vx\right)}$$

# Gravity

Effect of twisting (*cf.* spring pitch angle)

$$\frac{\kappa}{\kappa_1} = \left(\frac{\rho}{\rho_1}\right)^{1/3} = \left(\frac{\mu}{\mu_1}\right)^{-1/3} \;;\;\; n = \left(\frac{\rho}{\rho_1}\right)^{2/3}$$

Wave Equation (constant frequency $\gamma_1\omega_1$):

$$\frac{c_1^2}{n^2}\kappa^2 - \gamma_1^2\omega_1^2 + \frac{n^2\gamma_1^2\omega_1^2 v^2}{c_1^2} = 0$$

Simplifies to:

$$\frac{\gamma\kappa}{\gamma_1\kappa_1} = n \quad or \quad \frac{\gamma}{\gamma_1} = \left(\frac{\rho}{\rho_1}\right)^{1/3} = \sqrt{n}$$

# Gravity

Solve for speed: $\gamma^2 = n\gamma_1^2$

$$v^2 = \frac{c_1^2}{n^2}\left(1 - \frac{1}{n\gamma_1^2}\right)$$

$$\mathbf{v}\cdot\nabla\mathbf{v} + \mathbf{v}\times(\nabla\times\mathbf{v}) = \frac{1}{2}\nabla\left(\frac{c_1^2}{n^2}\left(1 - \frac{1}{n\gamma_1^2}\right)\right)$$

$$\gamma_1 \approx 1 \implies \mathbf{v}\cdot\nabla\mathbf{v} = \frac{d\mathbf{v}}{dt} = \frac{c_1^2}{2}\nabla\mathrm{n}$$

$$\gamma_1 \to \infty \;\&\; \mathbf{v_1} \perp \nabla n \implies \mathbf{v}\cdot\nabla\mathbf{v} = \frac{d\mathbf{v}}{dt} = c_1^2\nabla\mathrm{n}$$

# Gravity

One may interpret changes of width and rest frequency as "metric" changes:

$$g_{tt} = \frac{1}{g^{tt}} = \frac{\mu}{\mu_1} = \frac{1}{\sqrt{n}}$$

$$g_{xx} = \frac{1}{g^{xx}} = -\left(\frac{\rho}{\rho_1}\right)^{1/3} = -\sqrt{n}$$

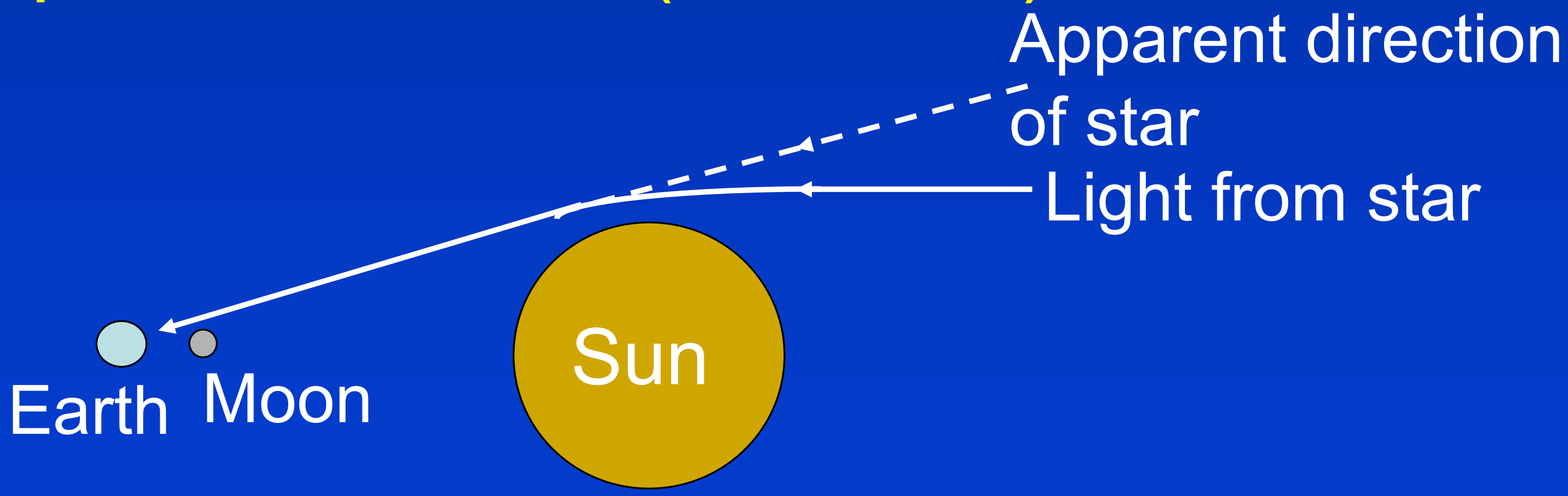
Refraction in the aether is equivalent to Einstein's geodesic:

$$\delta\sqrt{g_{tt}c_1^2 dt^2 + g_{\ell\ell} d\ell^2} = 0$$

*Cf.* Evans, et al., Am. J. Phys., Vol. 69, No. 10, October 2001, Eq. 14

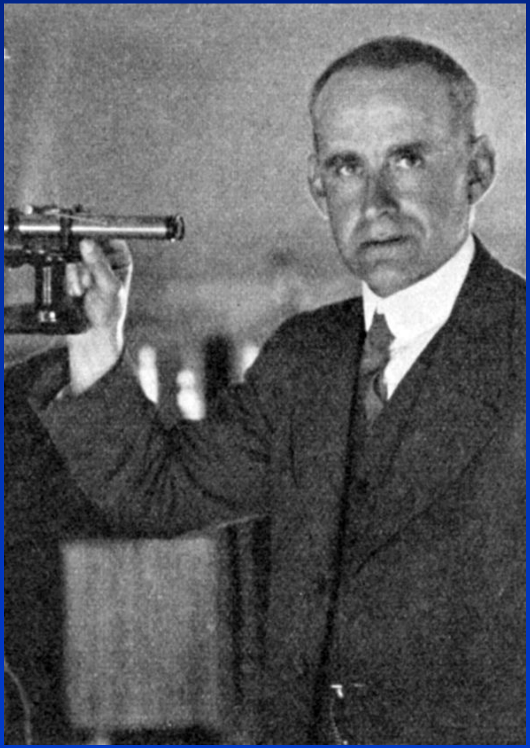
# Gravity

- Bending of light rays from stars can be observed as they pass near the sun during a solar eclipse. The relative change of wave speed is one part in a million (0.0001%).



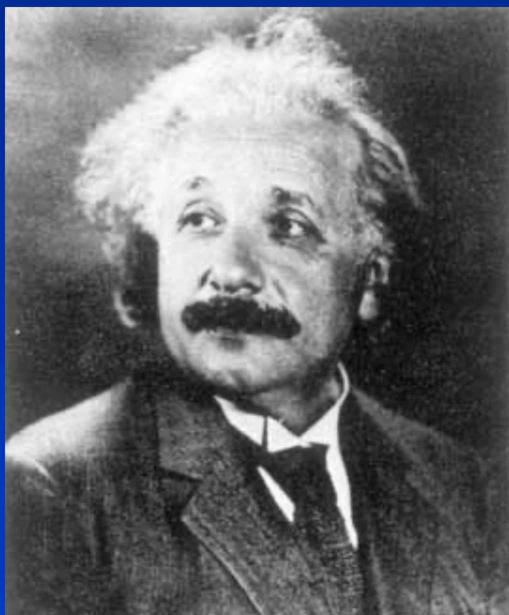
# Gravity (1919)

- Gravitational refraction of light passing near the eclipsed sun was observed by the Eddington expedition and subsequent observations.
- As predicted, deflection of light has twice the acceleration of massive particles.



