

May 1992. Current Problems

- Absence of Radiation : Solution of $\ddot{x}_\mu + (\dot{x}^2) \dot{x}_\mu = 0$

- Radial Eq's with selffield : spinor ED. (with O.Oguz)

- Radiation of ^{or from} a coherent state

Take, e.g. oscillator coherent state, calculate \bar{T} and then the field.

- Classical spin precession in terms of the evolution operator $\exp \int H_s \cdot \vec{J} dt$.

- L-D equation for a δ -function force $\uparrow \downarrow \rightarrow +$
Radiation.

- Radiation from a Josephson-junction.

- Localized solution of massless equation behave like massive particles
 \rightarrow implication to Heisenfeldt Theorem which is due to
the $\sqrt{p^2 + m^2}$ in the K-G-equation.

- Revive dyon-model of proton ; Monopoles are induced as in H_2 -molecule - one more term beyond Born-Oppenheimer Approximation

$$\rightarrow e^+ \oplus \frac{e^-}{F} \oplus e^+ \quad \text{Usual Born-Oppenheimer works for } M \gg m_- \\ \text{Now apply this to } m_+ = m_-, \text{ relativistically.}$$

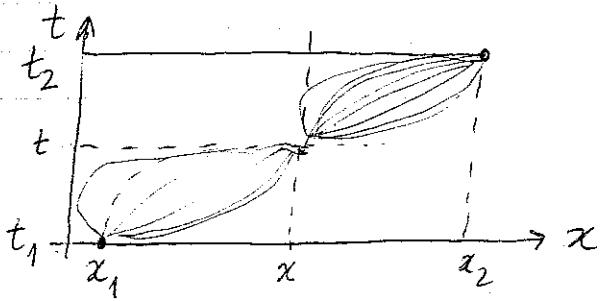


"... there is no logical prohibition against exceeding light velocity.
Indeed a hypothetical world in which tachyons exist is physically consistent.
Although tachyons have been looked for, none have been found --
G. Flinberg, Scient. Am. 222(6)68 (1970).

(from Time Travel, S. Deser, R. Jackiw, MIT preprint, CTP #2101 (3990/92)

↓ Comments on Nuclear & Particle Physns
B. 20, 337 (1992)

Schrödinger propagator



$$t \rightarrow it$$

$$\sqrt{\frac{m}{2\pi\hbar(t_2-t_1)}} e^{-\frac{m(x-x_1)^2}{2\hbar(t_2-t_1)}} = \int_{t_1}^{t_2} dt \sqrt{\frac{m}{2\pi\hbar(t-t_1)}} e^{-\frac{m(x-x_1)^2}{2\hbar(t-t_1)}} \times \frac{\hbar}{m} \frac{\partial}{\partial x} \left\{ \sqrt{\frac{m}{2\pi\hbar(t_2-t)}} e^{-\frac{m(x_2-x)^2}{2\hbar(t_2-t)}} \right\}$$

note: integrated result is indep. of x !

A. Auerbach et al., Nucl. Phys. B 257, 799 (1985); PRL 53, 411 (1984)

$$\sqrt{\frac{m}{2\pi\hbar(t_2-t_1)}} e^{-\frac{m(x_2-x_1)^2}{2\hbar(t_2-t_1)}} = \int_{-\infty}^{+\infty} dx \sqrt{\frac{m}{2\pi\hbar(t-t_1)}} e^{-\frac{m(x-x_1)^2}{2\hbar(t-t_1)}} \sqrt{\frac{m}{2\pi\hbar(t_2-t)}} e^{-\frac{m(x_2-x)^2}{2\hbar(t_2-t)}}$$

note: the integrated result is indep. of t !

$$(i\partial_t - H) G = \delta^4(x-x') \Rightarrow G = \frac{\int d^4p}{(2\pi)^4} \frac{e^{ip(x-x')}}{p^0 - \vec{p}^2/2m} = \frac{\int d^3p}{(2\pi)^3} \frac{e^{-i\vec{p}\cdot(\vec{x}-\vec{x}')}}{2\pi} \frac{\int dp^0}{p^0 - \vec{p}^2/2m} e^{ip^0(x_0-x'_0)} = \frac{i}{(2\pi)^3} \int d^3p e^{-i\vec{p}\cdot(\vec{x}-\vec{x}')} i e^{i\frac{p^2}{2m}(t-t')}$$

$$= \frac{i}{(2\pi)^3} \left(\frac{\pi}{2m} \right)^{3/2} e^{i\frac{(x-x')^2}{4m}(t-t')}$$

$$\rightarrow \left(\frac{m}{2\pi i\hbar(t-t')} \right)^{3/2} e^{i\frac{m}{\hbar} \frac{(\vec{x}-\vec{x}')^2}{2(t-t')}}.$$

Formule: $\int_{-\infty}^{\infty} e^{ax^2+bx} dx = \sqrt{\frac{\pi}{-a}} e^{+b^2/4a}$, or $\int_{-\infty}^{\infty} \frac{dx}{\sqrt{2\pi}} e^{-\epsilon x^2 + ixy} = \frac{1}{\sqrt{\epsilon}} e^{-y^2/2\epsilon}$

May 2, 1992 : Denver - Munich, TWA 850 →

- "It is better to keep your mouth shut and be thought a fool than to open it and leave no possible doubt" (A british lord making his maiden speech after 25 years in the House of Lords)
- Reading D.C. Cassidy, Scient. Amer. May 1992, p. 106, on Heisenberg --
(also his book: Uncertainty, ---, W.R. Freeman 1991)
"For the first time since Scientific Revolution a leading physicist had proclaimed a limitation to scientific understanding"
(Notes: Hilbert: there are no unsolvable problems; Gödel: within an axiom system, yes)
- A. Einstein, ibid. p. 149 : On Metaphores in Science.

Aristoteles : "a metaphor is a device in giving the theory a name which belongs to something else"

Hobbes : "metaphores deceive"

Locke : "they are perfect cheats", (should be) avoided.

Although metaphores may mislead, it is the least misleading thing we have
— we think in metaphors.

to proselytize =
the purveyor =

Reanalyse Heisenberg's microscope in terms of the "Q.T. of single events".

Transformation to accelerated frames

$$x'_\mu = L_{\mu\nu}(\beta) x^\nu + A_{\mu\nu\rho}(\beta, \alpha) x^\nu x^\rho + \dots$$

Lienard-Wiechert potential : $A_\mu(x) = L_{\mu 0} A^0(L^{-1}x)$

Lienard-Wiechert Field :

$$F_{\mu\nu}(x) = \underbrace{L_{\mu}^{(0)}(p) L_{\nu}^{(0)}(p) F_{\mu\nu}}_{\text{velocity dependent part}} + \underbrace{A_{\mu\nu\rho}(p, \alpha) L_{\nu\rho}(p) F^{\alpha\beta} F^{\rho\delta}}_{\text{accel. part}}$$

Ex: $x'_0 = \gamma x_0 + \vec{\beta} \cdot \vec{x} \gamma + A_{000} x^0 + \dots$

$$x'_i = \vec{\beta}_i \gamma x_0 + L_{ij} x^j + A_{i00} x^0 + \dots$$

$$A_{\mu\nu\lambda\sigma} F^{\lambda\sigma}$$

fit $A_{\mu\nu\lambda\sigma}$ from L-W-field. ?

$$\square A_\mu = j_\mu \xrightarrow{\text{ret. transf.}} \Delta A_0 = \rho \Rightarrow A_0 = e/r$$

$$A_\mu = e \frac{u_\mu}{(r, n)} \quad - - - - - \quad A_\mu = L_\mu^0 \frac{e}{r_\perp} = e \frac{u_\mu}{(r, n)}$$

$$\square A_{\nu, \mu} = j_{\nu, \mu}, \quad \square A_{\mu, \nu} = j_{\mu, \nu} \Rightarrow \square F_{\mu\nu} = j_{\nu, \mu} - j_{\mu, \nu} \xrightarrow{\text{ret. transf.}} \Delta F_{\nu i} = j_{i0} - j_{0i}$$

$$\begin{aligned} \rightarrow F_{\mu\nu} &= \int dy D(x-y) [\partial_\mu (\dot{z}_\nu \delta(y+z) ds) - \partial_\nu (\dot{z}_\mu \delta(y-z) ds)] \\ &= + \int ds [\dot{z}_\nu \partial_\mu D(x-\vec{z}) - \dot{z}_\mu \partial_\nu D(x-\vec{z})] = \partial_\mu A_\nu^{2W} - \partial_\nu A_\mu^{2W}. \quad \checkmark \end{aligned}$$

Lienard-Wiechert's Debye-Bromwich potentials

$$\vec{E} = \tilde{\ell} P_0 \psi^* + \tilde{p}_1 \tilde{\ell} \psi \quad , \quad P_0 = i \frac{1}{c} \frac{\partial}{\partial t}, \tilde{p} = -i \nabla, \tilde{\ell} = -i \vec{x} \times \tilde{\nabla}$$

$$\vec{B} = -\tilde{\ell} p_0 \psi + \tilde{p}_1 \tilde{\ell} \psi^*$$

Let $\psi = F(r) e^{-i\omega t}$, $\nabla F(r) = F'(r) \frac{\vec{x}}{r}$, $\tilde{\ell} = -i \begin{vmatrix} \vec{x}' & \vec{x}^2 & \vec{x}^3 \\ \vec{x}' & \vec{x}^2 & \vec{x}^3 \\ \vec{x}' & \vec{x}^2 & \vec{x}^3 \end{vmatrix} = 0$

$$\tilde{p}_1 \tilde{\ell} = - \begin{vmatrix} \delta_1 & \delta_2 & \delta_3 \\ \frac{\vec{x}^2 \vec{x}^3}{r} & \dots & \dots \end{vmatrix} = 0$$

\therefore There is no Debye-Bromwich potentials for Coulomb field!
Nor for Lienard-Wiechert pot.?

For any spherically symmetric \vec{E} , $\ell \neq 0$, $\ell = 1$ for example
and \vec{B} is never spherically symmetric.

$\ell \neq 0$

$$\psi = \frac{J_{\ell+1/2}(\frac{r_0}{c}r)}{\sqrt{r}} Y_{\ell m}(\theta, \phi)$$

• Large transitional magnetic moments ($\gamma_e \leftrightarrow \gamma_\mu$)

S.M. Barr et al PRL 65, 2626(1990)

K.S. Babu et al. Fermilab preprint 92/56.