- **<u>This confirms the wave nature of matter consistent with an elastic solild aether.</u>**

# Gravity (1920)

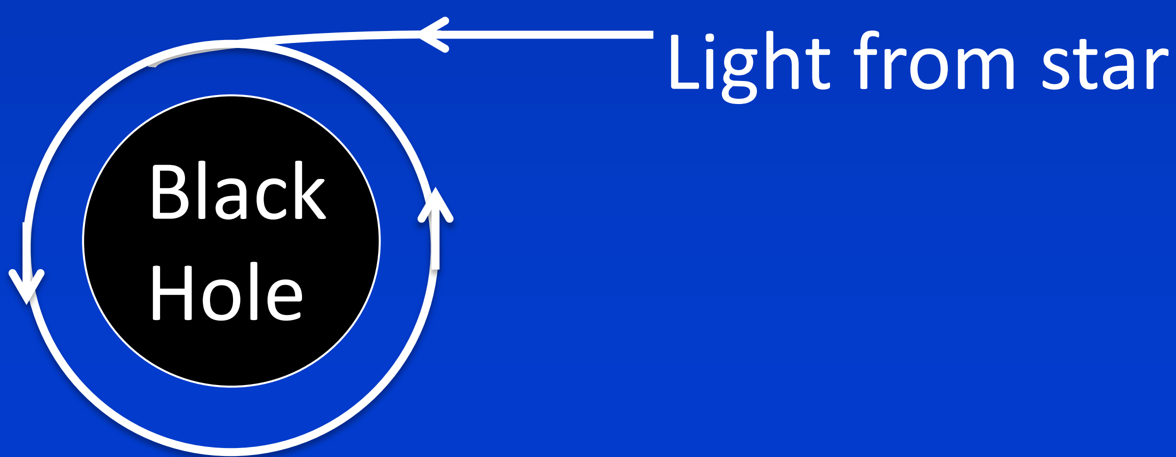


Einstein concludes there is an aether:

“There is a weighty argument to be adduced in favour of the ether hypothesis. To deny the ether is ultimately to assume that empty space has no physical qualities whatever. The fundamental facts of mechanics do not harmonize with this view.”

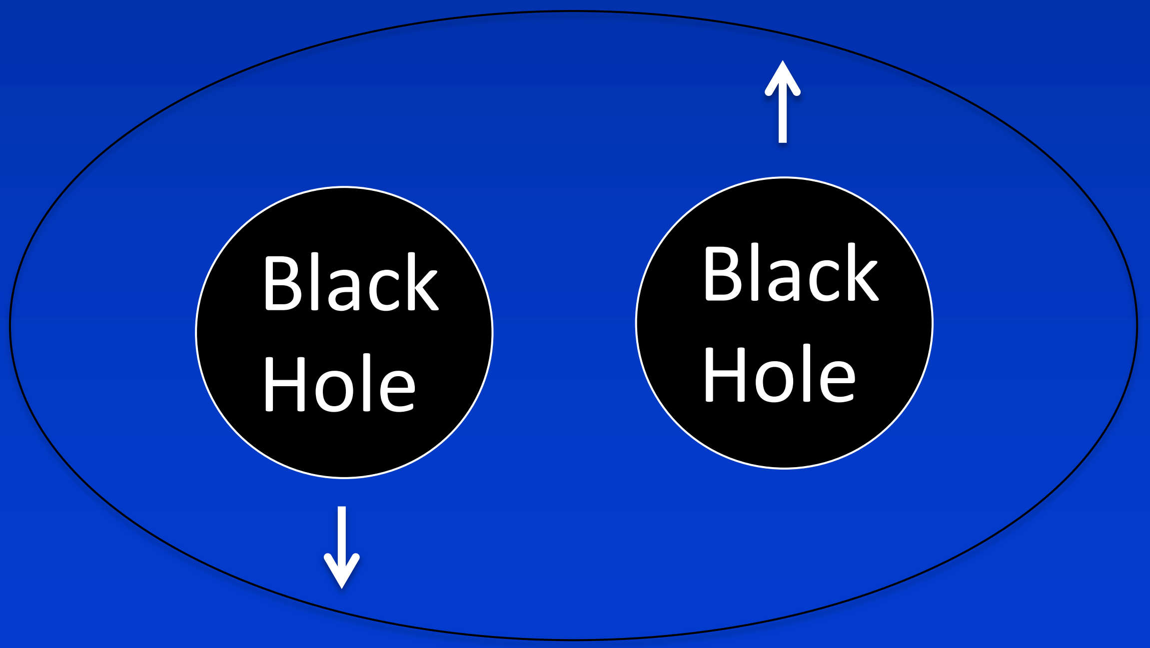
# Gravity

- If an object is dense enough to capture light (bend it into orbit), it is a black hole. The maximum radius for trapping light is called the <u>Schwarzschild radius</u>. Scientists have made similar “optical black holes” with refractive index increasing toward the center.



# Gravitational Waves

- Two interacting black holes produce distortions of space that propagate outward as a transverse wave ("spin 2").



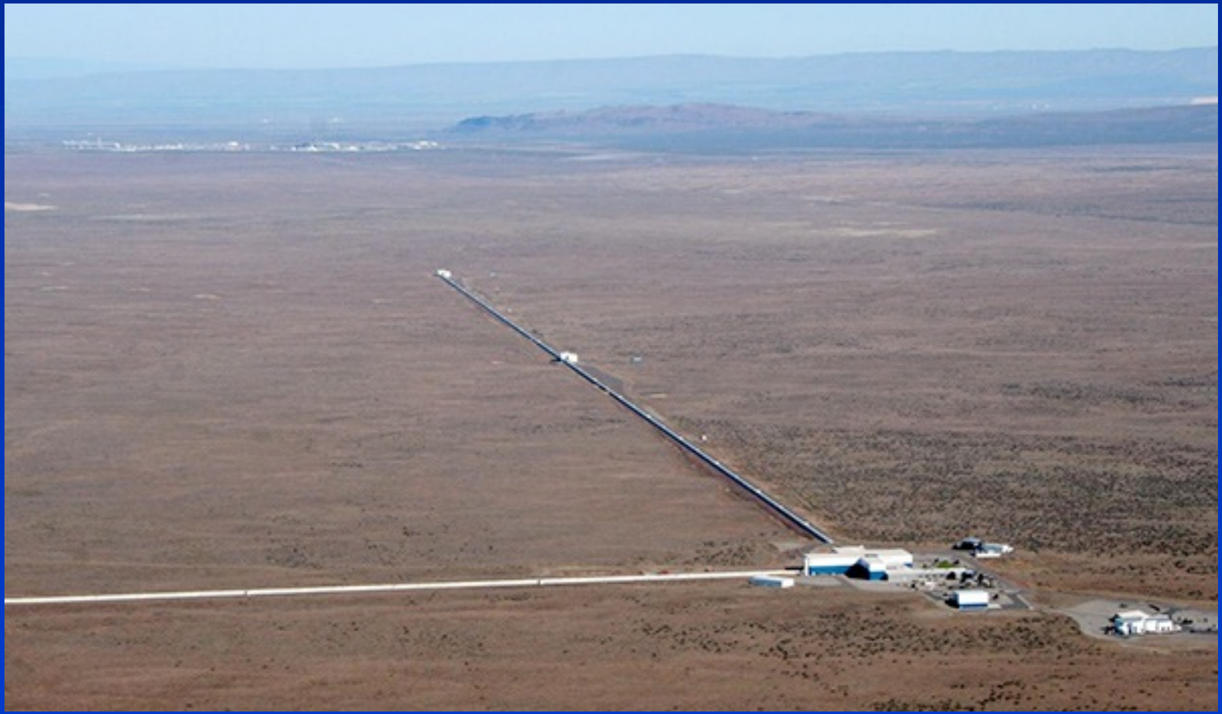
# Gravitational Waves 2015

- The resulting wave can be detected by measuring changes in the time it takes for light to traverse different directions in the distorted aether.

- Gravitational waves were first detected in September 2015 using laser interferometry.
- These waves also propagate with speed *c*.

# Gravitational Waves

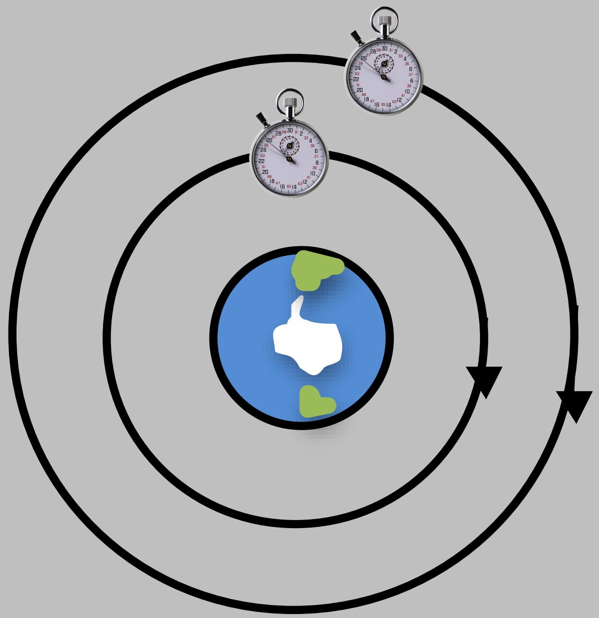
- One of these interferometers is located near Hanford, Washington.



LIGO Hanford’s two 4-km-long mirror arms can be seen stretching into the distance. Photo: LIGO

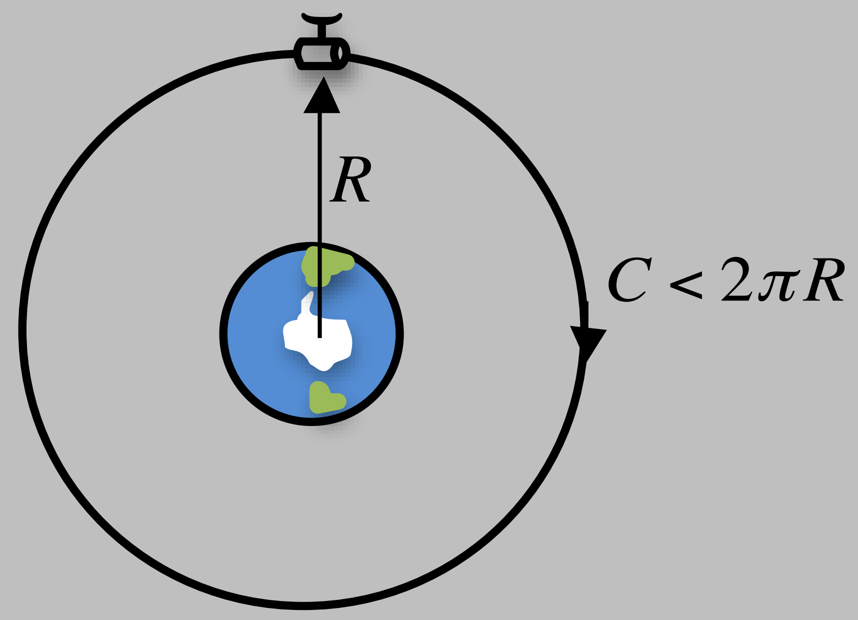
# Time

Clocks tick slower the closer they are to a massive object.



# Curved Space

- Light travels faster around the circumference of an orbit than it does across the diameter, so the circumference appears to be shorter than $\pi d = 2\pi r$.

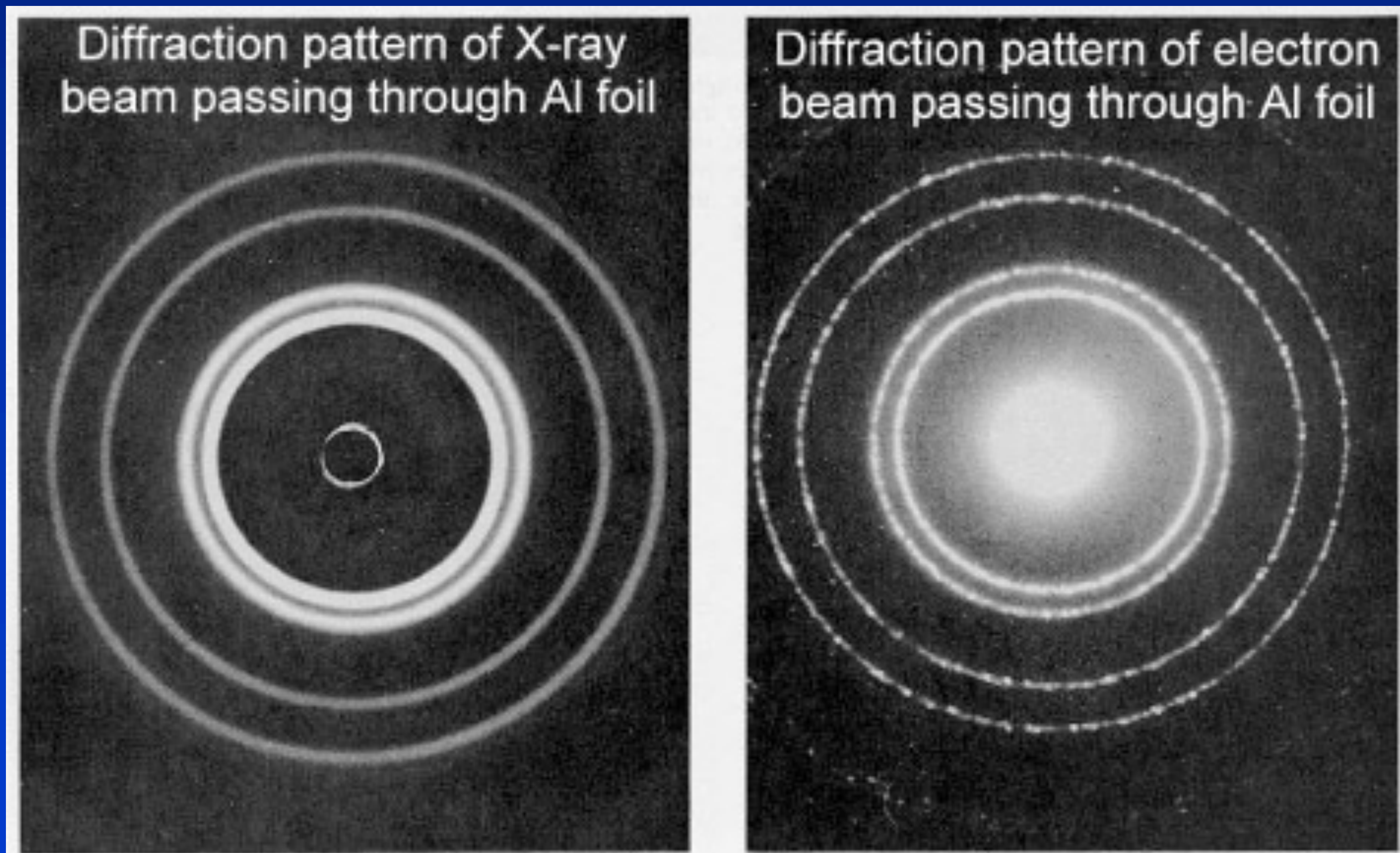


# Electron Diffraction (1927)

- Clinton Davisson and Lester Germer confirmed the wave nature of electrons by demonstrating diffraction of electrons by crystals.