L. VANZO (preprint 2574/92) - generalization of geodesic deviation
going back to Levi-Civita (1927)

M. L. Mehta, Saclay preprint, SPh-T/92-021

$$f(x) = \lambda \int_{-\infty}^{+\infty} K(x,y) f(y) dy, \quad K(x,y) = \frac{\sin \pi(x-y)}{\pi(x-y)}.$$

Corresponding Fredholm determ. $F(z,t) = \sum_{i=0}^{\infty} (1 - z \lambda_i(t))$

Satisfies a diff. Eq. This Kernel appears in many problems

POSITRONIUM : CERN-TH. 6420/92 . TS 2899/92

Exp. $E(2^3S_1) - E(1^3S_1) = 1\ 233\ 607\ 218.9 (10.9)$ Chu
Theory 211.7

$$E(2^3S_1) - E(2^3P_2) = 8628.4 (2.8), 8619.6 (2.7) \quad \text{Riis}$$

$$E(2^3S_1) - E(2^3P_1) = 13\ 001.3 (3.9) \quad \text{Riis}$$

$$E(2^3S_1) - E(2^3P_0) = 18\ 504.1 (10.0) \quad \text{Riis}$$

"Standard" Ref's : R. Barbieri & E. Remiddi, Nucl. Phys. B141, 413 (1978).
F. Gross, PR 186, 1448 (1969)
G. Lepage, PR A 16, 863 (1977)

Problems on Charmonium $1P_1$ states --- preprint 2931/92

Lehnke, Melke, Hehl, D-5000 Köln 41, Inst. Theor. Phys.

"Gravitational moments of a spin- $1/2$ particle" preprint 2987/92

May 7. Khalatnikov : Fermi Liquids.

He4 : Boson ; quasiparticles (Landau) -

He3 : Fermi gas of quasiparticles .

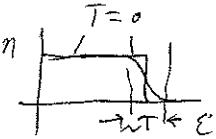
$n(\vec{p}, \vec{r}, t)$. Kinetic theory : $\frac{Dn}{Dt} = J(n) = \text{collision integral}$

$$\frac{\partial n}{\partial t} + \frac{\partial n}{\partial \vec{r}} \cdot \vec{v} + \frac{\partial n}{\partial \vec{p}} \cdot \vec{p} = J(n) , \quad \epsilon = \epsilon_{\vec{p}}$$

$$\frac{\partial n}{\partial t} + \frac{\partial n}{\partial \vec{r}} \frac{\partial \epsilon}{\partial \vec{p}} - \frac{\partial n}{\partial \vec{p}} \frac{\partial \epsilon}{\partial \vec{r}} = J(n) = \frac{\partial n}{\partial t} + \{n, \epsilon\}$$

Conserv. of momentum ?

$$p^i \frac{\partial n}{\partial t} + p^i \frac{\partial n}{\partial \vec{r}} \frac{\partial \epsilon}{\partial \vec{p}} - p^i \frac{\partial n}{\partial \vec{p}} \frac{\partial \epsilon}{\partial \vec{r}} = p^i J(n)$$



Integrate over $d\vec{p}$.

Mom. conservation is O.K. , but $\epsilon \neq \int \epsilon n d\vec{p}$
but only $\delta \epsilon = \int \epsilon \delta n d\vec{p}$.

Energy of quasi particles depends on the density of the surroundings .

N. Kh. Ibragimov, A.O. Oganesyan, "The hierarchy of Huygens eqs. in spaces with a non-trivial conformal group" Uspeshki Mat. Nauk, 46;3 (1991) 111-141
Russ. Math. Surveys 46:3 (1991) 137-170

M. Bergeron, Coherent state Path Integrals - - -
Fortschritte der Phys. 40, 119 (1992)

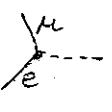
B. Torresani , --- wavelets - - - etc.
Ann. Inst. H. Poincaré , 56, 215 (1992)

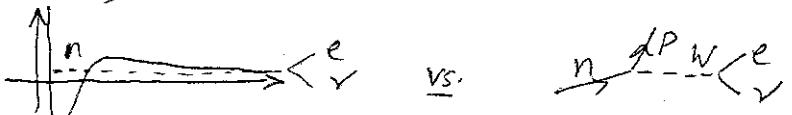
D. J. Moore, Berry phases and Rabi oscillations, Quantum Optics, 4, 123 (1992)
(relation to pancharatnam - - - phase)

S. A. Abel et al Testing locality via Bell inequalities at colliders
Phys. Lett. B 280, 304 (1992)

Special Issue of Helv. Phys. Acta devoted to 2-dim. Systems
Vol. 65, No. 2/3 , p. 131-504 (1992)

- If ν had a Magnetic Moment! ("If the elephant had a wing")

- 1) Neutral current (Carlson - Oppenheimer)
- 2) $\bar{\nu}e$ -bound state (Pauli)
- 3) Transition magnetic moment \Rightarrow flavour-changing neutral current 
- 4) Asymmetry in $e^+e^- \rightarrow \mu^+\mu^-$ due to transition magnetic moment
- 5) Increase in cross section in $e^+e^- \rightarrow \mu^+\mu^-$ towards Z^0 .
- 6) Tunnelling is not in contradiction with W^\pm or Z^0 :



- 7) ν -spin precession in B -field
- 8) ν -spin transmission and reflection in B -field. Total reflection
- 9) ν -polarization in periodic magnetic fields. Apply to sun's periodic field.
- 10) ν -halo of galaxies - candidate for dark matter.
- 11) $\nu_T \rightarrow \nu + \gamma$, trans. magn. moment of $10^{-14} \mu_0$ \rightarrow ionisation (D'Sciama)

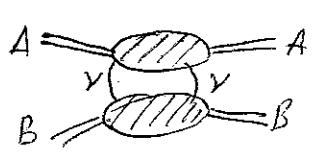
- Latest $e\nu_e, e\bar{\nu}_e$ scattering data: Phys. Lett. 281B, 159 (1992). Charm II
- Astrophysical limit from cooling of stars: G. Raffelt, Astrophys. J. 365, 559 (1990)
 - (2) Tunnelling of one component and reflection of the other component | Phys. Reports

$\mu < 10^{-12} \mu_0$

Standard model: one imposes "by hand" a massless neutrino.

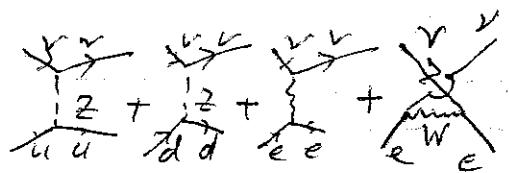
There is no principle which requires the neutrino to be massless

- Neutrinos as Mediators of long-range force



$$V(r) = \frac{1}{4\pi r^2} \int dt \frac{1}{4m_\nu^2} \text{Abs}(M_{AB}(t)) e^{-\frac{\mu}{2}r}$$

$\text{Abs}(M_{AB}(t))$ comes from



i) Bulk matter has a net weak charge $Q(\nu)$ as seen by ν :

$$Q^{(\nu)} = Z - \frac{N}{2}, \quad Q^{(Z, W)} = -N/2$$

$$\text{For } m_\nu = 0 \rightarrow V(r) = \frac{G^2}{4\pi^3 r^5} Q_A Q_B; \text{ For } r < 10^{-4} \text{ cm} \rightarrow \frac{|F_{weak}|}{|F_{grav.}|} \gg 10^{-12}$$

\therefore deviation from equivalence principle.

- Electric dipole moment:



$$\sigma_{\nu\nu} q^2 (\mu_{jj_1} + d_{jj_1} \delta^5)$$

W. Heisenberg (ZfPhys 43/184, 46, 172 (1927)).

A wave packet with band width $\Delta\omega = \Delta E/\hbar$, is general diffuse in the course of times of the order of $\Delta t \sim \hbar / (\frac{\partial^2 E}{\partial n^2} \cdot \Delta n)$.
 i.e. oscill. $\Delta t \rightarrow \infty$.

in the same book
 C.A.S. Luis: "Unit. theory's
 in intense atomic fields".

T. Fujiwara, H. Weyland, in "Essays in Theor. Phys." Progr. 1984; p. 313 / 53(04) ESS

Consider $\psi(t=0) = (\frac{\alpha}{\pi})^{1/4} e^{-\frac{\alpha}{2}(x-A)^2}$ ($\alpha = 1$: initial coherent state)

$$\rightarrow \psi(t) = (\frac{\alpha}{\pi})^{1/4} \left[e^{\frac{(x+i\alpha A \sin \omega t)^2}{2\sin^2 \omega t} + \frac{i}{2} \text{ctg } \omega t \cdot x^2 - \frac{\alpha}{2} A^2} \right] / \sqrt{2\pi i (\alpha \sin \omega t - i \cos \omega t)}^{1/2}$$

$$|\psi(t)|^2 = \left(\frac{\alpha/\pi}{\cos^2 \omega t + \alpha^2 \sin^2 \omega t} \right)^{1/2} e^{-\alpha \frac{(x-A \sin \omega t)^2}{\cos^2 \omega t + \alpha^2 \sin^2 \omega t}}$$

$$\overline{x^2}(t) = \frac{\hbar}{m\omega} \frac{1}{\alpha} \{ \cos^2 \omega t + \alpha^2 \sin^2 \omega t \} = \frac{\hbar}{m\omega} \left\{ \frac{1}{2}, t = n \frac{\pi}{\omega}, n=0,1,2, \dots \right.$$

$$\alpha \rightarrow \infty \quad |\psi(t)|^2 \rightarrow \begin{cases} \delta(x-A), & t=0, \frac{2\pi}{\omega}, \dots \\ \delta(x+A), & t=\pi/\omega, \frac{3\pi}{\omega} \end{cases}$$

The wave packet reappears at classical turning points, as δ -fn., otherwise disappears.

For systems whose spectrum is any subset of integers, the wave packet spreads, but reoccurs again.

e.g. particle in a box $(0, L)$: $E_n = \frac{\pi^2 \hbar^2}{2mL^2} n^2$. spreads to uniform density, then revival at times $(4mL^2/\pi\hbar)$ times in t_{geo} .