  (Also George Thomson and Alexander Reid working independently)

# Matter as Waves




http://www.mtbaker.wednet.edu/mbhs/science/images/XRayandElectronDiffPattern1.jpg

# Classical Spin Density: Incompressible Motion

Helmholtz Decomposition of momentum density:

$$\mathbf{p} \equiv \rho\mathbf{u} = \mathbf{p}_0 + \nabla\Phi + \frac{1}{2}\nabla \times \mathbf{s}$$

Incompressible and in “rest” frame:

$$\nabla\Phi = 0,\ \mathbf{p}_0 = 0$$

$$\nabla \cdot \mathbf{u} = 0 \rightarrow \rho = \text{constant}$$

$$\nabla \cdot \rho\mathbf{u} = \nabla \cdot \mathbf{p} = 0$$

$$\mathbf{p} = \frac{1}{2}\nabla \times \mathbf{s}$$

# Classical Spin Density

$$\mathbf{p} = \frac{1}{2}\nabla \times \boldsymbol{s}$$

Spin angular momentum density is the vector field whose curl is equal to twice the incompressible momentum density ($\mathbf{p}=\rho\mathbf{u}$).* Every physics student should learn this fundamental definition of spin density. The “moment of momentum” is less fundamental: depends on coordinates.

*R. A. Close, "A classical Dirac bispinor equation," in *Ether Space-time & Cosmology, vol. 3*, edited by M. C. Duffy and J. Levy (Apeiron, Montreal, 2009).

See also Publications at the end of this slide show.

# Integrated Spin Density

$$\mathbf{p} = \frac{1}{2}\nabla \times \mathbf{s};\ \ \mathbf{w} = \frac{1}{2}\nabla \times \mathbf{v}$$

$$\mathbf{S} = \int \mathbf{r} \times \mathbf{p}\, \boldsymbol{d^3r} = \int \mathbf{s}\, \boldsymbol{d^3r} + \mathrm{b.t.}$$

$$K = \int \frac{1}{2}\rho v^2\, d^3r = \int \frac{1}{2}\mathbf{w} \cdot \mathbf{s}\, \boldsymbol{d^3r} + \mathrm{b.t.}$$

Spin density yields the same total angular momentum and rotational kinetic energy as conventional calculations.

# Spin Density

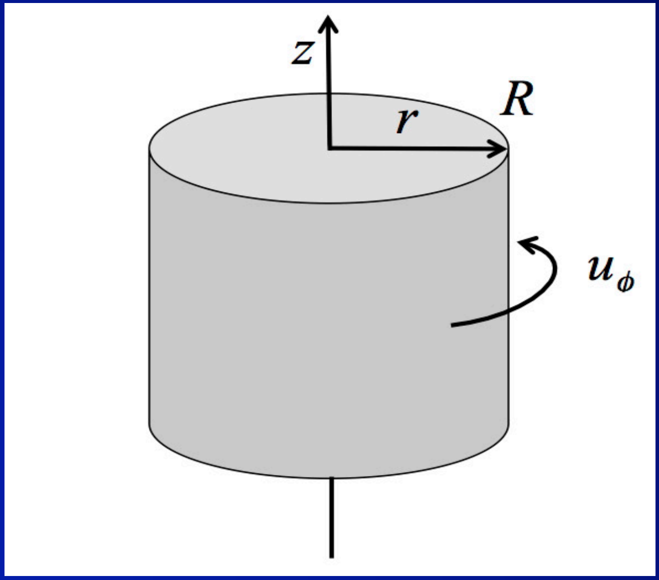
Two types of momentum:
"intrinsic" & "wave"
Two types of angular momentum:
"intrinsic" (**s**) & "wave" (**L**).

$$\frac{\delta}{\delta \mathbf{w}} \int \frac{\rho v^2}{2}\, d^3 r = \frac{\delta}{\delta \mathbf{w}} \int \frac{\mathbf{w} \cdot \mathbf{s}}{2}\, \boldsymbol{d^3 r} = \int \mathbf{s}\, d^3 r$$

For Lagrange density $\mathfrak{L} = \frac{1}{2} \rho v^2$,
**s** is the momentum conjugate to **w**.
**L** is derived from torque density.

# Rotating Cylinder

Parabolic radial distribution of spin density.



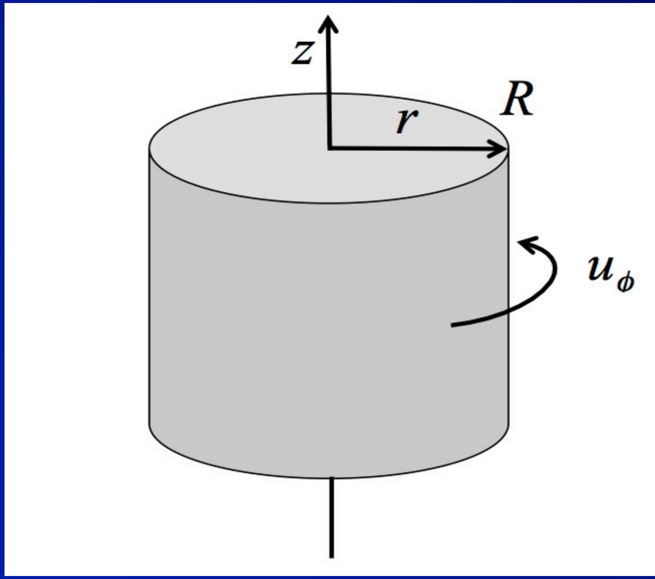

$$\mathbf{s} = \rho w_0[R^2 - r^2] \qquad r \leq R$$

$$u_\phi = \frac{1}{2\rho}\frac{\partial}{\partial r}s_z = r w_0 \qquad r \leq R$$

$$w_z = \frac{1}{2r}\frac{\partial}{\partial r} r u_\phi$$
$$= w_0[1 - R\delta(R - r)/2] \qquad r \leq R$$

# Rotating Cylinder

Integration yields the usual total angular momentum and kinetic energy.




$$S_z = \int s_z \, d^3r = \frac{MR^2}{2} w_0 = I w_0$$

$$K = \int \frac{1}{2} \rho u^2 \, d^3r = \int \frac{1}{2} \mathbf{w} \cdot \mathbf{s} \, d^3r$$

$$= \frac{1}{2} \frac{MR^2}{2} w_0^2 = \frac{1}{2} I w_0^2$$

# Equation of Evolution

Momentum density:

$$\partial_t \mathbf{p} + \mathbf{u} \cdot \nabla \mathbf{p} = \mathbf{F}$$

Spin density (Helmholtz decomposition):

$$\partial_t \mathbf{s} + \frac{1}{\pi} \nabla \times \int \frac{\mathbf{w}' \times \mathbf{p}'}{|\mathbf{r} - \mathbf{r}'|} d^3 r = \boldsymbol{\tau}$$

# Equation of Evolution

Elastic solid model: torque is derived from a vector potential **Q**:

$$\mathbf{s} \equiv \partial_t \mathbf{Q} \quad \text{and} \quad \boldsymbol{\tau} = c^2 \nabla^2 \mathbf{Q}$$

$$\partial_t^2 \mathbf{Q} - c^2 \nabla^2 \mathbf{Q} = -\frac{1}{\pi} \nabla \times \int \frac{\mathbf{w}' \times \mathbf{p}'}{|\mathbf{r} - \mathbf{r}'|} d^3 r$$

Nonlinear ⇒ Quantization & normalization?

Simple wave equation w/o nonlinear term

# Factor the Wave Equation

- 1st -order equation required to compute evolution.
- 2nd -order wave equation:

$$\partial_t^2 a - c^2 \partial_z^2 a = 0$$

- Solution is Forward + Backward waves:

$$a(z,t) = a_F(z - ct) + a_B(z + ct)$$

- Independent solutions are 180° apart. Wave solutions form a spin one-half system (3-D requires bispinors).

$\longleftarrow$ Backward $\qquad$ Forward $\longrightarrow$

# Factor the Wave Equation

$$\dot{a}(z,t) = \dot{a}_F(z-ct) + \dot{a}_B(z+ct)$$

- First-order matrix equation:

$$\partial_t \begin{bmatrix} \dot{a}_B \\ \dot{a}_F \end{bmatrix} - c \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \partial_z \begin{bmatrix} \dot{a}_B \\ \dot{a}_F \end{bmatrix} = 0$$

- Equivalent to second-order wave equations:

$$\partial_t^2 a_B - c^2 \partial_z^2 a_B = 0$$
$$\partial_t^2 a_F - c^2 \partial_z^2 a_F = 0$$

- The Dirac equation of quantum mechanics simply extends the matrix equation to vectors in 3D.

# Dirac Equation
# 1928

- Paul Dirac introduces a first-order Lorentz-invariant equation for matter. Each component of the Dirac wave function satisfies the Klein-Gordon equation.

# Factor the Wave Equation

- To accommodate rotation, separate positive and negative time derivative components:

$$
\begin{aligned}
\partial_t a(z,t) = {} & \dot{a}_{F+}(z-ct) \\
& - \dot{a}_{F-}(z-ct) \\
& + \dot{a}_{B+}(z+ct) \\
& - \dot{a}_{B-}(z+ct)
\end{aligned}
$$

Define the wave function (chiral representation):

$$
\psi(z,t) = \begin{bmatrix} (\dot{a}_{B+})^{1/2} \\ (\dot{a}_{F-})^{1/2} \\ (\dot{a}_{F+})^{1/2} \\ (\dot{a}_{B-})^{1/2} \end{bmatrix}
$$

# Factor the Wave Equation

- The first-order 1-D wave equation is:

$$\partial_t(\psi^T\sigma_{\mathbf{z}}\psi) + c\partial_z(\psi^T\gamma^5\psi) = 0$$

where:

$$\psi^T\sigma_{\mathbf{z}}\psi = \begin{bmatrix}(\dot{a}_{B+})^{1/2}\\(\dot{a}_{F-})^{1/2}\\(\dot{a}_{F+})^{1/2}\\(\dot{a}_{B-})^{1/2}\end{bmatrix}^T \begin{pmatrix}1 & 0 & 0 & 0\\0 & -1 & 0 & 0\\0 & 0 & 1 & 0\\0 & 0 & 0 & -1\end{pmatrix} \begin{bmatrix}(\dot{a}_{B+})^{1/2}\\(\dot{a}_{F-})^{1/2}\\(\dot{a}_{F+})^{1/2}\\(\dot{a}_{B-})^{1/2}\end{bmatrix} = \partial_t a$$

$$\psi^T\gamma^5\psi = \begin{bmatrix}(\dot{a}_{B+})^{1/2}\\(\dot{a}_{F-})^{1/2}\\(\dot{a}_{F+})^{1/2}\\(\dot{a}_{B-})^{1/2}\end{bmatrix}^T \begin{pmatrix}-1 & 0 & 0 & 0\\0 & -1 & 0 & 0\\0 & 0 & 1 & 0\\0 & 0 & 0 & 1\end{pmatrix} \begin{bmatrix}(\dot{a}_{B+})^{1/2}\\(\dot{a}_{F-})^{1/2}\\(\dot{a}_{F+})^{1/2}\\(\dot{a}_{B-})^{1/2}\end{bmatrix} = -c\partial_z a$$

# Dirac Equation

1-D wave equation:

$$0 = \{\psi^T \sigma_{\mathbf{z}} \partial_t \psi + \ \psi^T \gamma^5 \sigma_{\mathbf{z}} \sigma_{\mathbf{z}} c \partial_z \psi\} + \mathrm{Transp.}$$

$$0 = \partial_t^2 Q_z - c^2 \partial_z^2 Q_z$$

3-D wave equation (replace $z$ with $i$ or $j$):

$$\psi^\dagger \sigma_{\boldsymbol{i}} \left[\partial_t \psi + c\,\gamma^5 \sigma_{\boldsymbol{j}} \partial_j \psi\right] + adj. = 0$$

<u>Same as electron!</u> Vector wave equations:

$$0 = \partial_t[\psi^\dagger \boldsymbol{\sigma} \psi] + c\nabla[\psi^\dagger \gamma^5 \psi]$$
$$-ic[\nabla\psi^\dagger \times \boldsymbol{\sigma}\psi + \psi^\dagger \gamma^5 \boldsymbol{\sigma} \times \nabla\psi]$$

$$0 = \partial_t^2 \mathbf{Q} - c^2 \nabla(\nabla \cdot \mathbf{Q}) + c^2 \nabla \times \nabla \times \mathbf{Q}$$

# Dirac Equation

## Classical spin density = Quantum spin density

$$\mathbf{s} = \partial_t \mathbf{Q} = \frac{1}{2}\psi^\dagger \boldsymbol{\sigma}\psi$$

$$c\nabla \cdot \mathbf{Q} = -\frac{1}{2}\psi^\dagger \gamma^5 \psi$$

$$c^2\nabla \times \nabla \times \mathbf{Q}$$

$$= \frac{-ic}{2}\left[\nabla\psi^\dagger \times \boldsymbol{\sigma}\psi + \psi^\dagger\gamma^5\boldsymbol{\sigma} \times \nabla\psi\right]$$

$$0 = \frac{-ic}{2}\nabla \cdot \left[\nabla\psi^\dagger \times \boldsymbol{\sigma}\psi + \psi^\dagger\gamma^5\boldsymbol{\sigma} \times \nabla\psi\right]$$

# Plane Waves

Vector plane wave (longitudinal):

$$\mathbf{Q}(x, y, z, t) = \hat{z} Q_0 \sin(\omega t - kz)$$

$$\mathbf{s} = \partial_t \mathbf{Q} = \hat{z} \omega Q_0 \cos(\omega t - kz)$$

Dirac representation:

$$\psi = \sqrt{2\omega Q_0}\exp\left[-\mathrm{i}\left(\omega t - kz\right)/2\right]\begin{bmatrix} 0 \\ \sin\left([\omega t - kz]/2\right) \\ \cos\left([\omega t - kz]/2\right) \\ 0 \end{bmatrix}$$

Dirac phase is half of vector phase.

Rotate wave velocity for transverse waves.