Take again $\psi(t=0) = (\frac{\beta}{\pi})^{1/2} \exp(-\frac{\beta}{2}(x-x_0)^2 + i(p_0 x/\hbar))$ (+ image charges -B ARUT)

$$|\psi(t)|^2 = \left(\frac{\beta/\pi}{1 + (\beta t/m)^2 (t - mT_0)^2} \right)^{1/2} \exp \left[-\beta \frac{(x - x_0 \mp (\frac{p_0}{m}(t - nT_0)))^2}{1 + (\beta t/m)^2 (t - nT_0)^2} \right]$$

$$\beta \rightarrow \infty \text{ limit: } |\psi(t)|^2 = \begin{cases} \delta(x-x_0), & n=2, 4, 6 \\ \delta(x+x_0), & n=1, 3, 5 \end{cases}$$

$$-\frac{L}{2} < x < \frac{L}{2}; \quad \psi(0) = C \sum_{n=1}^{\infty} \sin n \xi \sin n \eta e^{-n^2/2\delta^2}, \quad \delta = \text{pos. real.}, \quad \xi = \frac{\pi}{L}(x - \frac{L}{2}), \quad \eta = \frac{\pi}{2}(x_0 - \frac{L}{2})$$

$$\delta \rightarrow \infty : \psi(0) \rightarrow \delta(x-x_0).$$

$$C^2 = \int_{-L/2}^{+L/2} |\psi(0)|^2 dx \rightarrow C^2 = 4/L \sqrt{\pi \delta} + \text{small terms}$$

$$\Rightarrow |\psi|^2 = \frac{\pi \delta}{L^2} e^{-\frac{\pi^2}{L^2} \delta (x-x_0)^2} + \text{small terms.}$$

$$\delta \rightarrow \infty$$

Thus both $|\psi|$ and $|\psi|^2$
 approach δ -function!

Fujiwara, Progr. Theor. Phys. 64, 715 (1980)!

Great physicists that I have met. (and Mathematicians). [act met Einstein, Schrödinger, Born, Klein O.,]
Sommerfeld (in Zürch.), N. Bohr (in Zürch.), Pauli, Fermi, Wentzel, Stiefel, Heisenberg, Dirac, v. Weizsäcker,
Jordan, Lanczos, B.L.vanderWaerden, Wigner, Bopp, Peierls, Rosenfeld, Uhlenbeck, Breit, Hand, Lamb
Pauling, Oppenheimer, Schwinger, Feynman, Gell-Mann, Weinberg, Salem, Glashow, F. Gürsey, Radicati, Pais,
Bell, Bohm, Ulam, Halmos, Chew, Goldberger, Low, Mandelstam, Ginzburg, Zeldovich, Khulatnikov,
Deitz, Kemmer, Penrose, Hawking, Sciama, Gedach, Hoßbauer, Ehlers, Kundt, Treder, Cabibbo, Piron, Tauch,
Gatto, Wen, zumino, Jacob, Wick, Rubbia, Thirring, Lieb, Lehmann, Szymansky, Zimmerman, Källen, Kimbu,
Teleki, Jost, Sudarshan, Reines, Gamow, Teller, Chapman, Wheeler, Segré, Chambeline, Marbas, A. Klein,
Dyson, Thirring, Trautman, I. Robinson, P.G. Bergmann, N. Rosen, Y. Ne'eman; Glauber, H. Welther, Scully
Weintraub, Frankel, Biedenharn, Mashinsky, Marshall, Arrowitt, Deaser, Polyakov, Regge, !

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European Community

Les Treilles : May 15 : Conference : "Hommage à L. de Broglie"

- G. Lotchek : 1) Dans la thèse de L. de Broglie, $\lambda = h/p$, apparaît pour la 1^{re} fois en page 116.
Pour lui, π et ν étaient plus fondamentaux.
- 2) "diffraction de l'électron" n'est pas mentionné dans la thèse. Mais dans le soutenance du thèse.
- 3) conception initiale très double situation, pas comme interprétation : concentration de champs
L. de Broglie did not share the complementarity ~~of~~ against foundations.

L. Ballantine, How do classical properties arise from Q.M.

- 1) Q.M. encompasses class. Mech. 2) Q.M. \rightarrow mesophysics \rightarrow class. Phys.
3) Class. Mech. contains class. Mech.

Spec. Rel. $c \rightarrow \infty$ Newt. Mech. But $t_0 \neq 0$; $Q_M \rightarrow$ class. ?

Interp. A : State refers to indiv. system, Observ. Q has def. value
only if $Q(4)=q(4)$,

Interp. B : Stat. behavior of an ensemble.

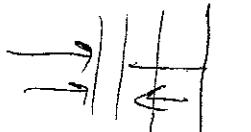
Measurement problem is either insoluble (A), or is solved (B).

Ehrenfest Thm.

$$\langle \partial V / \partial r \rangle \stackrel{?}{=} \frac{\partial \bar{V}}{\partial \langle r \rangle} / \partial \langle r \rangle$$

Hamilton-Jacobi : $\Psi = g e^{iS}$, $\partial S / \partial t + (\bar{V}S)^2 / 2\hbar + \bar{U}U + U_Q = 0$
 $U_Q = -\frac{\hbar^2}{2m} \nabla^2 S / \beta$, $U_Q \approx \bar{U}t$ $\bar{U} = \bar{V}S$. $\hbar^2 \rightarrow 0$ if $U_Q = 0$?

Einstein-Born, etc. Particle in a box.



Werner Heisenberg

NB

$$\Psi = \sqrt{\frac{C}{k(x)}} \cos(f(x)dx + \phi)$$

$k(x) = \sqrt{E - V}$

Slowly vary $\frac{x}{\hbar}$ in time

Wigner distrib. $\xrightarrow{\hbar \rightarrow 0}$ does not approach classical distrib. S.

Husimi distr. $P(q, p) = |\langle q, p | \Psi \rangle|^2$, $\langle x | q, p \rangle = C e^{ipx} e^{-(x-q)^2/\hbar^2}$

'Ligni Arcadi'.

- I) constructive period
- II) Description "
- III) AXIOMATIC

Noise in Q.M. View I : Noise is fundamental. Rev. Math. phys. 2 (1990).
View II : Hamilton's eq's fund., noise is due to approx.

Aitchison: ANYONS

Review: Contemp. physics,

- QM of identical impenetrable particles in 2-dim.
(How to formulate exchange symmetry in Hartree eq's instead of configuration space \mathbb{E})
- Pearle.
You have to change ψ , (I say no, don't change ψ)

Is a stochastic diff. eq. really an eq. for reality? because you have to know the prob. distrib. of white noise!

N. Mankos

$$H_1 = q + e^P \text{ and } H_2 = \frac{p^2}{e^t} \text{ both lead to the same eq. } \ddot{q} + \dot{q} = 0$$

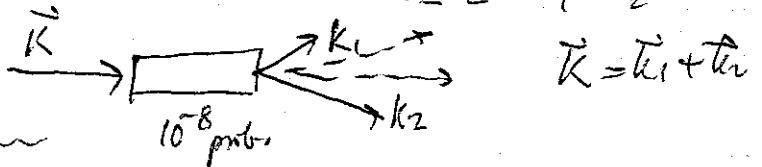
A. Zeilinger

$$\lambda_{\text{atom}} \approx 0.2 \text{ Å}, \quad r_{\text{atom}} \approx 3.0 \text{ Å}.$$

$\lambda_{\text{human}} = 10^{-3} \text{ m.}$ Schrödiger; Verschränkung

Class. physics: Known initial states \rightarrow interactions \rightarrow Known final states
Q.M. " " " " " \rightarrow entangled states

Momentum corr. $\frac{1}{\sqrt{2}} [|\vec{k}_1\rangle |k_2\rangle + |\vec{k}_2\rangle |k_1\rangle]$

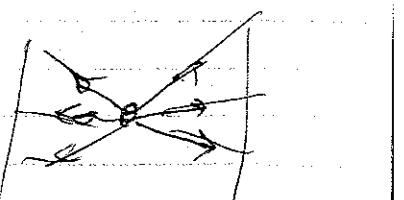
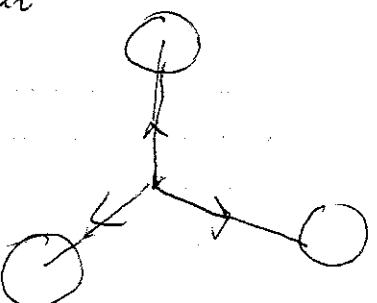


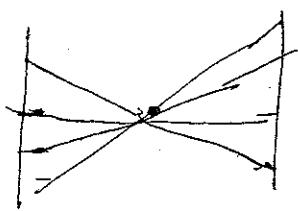
$$\frac{1}{\sqrt{3}} (|1\rangle |1\rangle |1\rangle + |1\rangle |1\rangle |2\rangle)$$

polar. in x-y plane

$$E(ABC) = \cos(\theta_1 + \theta_2 + \theta_3)$$

- state decaying into 2 spin 1 particles.





4-matic variable.

• H. Lichte.

in a Wavelet motion around the AB^- solenoid.

F. Braun, Ruska, Möllenstedt. (letter from Broglie to Möllenstedt 1956)

• J. Robert et al (Spin 1 transmission in magn. field)
lab J. de Physique II, 2, 601 (1992)

Debieer: Formulas for $\int \psi^* \Delta E \psi$ and for $\int \psi^* \psi$ tunnelling.

P. Lötchak.

"The general Hamiltonian problem is neither integrable nor ergodic"
A M.H. Memorial. Remarq AMS, 2 1974 Markos & Mye

Chavel - Eigenvalues in Riemannian Geometry, Academic Press
J. Moser, in Lezione Scuola Normale Pisa, 1984

"The circle problem": Two uncoupled oscill's. eigenvalues (n, n_2) .

$$N(\lambda) = \# \text{ of } e^{i\lambda} \text{ inside } (n_1^2 + n_2^2 < \lambda^2) \\ = e\lambda^2 + 1? \quad (\text{or } \lambda \text{-on a thorn})$$

(wave)

Sinai, Sovietas Selecta Mathematica, 1991

Pert. Theory $H(p, q) = h(p) + \epsilon f(p, q)$. "Le problème fondamental de la dynamique"
(H. Poincaré)

$$\langle \dot{p} \rangle = \langle \frac{\partial H}{\partial q} \rangle = \int \frac{\partial H}{\partial q} dq = 0, \text{ The average of pert. is zero}$$

"chaotic dynamics": geodesic flow on surfaces of negative curvature

on S^1 : $\epsilon' \rightarrow \epsilon + \alpha$. Simplest ergodic problem.