# Plane Waves

TABLE I. Spin and wave velocity operators

| Rotation Axis: | Initial | $\hat{\mathbf{x}}$ | $\hat{\mathbf{y}}$ | |
|---|---|---|---|---|
| Rotation Operator: | None | $e^{-i\sigma_1\pi/4}$ | $e^{-i\sigma_2\pi/4}$ | $e^{-i\sigma_3}$ |
| Change of variable: | None | $z \to -y$ | $z \to x$ | $z$ − |
| Final Spin Axis: | $\sigma_3\hat{\mathbf{z}}$ | $-\sigma_2\hat{\mathbf{y}}$ | $\sigma_1\hat{\mathbf{x}}$ | |
| Wave | $\gamma^6\sigma_3\hat{\mathbf{x}}$ | $\gamma^6\sigma_2\hat{\mathbf{x}}$ | $\gamma^5\sigma_1\hat{\mathbf{x}}$ | $\gamma^0$ |
| Velocity | $-\gamma^0\sigma_3\hat{\mathbf{y}}$ | $-\gamma^5\sigma_2\hat{\mathbf{y}}$ | $-\gamma^0\sigma_1\hat{\mathbf{y}}$ | $\gamma^6$ |
| Operators | $\gamma^5\sigma_3\hat{\mathbf{z}}$ | $-\gamma^0\sigma_2\hat{\mathbf{z}}$ | $-\gamma^6\sigma_1\hat{\mathbf{z}}$ | $\gamma^5$ |

$$\sigma_3 = i\sigma_1\sigma_2 \qquad \gamma^6 = i\gamma^0\gamma^5$$

# Plane Waves

Matrices $(\gamma^0, \gamma^5, \gamma^6)$ represent 3 orthogonal directions relative to wave velocity.

For plane waves, mass term $iM\gamma^0\psi$ represents rotation of wave velocity.

QM mass represents radial acceleration:

$$\psi_{l,m}^{(+)} = \frac{1}{r}\begin{bmatrix} \mathrm{i}G\Phi_{l,m}^{(+)} \\ F\Phi_{l,m}^{(-)} \end{bmatrix} = \sigma_r \psi_{l,m}^{(-)}$$

$$\psi^{(+)\dagger}\mathrm{i}M\gamma^0\sigma_i\psi^{(+)} = 4M\frac{FG}{r^2}\delta_{ir}\Phi_{l,m}^{(+)\dagger}\Phi_{l,m}^{(+)}$$

*Cf*. Hestenes, Found. Phys., 20, (10,) 1990: 1213-1232

# Dirac Equation

The elastic solid Lagrangian and Hamiltonian are the real parts of:

$$\mathfrak{L} = i\psi^\dagger \partial_t \psi + c\psi^\dagger \gamma^5 \boldsymbol{\sigma} \cdot i\nabla\psi - \psi^\dagger \chi \psi$$

$$\mathcal{H} = -c\psi^\dagger \gamma^5 \boldsymbol{\sigma} \cdot i\nabla\psi + \psi^\dagger \chi \psi$$

# Dirac Equation

Dynamical quantities:

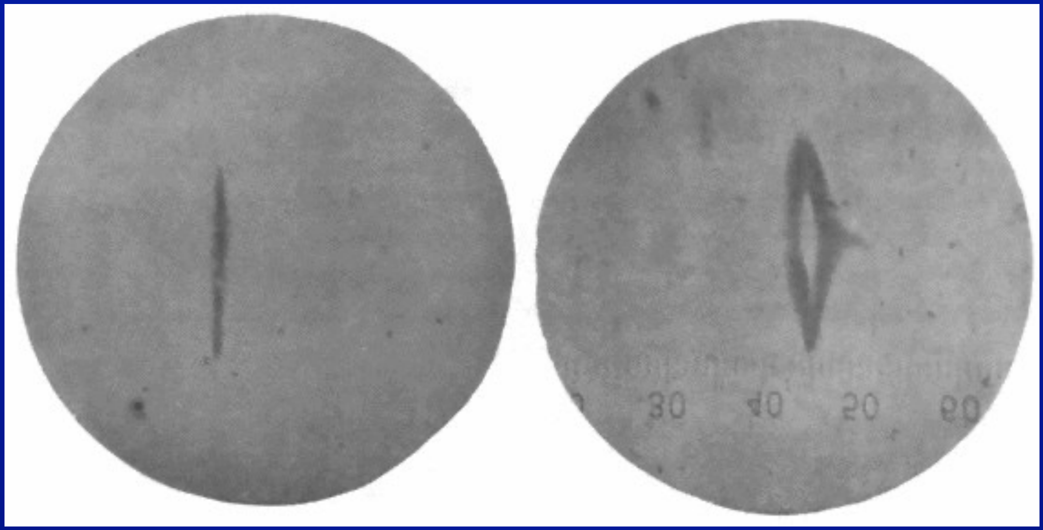
$$\mathbf{P} = -\left[\psi^\dagger i\nabla\psi\right] + \frac{1}{2}\nabla\times\left[\psi^\dagger\frac{\boldsymbol{\sigma}}{\mathbf{2}}\psi\right]$$

$$\mathbf{J} = -\mathbf{r}\times\left[\psi^\dagger i\nabla\psi\right] + \left[\psi^\dagger\frac{\boldsymbol{\sigma}}{\mathbf{2}}\psi\right]$$

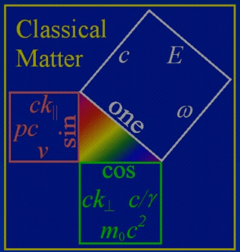
- The momentum of the medium is necessary for a symmetric energy-momentum tensor compatible with General Relativity. [Ohanian 1986]
- The solid aether model predicts two types of angular momentum: (1) wave or ”orbital” and (2) spin or intrinsic angular momentum of the aether.

# **Spin Angular Momentum**
# (1921)

Otto Stern & Walther Gerlach measured spin angular momentum by applying a nonuniform magnetic field to a beam of silver atoms, splitting the beam in two.



# **Matter Waves**
# 1951-1952




Dirac states:

“If one examines the question in the light of present-day knowledge, one finds that the Aether is no longer ruled out by relativity, and good reasons can now be advanced for postulating an Aether.”

# Rotational Waves (2010)

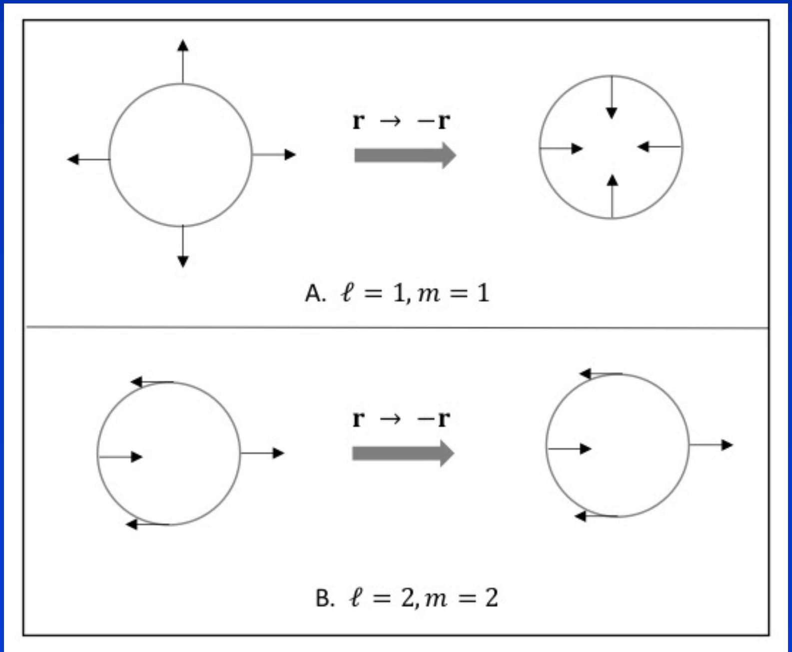
- The normalized correlation between an initial state and a possible final state is:

$$C\left(\psi_F \,|\, \psi(t_0)\right) = \left\langle \psi_F \right| e^{-\mathrm{i}H(t-t_0)} \left| \psi(t_0) \right\rangle$$

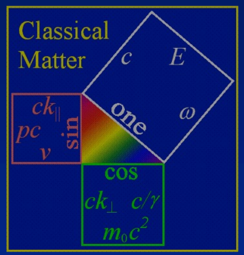
$$= \frac{\left| \int \psi_F^{\dagger} e^{-\mathrm{i}H(t-t_0)} \psi(t_0)\, d^3r \right|^2}{\left| \int \psi_F^{\dagger} \psi_F \, d^3r \right| \left| \int \psi^{\dagger}(t_0) \psi(t_0)\, d^3r \right|}$$

# **Parity** (2022)

- Vector spherical harmonics with odd ℓ-values have odd parity (distinct mirror-images).
- Vector spherical harmonics with even ℓ-values have even parity (identical mirror-images).