"Shadowing": If you make an error in each step, does there exist a true orbit close to it.

V. Man'ko

Time-dependent invariants in nonstationary system (Floquet thm)

$$\text{ith } \Psi_{\epsilon,t} = H(t)\Psi$$

$$\text{Schröd. (1930): } \delta q \delta p \geq \frac{\hbar}{2} \frac{1}{\sqrt{1-r^2}} = \frac{\hbar r_{\text{eff}}}{2}, \quad r = \text{corr. coeff. } (p, q)$$

$$r = (\delta q \delta p)^{-1} \left(\frac{1}{2} (q p + p q) - \overline{q} \overline{p} \right) = \frac{1}{2} \delta p \delta q \quad 1 - r^2 = 1 - \frac{C^2}{(\delta p \delta q)^2} = \frac{(\delta p \delta q)^2 - C^2}{(\delta p \delta q)^2}$$

→ See my paper of 1958.

$$H = \frac{1}{2} p^2 + \Omega(t) q^2 : \quad A(t) = \frac{i}{\sqrt{2}} [\epsilon(t)p - \dot{\epsilon}(t)q] \quad \text{integrl of mot}$$

$$A^\dagger(A) \text{, or } H = A^\dagger A \text{ are also integrals of motion.}$$

$$\text{Schröd. Rep. } i\hbar \frac{\partial}{\partial t} |\Psi(t)\rangle = H(t)|\Psi(t)\rangle$$

$$[i\hbar \frac{\partial}{\partial t} - H, I(t)] |\Psi(t)\rangle = 0 \quad \Rightarrow \quad \frac{d}{dt} \langle \Psi(t) | \hat{I}(t) | \Psi(t) \rangle$$

- $I(t)$ also intgal of motion

- eigenvalues of $I(t)$ are indep. of time

- $I(t)|\Psi(t)\rangle$ is a solution $\hat{I}(t)|\Psi(t)\rangle$ is also a solution.

- $\hat{I}(t)$ = dynamical group generators

- ~~green~~ Propagator

- Distribution fns of I are invariant

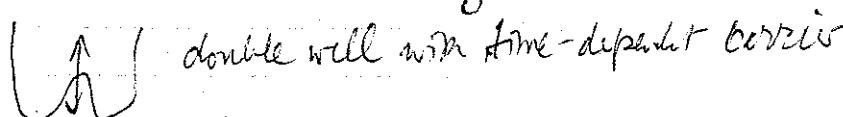
$$\begin{aligned} \ddot{x} + \gamma_1 x + \omega^2 x &= \lambda y, \quad \gamma_1 \neq \gamma_2, \quad \text{there is no Hamiltonian} \\ \ddot{y} + \gamma_2 y + \omega^2 y &= \lambda x \end{aligned}$$

$$\dot{\epsilon} + \Omega^2(t) \epsilon = 0, \quad \Omega \text{ slowly vary.} \quad \frac{\dot{\Omega}}{\Omega^2} \ll 1 \text{ adiab. parameter.}$$

↳ adiabatic invariants

- Casimir effect with oscillating plates, (Man'ko)

- Tunneling with oscillating barrier (Melnikov, Landau Inst.)



P. Hängi,
Grabeit (ESSN)
George Weiss -

TRIESTE. 21 May : Conference "Search for New Elementary Particles"

- D. Sciama: ν in Astrophysics / solar- ν , stellar- ν , supernova ν , galactic ν , quasar- ν , primordial ν , cosmological ν ,

Solar- ν : SAGE ; ABLEZOV et al PRL 67, 3332
 < 79 SNL (90% C.L.)

Solar Standard Model $\Rightarrow \bar{\nu}_e \pm 20$. GALLEX ; 132 (rumor)

Solar model is not responsible. NSM is the best model. $\Rightarrow m_{\nu_e} \sim 10^{-3}$ eV

See-saw model : $m_{\nu_e} : m_{\nu_\mu} : m_{\nu_\tau} = \frac{m_e}{M} : \frac{m_\mu}{M} : \frac{m_\tau}{M}$, $m_\mu =$
If $M \sim 10^2$ $\rightarrow m_{\nu_\tau} \sim 6-36$ eV.

Time variation $\Rightarrow \mu_\nu \sim 3 \times 10^{-11} \mu_B$. But stars, Supernovae
 $\mu_\nu < 10^{-12} \mu_B$?

Standard models $\Rightarrow \mu_\nu \sim 10^{-17} \frac{m_\nu}{300\text{eV}}$:

Lab. Limit $\mu_{\nu_e} < 10^{-9}$.

$$\mu_{\nu_\mu} < 7.4 \times 10^{-10}, \mu_{\nu_\tau} < 5.4 \times 10^{-7}$$

Astrophysics $\mu < 10^{-12}$.

Supernova 1987 A.

$N_\nu < 6$ (energetics), $m_{\nu_e} < 20$ eV (timing), $\mu_\nu < 10^{-12} \mu_B$?

Galactic ν : Dark matter in Halo, extended flat rotation curve

$$g \sim 1/r^2 \cdot \text{If DM is } \nu_\tau.$$

$$m_{\nu_\tau}^4 = \frac{1}{6\pi} \left(\frac{3}{2\pi}\right)^{3/2} \frac{R^3}{G r_0^5 a^2}, r_0 = \text{value of disp.} \sim 230 \text{ km sec}^{-1} \text{ at 8 kpc} \rightarrow m_{\nu_\tau} = 27.6 \pm 1 \text{ eV}$$

Primordial ν :

Hot big bang : $e + e^- \rightarrow 2\nu$. ν 's in thermal equil. $T > \sim 1$ MeV.

Synthesis of D, He³, He⁴, Li⁷ ... $\Rightarrow N_\nu < 3.5$

Cosmological ν :

What is left over to-day from big bang $N_\nu = \frac{3}{11} n_\gamma (300\text{K}) \sim 115 \text{ cm}^{-3}$

$$\frac{8\pi}{3} G S_{\text{crit}} = H^2, S_{\text{crit}} = 8V/S_{\text{crit}}, \rightarrow m_\nu \sim 3 h^2 D_\nu (\text{eV})$$

$$H = 100 h, \text{km sec}^{-1}$$

If $L = 1, \lambda = 0$, obs. age of universe $\Rightarrow h \approx 0.5 - 0.6$

$$m_{\nu_\tau} \sim 23-33 \text{ eV}$$

Decaying ν :

$$\nu_\tau \rightarrow \gamma + \nu_{\mu, e}. E_\gamma = \frac{m_\tau^2 - m_{\nu_\mu}^2}{2m_\tau} \text{ is the rest frame of decaying } \nu$$

This δ 's of single energy can

$$= \frac{1}{2} m_{\nu_\tau}$$

$$\text{ionize atoms} \quad m_{\nu_\tau} \sim 3 \text{ eV} \rightarrow E_\gamma \sim 15 \text{ eV} \cdot \text{Ioniz. of H} = 13.6 \text{ eV} \quad N = 14.5 \text{ eV}$$

• Physics Letters 259 B, 323 (1991)

Inter-stellar medium has ionized H, N. Why?

Needs $\tau \sim 3 \times 10^{23}$ sec, $m_{\nu_T} \sim 30$ eV Standard model $\tau \sim 10^{33}$!

SUSY with broken R parity would give this value.

$\rightarrow m_{\nu_T} \sim$ within 1%. $\rightarrow E_\gamma = 14.7 \pm 0.2$ eV, $m_{\nu_T} = 29.4 \pm 0.4$ eV

F. VANNUCI (Paris)

$N_f = 3$ recent assume Stand. model with massless ν 's.

($SU(5)$); 2^1 's still massless, you have to go to $SO(10)$ - etc.

New neutrinos (ν_{13}) ; or old 2^1 's with new properties; excited 2^1 's.

Z^0 (LEP), total width $\Gamma = 2484 \pm 11$ MeV; $\Gamma_{\tilde{\nu}\tilde{\nu}} = 166 \pm 1$ MeV for each generation

$P_{LE} \leq 0.20 \Gamma_{\tilde{\nu}\tilde{\nu}} \Rightarrow M_L > 45$ GeV Dirac, > 39 GeV Majorana
no new 2^1 's with these masses.

$$\text{Heavy } \nu_H \xrightarrow{\text{Dec}} e^- \quad \nu_e \quad \nu_H \xrightarrow{\text{Dec}} e^+ \quad \nu_e \quad \tau = \tau_\mu \left(\frac{m_\mu}{m_\nu} \right)^5 \frac{1}{T^{1/2}}, \quad \tau_\mu = 2.2 \times 10^{-6}$$

ν is the most unknown of all particles: m , $\bar{\nu}$, mixing, τ , μ_ν ; B_e, G_e, T_e
Transition magn. moments

$$\mu(\nu_e) < 1.1 \times 10^{-9} \mu_B, \quad \mu(\nu_\mu) < 7.4 \times 10^{-10} \mu_B$$

$$e^- \rightarrow \nu_e \quad \frac{d\Omega_\nu}{d\Omega_e} = \pi r_e^2 \left(\frac{\mu_\nu}{\mu_B} \right)^2 \left(\frac{1}{T_e} - \frac{1}{E_\nu} \right)$$

$$\mu(\nu_\tau) < 5.4 \times 10^{-7} \mu_B. \quad \text{No angul. distr. yet!}$$

$$m(\nu_e) < 9 \text{ eV}, \quad m(\nu_\mu) < 270 \text{ keV}, \quad m(\nu_\tau) < 35 \text{ MeV}$$

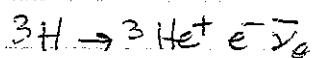
"No reason for no mass".

$$\langle \nu_\tau \rangle = \rho(\cos(\theta)), \quad \nu(t) = \nu_\mu \rightarrow \nu(t) = -\nu_1 \sin \theta e^{iE_1 t} + \nu_2 \cos \theta e^{-iE_2 t}$$

$$P(\nu_1 \rightarrow \nu_2) = |K(\nu_1 t) \nu_2|^2 = \frac{1}{2} \sin^2 \theta [1 - \cos(E_1 - E_2)t], \quad (E_1 E_2)t \approx \frac{m^2 - m^2}{2} \frac{R}{E}$$

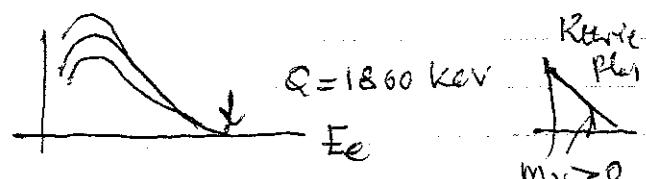
$$P = \sin^2 \theta \sin^2(\pi \frac{R}{L}), \quad L = \frac{2.3 E}{\delta m^2} (\text{GeV}),$$

J. JANCS



Latest exp. LANL; $m_\nu < 9.3$ eV (95%)
Livermore $m_\nu < 8.0$ eV

17 keV ν & ?



Rene

Pla

$m_\nu > 0$

G. Raffelt, *Astrophys. J.* **365**, 559 (1990) and *Phys. Rep.*

From energy loss of plasmons into $\nu\nu\gamma$ (cooling of stars)

$$\mu_{\nu\nu\gamma} < 10^{-12} \mu_0$$

May 21. S-Matrix Theory of the Standard model.

S.M., take away Higgs, add Z, W, γ etc. with their masses, as an effective theory. If the coupling constants are fixed, one would violate unitarity bound at ~ 1 TeV. But in S-matrix theory these couplings are form factors. One would make successive pole approximations at higher and higher energies.

Leff: cf. I.Jack, DRTJnw Phys. lett B234, 321 (1990)
Ruiz-Altaba, Gonzalez, B, Vargas, N; CERN-TH 5358/89

Generalize QED-S Matrix theory to include the magnetic vertex also, and then make successive pole Appm $\rangle \dots f_1$ and f_2 .

Yates (told by Abner Shimony, May 23)

"Rethoric is fight with others, poetry is fight with oneselfs"

Physics should be poetry: to be self-critical.

- Fry's planned experiment of spin $1/2$ -EPR: Molecule dissociates into 2-atoms in spin-superpositions.. The two spin states have different ionization energies. Thus by measuring the number of atoms ionized, one can count spin up and down (Texas A&M)
- Longit. Stern-Gerlach effect: separation and recombination (L. H. Keldysh).
- Electric dipole analogue of Stern-Gerlach effect: two level atoms in inhomog. electric fields.
 $F = \vec{d} \cdot \nabla E$
- $\vec{\nu}$ -precession in a rotating magnetic field. (Combine "v-pipe" with "phase pipe" - Bozic)
cf. Int. J. Mod. Phys. A6, 2375 (1991)
Phys. lett. B 271, 179 (1991) & preprint 3411/92; 3502/92
M. Moretti, SISSA preprint 984/92. ICTP: 3656/92

A. Horzela, E. Kapušák, C.A. 0200:

May 24

$$iD_\mu = i\frac{\partial}{\partial x^\mu} - ((1-\alpha)A_\mu - \alpha B_\mu); \quad B_\mu = \frac{V}{-i} \frac{4^* \frac{\partial \psi}{\partial x^\mu} - \frac{\partial \psi^*}{\partial x^\mu} \psi}{24^* \psi}$$

(AOB): Under $\psi \rightarrow \psi e^{-i\Lambda}$, $\psi_\mu \rightarrow (\psi_\mu + i\Lambda_\mu) e^{-i\Lambda}$

$$A_\mu \rightarrow A_\mu + \Lambda_\mu, \quad B_\mu \rightarrow B_\mu - i4^* [i\Lambda_\mu + i\Lambda_\mu] \frac{\psi}{24^* \psi} = B_\mu + \frac{\Lambda_\mu}{24^* \psi}$$

$$\begin{aligned} \psi^* D_\mu \psi &\Rightarrow \psi^* (iD_\mu - ((1-\alpha)A_\mu - \alpha B_\mu)) \psi \\ &= \psi^* i\partial_\mu \psi + \psi^* \Lambda_\mu \psi - \psi^* (1-\alpha) \Lambda_\mu \psi - \psi^* \alpha \Lambda_\mu \psi = \psi^* i\partial_\mu \psi \end{aligned}$$

Hence

$$\overline{\psi} \gamma^\mu D_\mu \psi + m^2 \overline{\psi} \psi = \overline{\psi} \gamma^\mu i\partial_\mu \psi - \overline{\psi} ((1-\alpha)A_\mu \psi - \alpha \frac{4^* \psi}{24^* \psi} \Lambda_\mu \psi - \frac{4^* \psi}{24^* \psi} \Lambda_\mu \psi) + \frac{m^2}{4} \psi$$

No look at for scalar field:

$$(D_\mu \psi)^* (D^\mu \psi) = ((i\partial_\mu - ((1-\alpha)A_\mu - \alpha B_\mu)) \psi)^* (i\partial_\mu - ((1-\alpha)A_\mu - \alpha B_\mu)) \psi$$

$$\Rightarrow \frac{\partial \mathcal{L}}{\partial \psi_{,\mu}} = (i\partial_\mu - ((1-\alpha)A_\mu - \alpha B_\mu)) \psi^* (1 - \alpha \frac{1}{24})$$

$$\frac{\partial \mathcal{L}}{\partial \psi} = (-((1-\alpha)A_\mu - \alpha \frac{4^* \psi}{24^* \psi})) (i\partial_\mu - ((1-\alpha)A_\mu - \alpha B_\mu)) \psi^*$$

$$\delta^\mu \left[(i\partial_\mu - ((1-\alpha)A_\mu - \alpha B_\mu)) \psi^* (1 - \alpha \frac{1}{24}) \right] = f((1-\alpha)A_\mu - \alpha \frac{4^* \psi}{24^* \psi}) \times (i\partial_\mu \psi^* - ((1-\alpha)A_\mu \psi^* - \alpha B_\mu \psi^*))$$

For $\alpha = 1 \rightarrow$ This should give the Heisenberg nonlinear eq. (?)

Heisenberg-ton $(\overline{\psi} \gamma^\mu \psi)^2$ is gauge invariant

Also the eq. for A_μ could be

$$\square A_\mu - \partial^\nu (\partial_\nu A^\mu) + m^2 A_\mu = m^2 B_\mu + j_\mu$$

under gauge transf.

$$\rightarrow \square A_\mu + \square \Lambda_\mu - \partial^\nu (\partial_\nu A^\mu + \partial_\nu \Lambda^\mu) + m^2 A_\mu + m^2 \Lambda_\mu = m^2 (B_\mu + m^2 \Lambda_\mu) + j_\mu$$

or

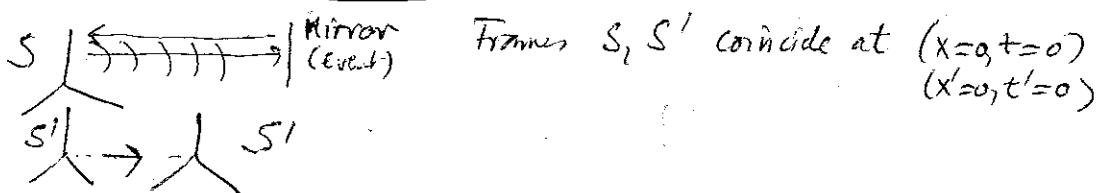
$$\square \Lambda_\mu - \partial^\nu \square \Lambda_\nu + m^2 \Lambda_\mu = m^2 \Lambda_\mu \quad \underline{O.K.}$$

\rightarrow Extend this to my nonlinear integro-diff. equation

$$A'_0 = A_0 = \frac{e}{c}, \quad \vec{A}' = \vec{A} + \vec{v}^* t = \vec{v}_{S_0}^* t$$

Problem: Galilean limit of the Lienard-Wiechert potential, and L-W fields \vec{E} and \vec{B} , and compare it with Galilean Electrodynamics.

Cf. M. Le Bellac, J.-M. Levy-Leblond, N.C. 14B, 217 (1973)
 F.S. Crawford, Am. J. Phys. 60, 109 (1992)
 A. Horzela, ... et al.



Frame S : send light at t_1 , reflect, receive it at t_2
 " S' : " " t'_1 " " " t'_2 (as seen from S')

Then the coordinates of the events are: $t = \frac{1}{2}(t_1 + t_2)$; $t' = \frac{1}{2}(t'_1 + t'_2)$
 $x = \frac{c}{2}(t_2 - t_1)$; $x' = \frac{c}{2}(t'_2 - t'_1)$

Set $t'_1 = \lambda_1 t_1$ ($\lambda_1 = \lambda_2 = 1$ Newtonian space-time)
 $t'_2 = \frac{\lambda_2}{\lambda_1} t_2$ λ_1, λ_2 dimensionless

then one can show

$$x' = \frac{x(\lambda_1 + \lambda_2) + ct(\lambda_2 - \lambda_1)}{2}, \quad t' = \frac{t(\lambda_1 + \lambda_2) + \frac{1}{c}x(\lambda_2 - \lambda_1)}{2}$$

The relative velocity of the two frames:

$$\frac{dx'}{dt'} = \frac{(\lambda_1 + \lambda_2) \frac{dx}{dt} + c(\lambda_2 - \lambda_1)}{(\lambda_1 + \lambda_2) + \frac{1}{c}(\lambda_2 - \lambda_1) \frac{dx}{dt}}$$

$$\text{When } \frac{dx}{dt} = 0 \Rightarrow \frac{dx'}{dt'} = w = \frac{c(\lambda_2 - \lambda_1)}{(\lambda_1 + \lambda_2)}.$$

Let $\lambda = \lambda_1$, solve λ_2 in terms of w and λ , then

$$x' = \lambda \frac{x - wt}{1 + w/c}, \quad t' = \lambda \frac{t - w/c^2 x}{1 + w/c}$$

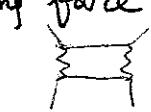
$$\text{group property, a third frame } \rightarrow w_{12} = \frac{w_1 + w_2}{1 + w_1 w_2 / 2}$$

$$\text{from the group property the most general } \lambda(w) = \left(\frac{1 + w/c}{1 - w/c} \right)^\mu$$

$$\mu = 1/2 \rightarrow \text{usual Lorentz transf'}$$

OV Teryaev (IC/91/390) 3218/92

Claim: $e^+e^- \rightarrow \gamma\gamma$ spin-dependent total cross-section has a $\delta(q^2)$ singularity
(Anders) for $m_e \rightarrow 0 \Rightarrow$ there's a long range pairing force between transverse polarized electrons moving in a plane.