# Mirror Images




- Vector spherical harmonics:
  - Distinct for odd integers.
  - Identical for even integers.
- Dirac (half the phase of vectors):
  - Distinct for half-integers.
  - Identical for whole integers.
- Standard Model:
  - Fermions have distinct antiparticles.
  - Bosons have identical antiparticles except $W^{+/-}$ (not spherical harmonics)?

# **Parity** (1956)

- Lee and Yang suggest conventional parity operator not consistent with parity conservation in weak interactions.
- Conventional theory predicts that all mirror-image processes can occur with matter. Assumes *physical* Minkowski space.
- Aether model predicts that mirror-image processes generally occur only if matter and antimatter are exchanged.

# My Pet Peeve

Dirac equation was derived from Galilean spacetime:

$$\psi^{\dagger}\sigma_{\boldsymbol{i}}\left[\partial_t\psi + c\,\gamma^5\sigma_{\boldsymbol{j}}\partial_j\psi + i\gamma^0 M\psi\right] = 0$$

Multiply by $\gamma^0\gamma^0 = I$:

$$\psi^{\dagger}\gamma^0\sigma_{\boldsymbol{i}}\left[\gamma^0\partial_t\psi + c\,\gamma^0\gamma^5\sigma_{\boldsymbol{j}}\partial_j\psi + iM\psi\right] = 0$$

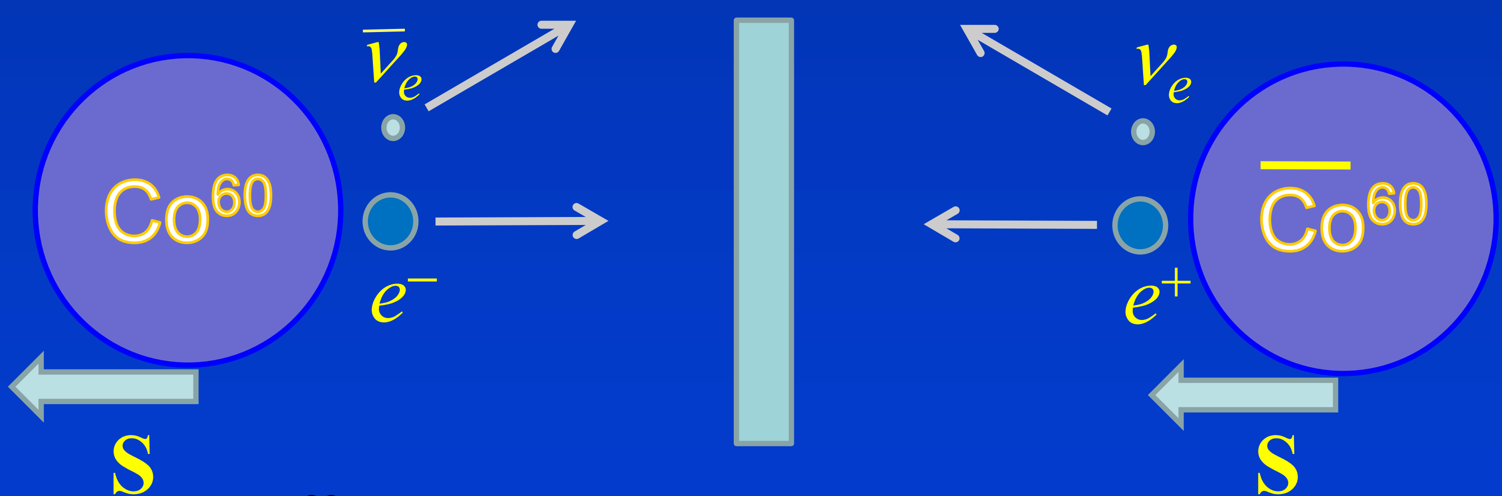
$$\bar{\psi}\sigma_{\boldsymbol{i}}\left[\gamma^{\mu}\partial_{\mu}\psi + iM\psi\right] = 0$$

Is physical space now Minkowski space???

Nothing changed.

# **Parity** (1957)

- Chien-Shiung Wu’s beta decay experiment demonstrates that mirror processes require exchange of matter and antimatter, confirming the aether model.



# Exclusion Principle & Potentials

- Wave superposition:

$$[\psi_A + \psi_B]^\dagger \boldsymbol{\sigma} [\psi_A + \psi_B] = \psi_A^\dagger \boldsymbol{\sigma} \psi_A + \psi_B^\dagger \boldsymbol{\sigma} \psi_B + \psi_A^\dagger \boldsymbol{\sigma} \psi_B + \psi_B^\dagger \boldsymbol{\sigma} \psi_A$$

- Interference terms cancel for "independent" particles. For eigenfunctions this yields the <u>exclusion principle</u> (anti-commutation):

$$\psi_A^\dagger \psi_B + \psi_B^\dagger \psi_A = 0$$

- <u>Potentials</u> are phase shifts introduced to maintain zero interference (e.g. magnetic flux quantum is loop integral of phase shift).

# Exclusion Principle & Potentials

Phase shifted waves have no interference:

$$\psi_A^{\dagger} e^{-i\varphi_A} e^{i\varphi_B} \psi_B + c.c. = 0$$

Transformation of operators on $\psi_A$:

$$\psi_A^{\dagger}(-i\nabla)\psi_A \rightarrow \psi_A^{\dagger} e^{-i\varphi_A}(-i\nabla) e^{i\varphi_A} \psi_A$$

$$= \psi_A^{\dagger}(-i\nabla + \nabla\varphi_A)\psi_A$$

$$\psi_A^{\dagger}(\partial_t + \mathrm{i}H)\psi_A \rightarrow \psi_A^{\dagger} e^{-i\varphi_A}(\partial_t + \mathrm{i}H) e^{i\varphi_A} \psi_A$$

$$= \psi_A^{\dagger}(\partial_t + \mathrm{i}H + \mathrm{i}\partial_t\varphi_A + \mathrm{i}c\gamma^5 \boldsymbol{\sigma} \cdot \nabla\varphi_A)\psi_A$$

$$= \psi_A^{\dagger}(\partial_t + \mathrm{i}H + \mathrm{i}e\Phi - \mathrm{i}\gamma^5 \boldsymbol{\sigma} \cdot e\mathbf{A})\psi_A$$

# Exclusion Principle & Potentials

Change of wave momentum: $\frac{d}{dt}P_i =$

$$\psi_A^\dagger\Big((\partial_t\partial_i - \partial_i\partial_t)\varphi_A - c\gamma^5\sigma_j\big(\partial_i\partial_j - \partial_j\partial_i\big)\varphi_A\Big)\psi_A$$

Multivalued phase $\Longrightarrow$ Non-commuting!