S. Ferrara et al (3327/92). See also Ferrara, Porrati, CERN-TH 6493/92 (4293/92)

Minimal coupling schemes gives $g = 1/s$. (ev-bound states have $g = 2$?)
But W-meson at the 3-level gives $g = 2$.
For higher spin "elementary" particles, a non-minimal coupling is suggested which gives $g = 2$ for all particles!

Y. Kluger et al . 3228/92 , PR D

Fermionic pair production in a strong electric field

H. Rupertsberger : 3234/92 .

$$H = \sum_1^n \frac{p_i^2}{2} + V_n(x_1 \dots x_n) ; V_n = \lambda \prod_{i=1}^n \Theta(|x_i| - a) - \lambda$$

$$\lambda = 2 , V(x_1, x_2) = \lambda \Theta(|x_1| - a) \Theta(|x_2| - a) - \lambda$$

even though classically particle escapes to ∞ , there is a bound state for $D \geq 2$

W. Thirring et al (Variant QED without indefinite metric) . 3231/92

A. V. Manohar, Introduction to spin-dependent deep inelastic scattering
UCSD /PTH 92-10 . 3246/92 (review)

Parity violation in e-scattering (review) 3151/92 , cf. 3158/92

M. Bando, H.K. Kubo, Proton β -decay in Large magnetic fields , Lippisa preprint Apr. 92

Energy levels of p and n in a magnetic field with anomalous magnetic moments
for $B > 2 \times 10^{14}$ T neutron becomes stable, and for $B > 5 \times 10^{14}$ T proton
 β -decay?

Remark: AOB: For such high B , anomalous magnetic moment must be calculated from self-energy anew, from the beginning!

for proton : $E_{n,m,s} = [2eB(n+1/2) - eBs + M_p^2]^{1/2} - \frac{e}{2M_p} \left(\frac{g_p}{2} - 1\right)Bs$

for neutron $E(P_1, P_2 = 0) = \frac{e}{2M_n} \left(\frac{g_n}{2}\right)B + \sqrt{P_1^2 + M_n^2}$

is $\textcircled{1}$ stable if $-\frac{e}{2M_n} \left(\frac{g_n}{2}\right)B - \frac{e}{2M_p} \left(\frac{g_p}{2} - 1\right)B \geq M_n - M_p - \text{He} \Rightarrow B \geq 2 \times 10^{14} T$

p unstable if $\textcircled{1} \approx 0.12 \mu_N B \geq M_n + M_e - M_p \Rightarrow B \geq 5 \times 10^{14} T$

A. Ashtekar (variables) : PR D 36, 1587 (1987)
" preprint 3904/92

C. Mack, V. Schomerus ; Nucl. Phys. 370, 185 (1992) ; Phys. Lett. B 267, 207 (1991)
" DESY 92 053 ; 3444/92

For supersymmetry, quantum groups, etc. The group is not changed, only the law of tensor product, e.g. commutativity, - -

AOB: Since tensor product is a physical assumption, follows from a variational principle, of course, more general schemes can be considered.

J.S. Bell, JM Leinaas, Nucl. Phys. B212, 131 (1983), B224, 488 (1987)
interpreted depolarization of electrons in a storage ring as a kind
of Unruh effect; W.G. Unruh, PRL 48, 1351 (1981) - which has also
a standard QED interpretation - Soshkov-Ternov effect

O.F. Sylju sand et al. : Limits from anom. magn. moment ... 3405/92

• α_{exp} is larger than α_{th} : $\alpha_{\text{exp}}^{\ell} = 1.59652 \quad 188.4 (\pm 4.3) \times 10^{-12}$
 $\alpha_{\text{theor}}^{\ell} = 1.165937 (\pm 12) \times 10^{-9} \quad \alpha_{\text{theor}}^{\ell} = 1.140 (\pm 28)$

• Unbroken supersymmetry gives $\alpha = \alpha/2\pi - \alpha/2\pi = 0$.
(Ferrara, E. Rennidi, Phys. Lett. B 53, 347 (1974))

Even broken supersymmetry gives $\alpha_{\text{exp}} < 0$: Also axions, $\alpha \neq 0$.

- PJE Peebles et al The Case for the relativ. hot Big Bang Cosmology. *Nature*, 352 769 (1991)
 - H.C. Arp, T. van Flandern, The Case against the big bang; *Phys. Lett. A* 164, 263 (1992)
-

Since the coupling of Schröd. or K-G. fields to A_μ is awkward (j_μ depends on A_μ) first couple relativistically in Dirac eq. and then go to nonrelat. limit, instead of first going to spinless and N.L. limit and then coupling it minimally.

June 2.

Train from Trieste (June 1) 20.20, Monte 22.10 → 22.12 Conchette to Hanover 6.30

Not much sleep in the Conchette at all as usual. Md 6.50 → Hannover

- The idea for "Electromagnetic Realization of the Standard Model"

parameters

$e, m_e, K_{ee}, K_{ep}, K_{ev}, \dots$

A new point of view outside the usual paradigm of gauge theories!

- The idea for

"Surprising Solutions of No-go-Theorems in Theoretical Physics"

- 1) You can't do S-Matrix Theory for long-range EM interactions
- 2) You can't make a spin $1/2$ particle out of two bosons (origin of spin)
- 3) You can't have relativistic 2-body wave Eq. of Breit type
- 4) You can't have a local hidden variable theory
- 5) There are runaway solutions to Lorentz - Dirac eq. & preacceleration
- 6) Linear wave equations cannot have localized solutions; $v < c$ or $v > c$
- 7) You cannot have finite QED.
- 8) EM field must be quantized
- 9) Gravitational field must be quantized if matter is.
- 10) massless ν cannot have magnetic moment.
- 11) You cannot treat antiparticles in first quantized theory
- 12) Magnetic forces cannot produce new bound states at short distances.
- 13) You can't treat spontaneous emission without field quant.; Casimir effect, Unruh eff.
- 14) Can you embed supersymmetry groups into ordinary Lie groups?
- 15) All internal symmetries can be described by finite groups (permutations)
- 16) Tachyonic bound states.

"Dynamical Systems" Trieste 25-May, 5 June

Lecture on Bifurcations; KAM Theory; Sinai; "Geodesic Flow on M of negrt. curvature"

June 2-3: Braunschweig. Chez G. Gerlich, Frau Monika, Gerhard, Annemarie, Richard; Hahn-
Colloq. June 2: Standard QM; Standard QEM; Standard Model (Krank)

Extrapolation of QED zu kurzen Abständen. Nachsitzung.

Seminar June 3: Wavelets; spin correlations .. Thomas Görlitz.
Tel. H. Doebner; Tel. H. Kleinert. Herr Richter; Hahn.

) cf. Diplomarbeit Dietert: Magnetic Top u. Bloch eq. (cf. next page Takabayasi)
) " Lokalisierte Lösung der Phasenraumgleichung.

: $e\gamma$ -scattering with full nonperturb. interaction or potential.

The Born Approx. of which gives

$$\frac{e^2}{r} \rightarrow -\frac{e^2}{r} \approx -g \cdot \frac{1}{2r} \cdot g \quad \frac{ek}{t} \sim \frac{g^2}{t - m_e^2}$$

In reality we should calculate with a potential



beyond Born Approx.

This accounts for Z^0 -resonance region.

Next we must also account for strong interactions:

$$e^+e^- \rightarrow \pi^0, \eta, \omega, \dots$$

$$\text{and } \pi\pi, \dots K\bar{K}, \dots$$

Instead of lepton-quark symmetry, we just have leptons.

The Meson-Nucleon Polariz., R. Rosenfelder, Paul Scherrer Inst. 3879/92
CH-5232 Villigen PSI

Books:

Fushchich and

"Symmetries of Maxwell's Equations"
D. Reidel

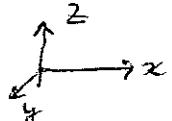
T. Takabayasi, Theory of Relativistic Top and Electromagnetic interactions
Prog. Theor. Phys. 67, 357 (1982).

ARP Rao, Asymmetric Rotor as model of Localization
Rev. Mod. Phys. 64, 622 (1992)

→ Search for Casimir's result that the maximum of energy is stable, not minimum.

D. E. Peltt, Stern-Gerlach Exp., Am. J. Phys. 60, 306 (1992)

$$H = \frac{p^2}{2m} + (q\mu_0/\hbar) \vec{S} \cdot \vec{B}(x), \quad B(x) = \beta y \hat{j} + (B_0 - \beta z) \hat{k}$$



$$\Psi = \begin{pmatrix} \psi_+ \\ \psi_- \end{pmatrix}; \quad -\frac{\hbar^2}{2m} \nabla^2 \Psi_{\pm} \pm \frac{g\mu_0\beta}{2i} y \Psi_{\mp} \pm \frac{g\mu_0}{2} (B_0 - \beta z) \Psi_{\pm} = i\hbar \Psi_{\mp}, t$$

$$\frac{d\vec{S}}{dt} = -\mu_0 \frac{q}{\hbar} \vec{B}(x) \times \vec{S}.$$

$$\text{Separate rapid } B_0\text{-oscill's: } \Psi_{\pm} = e^{\mp i g \mu_0 B t / 2 \hbar} \tilde{\Psi}_{\pm}$$

Now average over a time long compared to oscillations (B_0), but short compared to the motion of wave packets makes the coupling term $\frac{g\mu_0\beta}{2i} y \tilde{\Psi}_{\mp}$ vanish, and one gets 2 uncoupled eq's

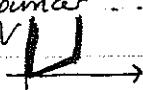
$$-\frac{\hbar^2}{2m} \nabla^2 \tilde{\Psi}_{\pm} \mp \frac{g\mu_0\beta}{2} z \tilde{\Psi}_{\pm} = i\hbar \frac{\partial \tilde{\Psi}_{\pm}}{\partial t}.$$

Linear potential \rightarrow Airy functions (cf. Landau-Lifshitz)

Notes: cf. Found. of Phys. 17, 575 (1987)

How to do the averaging over B_0 -oscill's in Heisenberg Repr.?

cf. A. Böhm's book (several mistakes ---)

Quantum bounces Am. J. Phys. 49, 648 (1981); 51, 82 (1983): linear potential
 Airy functions

R. A. Muller, Thomas precession; where is the torque? Am. J. Phys. 60, 313 (1992)

accelerated gyroscope precesses; hence \vec{L} is not conserved. Where is the torque?