Electromagnetic variables:

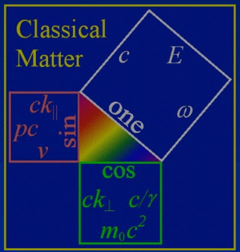
$$e\mathbf{A} = -\hbar\nabla\varphi_A; \quad e\Phi = \hbar\partial_t\varphi_A$$

$$\rho_e = e\psi_A^\dagger\psi_A; \quad \mathbf{J} = e\psi_A^\dagger c\gamma^5\boldsymbol{\sigma}\psi_A$$

$$\mathbf{E} = -\frac{\hbar}{e}\nabla(\partial_t\varphi_A) + \frac{\hbar}{e}\partial_t(\nabla\varphi_A) = -\nabla\Phi - \partial_t\mathbf{A}$$

$$\mathbf{B} = \nabla\times\mathbf{A} = \frac{\hbar}{e}2\pi\boldsymbol{\delta}^{(2)}(\boldsymbol{x},\boldsymbol{y})$$

$$\frac{d}{dt}\mathbf{P} = \rho_e\mathbf{E} + \mathbf{J}\times\mathbf{B}$$




Stokes' Law:

$$\oint \mathbf{A} \cdot d\boldsymbol{\ell} = \iint (\nabla \times \mathbf{A}) \cdot d\mathbf{S}$$

Pure phase shift: magnetic flux quantized:

$$\varphi_A = \frac{\left(m_\phi \phi - \omega t\right)}{2}$$

$$\oint \mathbf{A} \cdot d\boldsymbol{\ell} = -\frac{\hbar}{2e} 2\pi m_\phi \xrightarrow{m_\phi = 1} \frac{h}{2e}$$

# Radially weighted phase shift:

$$\varphi_A = \frac{(m_\phi \phi - \omega t)}{2}\left(\frac{e^2}{4\pi\epsilon_0 \hbar c}\right)\frac{c}{\omega r}$$

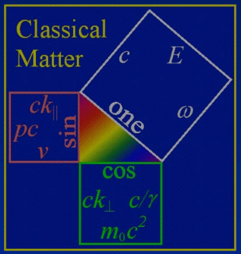
$$e\mathbf{A} = \left(\frac{e^2}{4\pi\epsilon_0 \hbar c}\right)\frac{c}{2\omega r}\left\{\left(\frac{m_\phi}{r\ \sin\theta}\right)\hat{\phi} - \frac{m_\phi \phi}{r^2}\hat{r}\right\}$$

# Neglect radial term (no flux).

$$e\mathbf{B} = \left(\frac{e^2}{4\pi\epsilon_0 \hbar c}\right)\frac{c}{2\omega}\left(\frac{m_\phi}{r^3\ \sin\theta}\right)\hat{\boldsymbol{\theta}}$$

# Same flux as $e^-$ dipole moment: $\mu_0 M/2r$:

$$\oint \mathbf{A}\cdot d\boldsymbol{\ell} = -\frac{m_\phi e}{4\epsilon_0 \omega r} \xrightarrow{m_\phi = 1} \frac{\mu_0 \hbar e}{4 m_e r}$$




Radially weighted phase shift:

$$\varphi_A = \frac{(m_\phi \phi - \omega t)}{2}\left(\frac{e^2}{4\pi\epsilon_0 \hbar c}\right)\frac{c}{\omega r}$$

Electric field (Assume $\partial_t \varphi_A = -\mathbf{v}\cdot\nabla\varphi_A$):

$$v_\phi = \frac{2\omega}{m_\phi}\, r\sin\theta$$

$$eE_i = \hbar\left(\partial_i v_j\right)\partial_j \varphi_A + \hbar v_j\left(\partial_i\,\partial_j - \partial_j\,\partial_i\right)\varphi_A$$

Only singularity contributes to integrals:

$$\mathbf{E} = \frac{\hbar}{e}\mathbf{v}\times\mathbf{B} = \left(\frac{e}{4\pi\epsilon_0 r^2}\right)\hat{\mathbf{r}}$$

Possible resolution of singularity at origin.

For large $\kappa$, radially weighted phase shift:

$$\varphi_A \sim \frac{|\sin \kappa r|}{r} \approx \frac{0.63662}{r} \text{ for } r > 1/\kappa$$

# Quantum Electrodynamics

2-Particle Lagrangian:

$$\mathfrak{L} = \bar{\psi}_A\left[\gamma^\mu\left(\mathrm{i}\,\partial_\mu - A_\mu\right) - m_A\right]\psi_A$$
$$+\ \bar{\psi}_B\left[\gamma^\mu\left(\mathrm{i}\,\partial_\mu - A_\mu\right) - m_B\right]\psi_B$$

Separate particle B interactions:

$$\mathfrak{L} = \bar{\psi}_A\left[\gamma^\mu\left(\mathrm{i}\,\partial_\mu - A_\mu\right) - m_A\right]\psi_A$$
$$+\ \bar{\psi}_B\left[\gamma^\mu\left(\mathrm{i}\,\partial_\mu\right) - m_B\right]\psi_B - J^\mu A_\mu$$

Apply Dirac equation to B:

$$\mathfrak{L} = \bar{\psi}_A\left[\gamma^\mu\left(\mathrm{i}\,\partial_\mu - A_\mu\right) - m_A\right]\psi_A$$
$$+\ J^\mu A_\mu - J^\mu A_\mu$$

# Quantum Electrodynamics

Green's 1st identity, vector identities, etc.:

$$\int J^\mu A_\mu = \int \left(-\Phi\nabla^2\Phi - \mathbf{A}\cdot(\nabla\times\nabla\times\mathbf{A})\right)$$

$$= \int (E^2 - B^2) = -\frac{1}{2}\int F^{\mu\nu}F_{\mu\nu}$$

QED single-electron Lagrangian includes factor of ½ to compensate for double-counting in variations:

$$\mathfrak{L} = \bar{\psi}_A\left[\gamma^\mu\left(\mathrm{i}\,\partial_\mu - A_\mu\right) - m_A\right]\psi_A$$

$$+\frac{1}{2}(E^2 - B^2) - J^\mu A_\mu$$

# Future Work

- Find Dirac bispinor expressions for vector spherical harmonics. Compare Dirac eqn.
- Determine exact phase shifts for coulomb interactions.
- Define a “measurement”.
- Explain Bell inequality violation.
- Educate physicists that aether is not disproven.

# Solid Aether Model

- Lorentz-invariant wave equation (SR).
- “Gravity” is wave refraction (GR).
- Spin is the angular momentum of the medium.
- Mass as spatial localization, velocity rotation.
- QM momentum & angular momentum operators.
- Odd/even spherical harmonics: fermions/bosons
- Spatial reflection yields “antiparticles”.
- Exclusion principle and interaction potentials.
- Interpretation of electromagnetism.
- Magnetic flux & electric charge.
- Wave uncertainty principle.

# Publications

- Torsion Waves in Three Dimensions: Quantum Mechanics With a Twist," **Found. Phys. Lett.** 15(1):71-83, Feb. 2002.
- "A Classical Dirac Bispinor Equation," in *Ether Space-time & Cosmology, vol. 3,* eds. M. C. Duffy & J. Levy, (Aperion, Montreal, 2009).
- "Exact Description of Rotational Waves in an Elastic Solid," **Adv. App. Clifford Algebras 21**:273-281, 2010.
- *The Wave Basis of Special Relativity* (Verum Versa, 2014)
- "Spin Angular Momentum and the Dirac Equation," **Electr. J. Theor. Phys. 12**(33):43-60, 2015

- More at: www.ClassicalMatter.org

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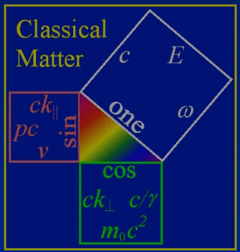



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