- i. The force that accelerates gyroscope, also causes a distortion of the mass distribution in the gyroscope, the center of mass moves away from the axle \rightarrow torque

T. P. Heid et al Classical view of Stark effect in Hyd. ... Am. J. Phys. 60, 324 (92)
" " of Rydberg atoms -- 60, 329 (92)

P. Erdős et al Floating equilibrium of symmetrical objects and symmetry breaking
I, II, ibid, p. 335, 345

$$e^{ikrcos\theta} = \sum_{l=0}^{\infty} i^l (2l+1) j_l(kr) P_l(\cos\theta) : \text{Am. J. Phys. 60, 378 (92)}$$

M. B. James, ... "Why the speed of light is reduced in a transparent medium"
Am. J. Phys. 60, 309 (1992)

Radiation from many induced molecular dipoles conspires
to produce a single wave propagating at the reduced speed by a factor n
which is then related to the electric susceptibility of the medium.

-
- Solve $\vec{\mu} \cdot \vec{B}$ problem with a classical vector $\vec{\mu}(\theta, \phi)$.

a) Classical Hamiltonian (Schrödinger)

b) Schrödinger eq. with $\vec{\mu}$ -vector; not rotationally symmetric.

$i\hbar \Psi_t = -\frac{\hbar^2}{2m} \Delta \Psi + g \vec{\mu}(\theta, \phi) \cdot \vec{B} \Psi \Rightarrow$ rot. symmetry after θ, ϕ integration

Ex: $\vec{B} = B \hat{k} = \text{const.}$ $i\hbar \Psi_t = -\frac{\hbar^2}{2m} \Delta \Psi + g \mu_0 B \cos\theta \Psi.$

The solution is $\Psi = e^{ig\mu_0 B c_0 \theta t} e^{i(\vec{k} \cdot \vec{x} - \omega t)} F(x-vt)$ with or without F

Averaging over all values of θ_0 gives zero

$\int_0^{2\pi} \int_{-\pi/2}^{\pi/2} \sin\theta d\theta d\phi > 0$ But the stat. states \uparrow, \downarrow corresponds to averaging over
 $\vec{k} \cdot \vec{r} \approx 0$ upper and lower half planes, respectively.

J.C. Varilly, J.M. Gracia-Bondia : "The Moyal Representation for Spin"
Ann. of Phys. 190, 107 (1989)

June 5 : Lect. in KomFanz. → Zürich →
Theory of Stern-Gerlach Exp.

June 6 : Zürich → TS. Gotthard tunnel : 8 minutes

Compare high order correlations :

$$\langle \psi | (AB)^n | \psi \rangle \quad \text{with} \quad \int d\theta \sin \theta d\varphi (A(\theta, \varphi; a) B(\theta, \varphi; b))^n.$$

Eikonal Approx. to potential scattering Amplitude

$$f(q) = \frac{k}{i} \int_0^\infty db b J_0(qb) (e^{i\chi(b)} - 1), \quad \chi(b) = -\frac{1}{2k} \int_{-\infty}^{+\infty} U(b, z) dz$$
$$U = 2m V(r)/\hbar^2$$
$$ka \gg 1, \quad \frac{1}{2} \ll 1, \quad \theta < O(\sqrt{\hbar})$$

is actually valid for much larger angles for potentials with sharp edges, e.g. square well
(preprint 3589/92) - Beijng

R. Voss : Deep inelastic polarized μ -scattering : CERN-PPE/92-44/45, /3623-24/92

$\mu \rightarrow e \nu \gamma_\mu$ energy spectrum of e measures longit. polarization of μ .
 $e e \rightarrow e e$ scattering from polarized e measures the polarization of other e .

• How to do self-field QED with magnetic monopoles or dyons ?

• There is an expression for self-field A_μ in terms of j_μ^{elect} and j_μ^{string} for monopoles.

This should be used for the formulation of the 2-body problem.

June 12: Konstanz lecture "Electromagnetic Realization of the Standard Model"

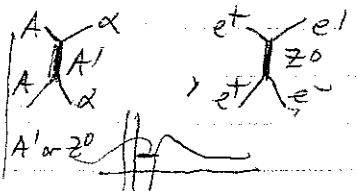
like a group Repr. has many realizations with different choice of coordinates,
The electro-weak reactions observed (and strong interactions) may have also
different realizations in terms of underlying fields. Find an economic one.

M. Riordan, The discovery of quarks, SLAC-PUB-5724, to appear in Science / 3736/92
(reality of quarks ?)

- 1) There are 4 currents in the (phenom.) standard electroweak model; and they can be identified with $(e^+ \nu = W^+)$, $(e^- \bar{\nu} = W^-)$, $\nu \bar{\nu}$ and $e^+ e^- = Z^0$ and ∂^μ .
- 2) all particles can be built up from e, ν . The "Aufbau principle" is isomorphic to the quark model grouptheoretically. (see references for extensive tables and figures)
Bosons $l\bar{l} + l\bar{l}\bar{l}\bar{l}$, Baryons $b\bar{b} + l\bar{l}\bar{l}\bar{l}$
- $Q_q + B_q = Q_\ell + B_\ell$; $Q_q = Q_\ell + \frac{2}{3} B_\ell$, $B_q = B_\ell - \frac{2}{3} B_\ell = -\frac{1}{3} B_\ell$
- 3) Regularities in stability.
- 4) Model for K_0, \bar{K}_0 mixings and mechanism for CP violation
- 5) Charge quantization and charge conservation. Internal quantum numbers as "particle numbers". Isospin as ($e\bar{e}$) - exchange: discrete all intersymmetries are EX; Isospin in NN-system. no need for a non-abelian gauge theory.
- 6) Both Dirac and Pauli couplings are the result of a $U(1)$ -gauge group.
- 7) If a particle has several decay modes \Rightarrow rearrangement of constituents,
$$K \rightarrow \mu^+ \bar{\nu}_\mu \rightarrow (e^+ \nu_e \nu_\mu)(\bar{\nu}_\mu) = (e^+ \nu_e)(\nu_\mu \bar{\nu}_\mu) = \pi^+ \pi^0 \quad 21\%$$

$$\rightarrow (e^+ \nu_e)(e^+ e^-)(\nu_\mu \bar{\nu}_\mu) = \cancel{(e^+ \nu_e)} \cancel{(e^+ e^-)} \cancel{(e^- \bar{\nu}_e)} \cancel{(e^+ \bar{\nu}_e)} \pi^+ \pi^0 \pi^0 \quad 1\%$$
- 8) Neutrino magnetic moment $\mu_\nu = 10^{-9} - 10^{-10} \mu_0$ from several different arguments
This could be also the intrinsic part of the electron's magnetic moment.
- 9) Solution of the family problem: instability of the next lepton ...
- 10) Solution of the unification problem: not going to large groups, but to smaller!

Ref. Quant. Theory of Space-Time, Vol. IV.5
AIP Conf. Proceedings
Lett. N. C. 35, 200 (1982); 38, 225 (1983)



Theorem

(heard from Y. Sinai, June 1, 1992)

$$1) L = \frac{1}{2} a_{ij} \dot{q}_i \dot{q}_j - V(q)$$

$$\therefore \ddot{q}_K + \Gamma_K^{jl} \dot{q}_j \dot{q}_l + (\bar{a}^{-1})_{KL} \frac{\partial V}{\partial q_L} = 0$$

$$\Gamma_K^{jl} = \frac{1}{2} (\bar{a}^{-1})_{kl} \left(\frac{\partial a_{jl}}{\partial q_k} + \frac{\partial a_{lk}}{\partial q_j} - \frac{\partial a_{lj}}{\partial q_k} \right)$$

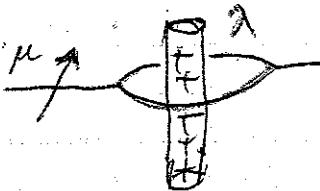
$$2) ds^2 = (\epsilon - V(q)) a_{ij} dq_i dq_j, \text{ use, } \epsilon = \frac{1}{2} a_{ij} \dot{q}_i \dot{q}_j + V = \text{const}$$

↓ geodesic gives you the same equation of motion (checked by M. Cruz)
(independent of ϵ !)

Continue: The space is flat if $\exists y_i = y_i(q)$ $\ni \frac{\partial y_K}{\partial q_i} \frac{\partial y_K}{\partial q_j} = (\epsilon - V(q)) a_{ij}$
then the curvature R is zero.

$$\Delta Q_{AC} = \frac{4\pi}{t_C} \mu \cdot \lambda$$

$$\Delta Q_{AB} = \frac{e}{\hbar} \int B \cdot df = \Phi$$



Aharonov-Bohm effect
Siegert's Ansatz

and against

- Consider all the arguments for the "reality" of quarks and uniqueness of the model.
- T. SLOAN, Nature 323, 405 (1986). cf. C.K. Chen, Physics Today, Jan. 1992, p. 101
- a) Deep inelastic scattering :
can be fitted both by fractional and integer charge constraints + Additivity of magn. moment
implies fractional charge. (K. Berkelman)
- b) confinement problem
- No way of calculating bound states
- Polarization asymmetries
(parton conjecture is not derivable)
from QCD or vice versa

Lec. continued on June 23.

JM Namystowski, Nonperturbative QCD-Methods (Warsaw 1992 - 465a/91)

→ There are no nonperturbative renormalization methods!

Problems: (1) mechanism of confinement (2) mass scales: 0.24 GeV for q , 0.56 GeV for \bar{q}
(3) hadron mass spectrum and other static properties?
There are no continuum states in $q\bar{q}, q\bar{q}, q\bar{q}\gamma$ etc?

Kramers-Henneberg transf. (Phys. Lett A 165, 341 (1992))

$$H = \frac{1}{2\mu} [(\vec{p} - e\vec{A})^2] + V \quad \text{with} \quad \vec{A}(t) = \frac{E}{\omega} \cos \omega t \, e_z$$

$$\Psi = U X, \quad U = \exp \left[i \frac{e}{\mu} \int_0^t d\tau \vec{A}(\tau) \cdot \vec{p} \right] = \exp \left(i \frac{e}{\mu} \int A^i dx^i \right)$$

$$\therefore i \dot{X}_{,t} = \left(\frac{\hbar^2}{2m} + \frac{e^2}{2\mu} A^2(t) + V(\vec{x} - \vec{\xi}(t)) \right) X \quad \text{where} \quad \vec{\xi}(t) = \frac{eE}{\mu\omega^2} \sin \omega t \, e_z$$

classical trajectory.

This is a special case of (AOB)

$$i \dot{\Psi}_{,t} = -\frac{\hbar^2}{2m} (-i\nabla - e\vec{A})^2 \Psi + V \Psi = -\frac{\hbar^2}{2m} \Delta \Psi + V \Psi - \frac{\hbar^2}{2m} (ie \nabla(A\Psi) + ie A \cdot \nabla \Psi)$$

under $\Psi = U X$

$$\begin{aligned} i \dot{X}_{,t}^* &= -\frac{\hbar^2}{2m} \Delta X + U^{-1} V U X - \frac{\hbar^2}{m} U^{-1} \nabla U \cdot \nabla X = i U^{-1} \frac{\partial U}{\partial t} X - \frac{\hbar^2}{2m} U^{-1} \nabla^2 U X \\ &\quad - e i \frac{\hbar^2}{2m} U^{-1} (\nabla \cdot A) U X - e i \frac{\hbar^2}{2m} U^{-1} \left(\vec{A} \cdot (\nabla U X + U \nabla X) \right) - \frac{e^2 \hbar^2}{2m} U^{-1} \vec{A}^2 U X \end{aligned}$$

More generally,

June 17 on train

$$(\delta^\mu(i\partial_\mu - eA_\mu) - m) \Psi = 0$$

$$\Psi = U X : \left[(U^{-1} \delta^\mu U) i\partial_\mu - e U^{-1} \delta^\mu A_\mu U - m + i U^{-1} \delta^\mu \frac{\partial U}{\partial x^\mu} \right] X = 0$$

Special cases: a) If U commutes with δ^μ : $(\delta^\mu(i\partial_\mu - eU^{-1}A_\mu U) - m + i \delta^\mu U \frac{\partial U}{\partial x^\mu}) X = 0$
 b) $\{U^{-1} \delta^\mu U (i\partial_\mu - eA_\mu) - m + i U^{-1} \delta^\mu \frac{\partial U}{\partial x^\mu}\} X = 0$, if U commutes with A_μ .

For $U = e^{-ie \int^x A_\mu dx^\mu}$ $\rightarrow i \delta^\mu U \frac{\partial U}{\partial x^\mu} = e \delta^\mu A_\mu$, if U is well-defined or free from singularity.

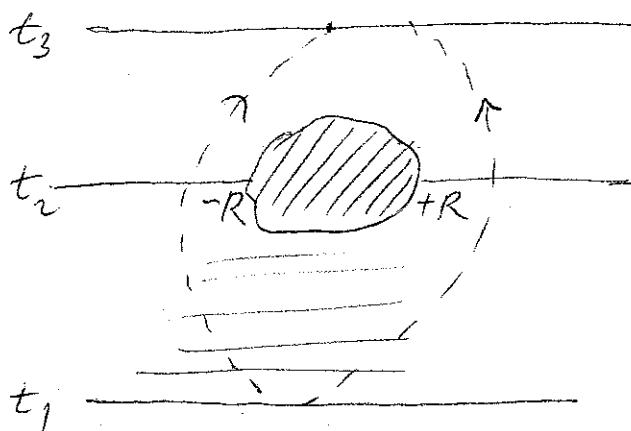
Interpolate Volkov solution as such a U !

Problem: Path integral of a spinning electron for Volkov solution.

• AB effect for light:

June 20

Scattering of light from an obstacle can be viewed as an AB effect or its reciprocal, (scattering from a hole).



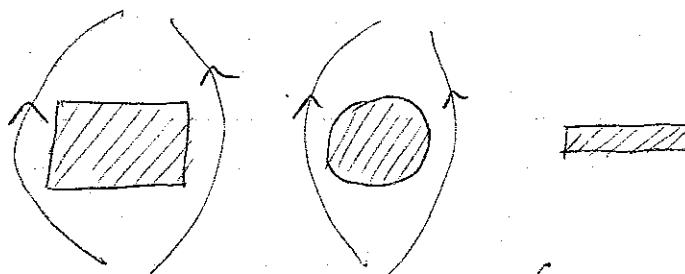
By Huygens' principle
The wave at t_3 is a sum of two Integrals at t_2

$$\int_{-\infty}^{-R} + \int_R^{\infty}$$

which interfere!

Look up diffraction from a sphere.

- AB effect is actually not fully topological, it must be shape-dependent : Square, cylindrical, --- solenoids, same flux



But phase shift is prop. to $\oint A \cdot d\ell = \int B \cdot d\phi = \Phi$!

- Berry's phase as a forward scattering amplitude.

In the rest frame of the particle the external field will increase and then decrease to zero.

June 21

• H-Functions : C. Fox, Trans. Am. Math. Soc. 98, (1961) 395

$$a) H_{p,q}^{m,n} \left[z \mid \begin{matrix} (a_1, \alpha_1), \dots, (a_p, \alpha_p) \\ (b_1, \beta_1), \dots, (b_q, \beta_q) \end{matrix} \right] = H(z)$$

$$= \frac{1}{2\pi i} \int_C \frac{\prod_{j=1}^m \Gamma(b_j - \beta_j s)}{\prod_{j=m+1}^q \Gamma(1 - b_j + \beta_j s)} \frac{\prod_{j=1}^n \Gamma(1 - \alpha_j + \alpha_j s)}{\prod_{j=n+1}^p \Gamma(a_j - \alpha_j s)} z^s ds$$

$$0 \leq m \leq q; 0 \leq n \leq p, \alpha_j > 0 \text{ for } j=1, 2, \dots, p; \beta_j > 0 \text{ for } j=1, 2, \dots, q$$

an empty product is unity. a_j ($j=1 \dots p$), b_j ($j=1 \dots q$) are complex numbers such that no pole of $\Gamma(b_j - \beta_j s)$ for $j=1, 2, \dots, m$ coincides with any pole of $\Gamma(1 - \alpha_j + \alpha_j s)$ for $j=1, 2, \dots, n$.

C = contour in the complex s -plane from $w-i\infty$ to $w+i\infty$, \exists the points

$s = (b_j + k)/\beta_j$ for $j=1, 2, \dots, m$, $k=0, 1, \dots$ are to the right of C , and

the points $s = (a_j - 1 - k)/\alpha_j$ for $j=1, 2, \dots, n$, $k=0, 1, \dots$ to the left of C

(i.e. a special Mellin-Barnes integral : Erdelyi, Higher transc. functions)

b) The G-functions of Meijer are a special case of H-function, if

$\alpha_j = \beta_j = 1$ for every j . (Y. L. Luke, Special functions, Acad. P. 1969)

$$G_{p,q}^{m,n} \left[z \mid \begin{matrix} a_1, \dots, a_p \\ b_1, \dots, b_q \end{matrix} \right] = H_{p,q}^{m,n} \left[z \mid \begin{matrix} (a_1, 1), \dots, (a_p, 1) \\ (b_1, 1), \dots, (b_q, 1) \end{matrix} \right]$$

Particular examples:

$${}_1F_0(a, z) = (1-z)^{-a} = \frac{1}{\Gamma(a)} H_{1,1}^{1,1} \left[-z \mid \begin{matrix} (1-a, 1) \\ (0, 1) \end{matrix} \right]$$

$$\exp(z) = {}_0F_0 = H_{0,1}^{1,0} \left[-z \mid (0, 1) \right].$$

In Laser-physics, Ebel & Milloni

June 21.

a) .. (measured) recoil of spontaneously emitting atom is not contained in the classical wave theory of radiation" --

This statement is wrong.

b) lowers the intensity of light in front of a polarizer, - finally each "photon" either passes or not, "all or nothing", with probability $\cos^2\theta$ --

This is an abstraction, unsubstantiated. One takes quantization of EM field as granted and attributes quantal properties to individual events. The hidden variable theory should do otherwise: assume a deterministic behavior for individual events and obtain the quantum results after averaging. It further assumes perfect source, perfect detector.

\Rightarrow YOU CAN DO QED WITHOUT PHOTONS

Counterexample: Coin for each individual event has two outcomes!

June 23.

H. Rechenberg: History of Nucl. Physics in Leipzig 1920-1938

$eV, e+e^-$, -- exchanges: Stuckelberg, Wentzel, Heisenberg, Ivanenko, -- (Nachsitzung in Mainau)

June 24:

Landau-Lifshitz treatment of positronium.

Start from Feynman diagram \rightarrow derive a potential (to order α)
and then solve the Wave Eq.

I start from full Dirac fields ψ_1, ψ_2 (not plane waves), derive 2-body Eq.

Breit terms appear as Approximations.

*)

$$\Gamma(\mu \rightarrow e \nu \bar{\nu}) = \frac{G_F^2 m_\mu^5}{192\pi^3} f\left(\frac{m_e^2}{m_\mu^2}\right) \left(1 + \frac{3}{5} \frac{m_\mu^2}{m_W^2}\right) \underbrace{\left[1 + \frac{\alpha(m_\mu)}{2\pi} \left(\frac{25}{4} - \pi^2\right)\right]}_{QED \text{ Rad. Corr. term}}$$

$$f(X) = 1 - 8X + 8X^3 - X^4 - 12X^2 \ln X$$

$\alpha^{-1}(m_\mu) \approx 136$

all other electroweak rad. corrections are absorbed in G_F .

Same for $\Gamma(\tau \rightarrow l \nu \bar{\nu})$

- We live in a universe with an imbalance of matter over antimatter. 3 necessary conditions:
 - Baryon number is violated. (otherwise baryon # now would be equal to initial baryon #)
 - CP (hence T) must be violated; otherwise baryons and antibaryons on equal footing
 - "an arrow of time" must be provided.

CP-violation $K^0 \rightarrow \pi^+ e^- \bar{\nu}_e$ proceeds slightly faster than $K^0 \rightarrow \pi^+ e^- \bar{\nu}_e$.

$$e^\mu \rightarrow e^- (\bar{e} \nu_e \bar{\nu}_\mu) = e^- (\bar{e} \nu_e \bar{\nu}_e \nu_e \bar{\nu}_e) = (\bar{e} \bar{\nu}_e)(\bar{e} \nu_\mu) = \pi^+ e^- \bar{\nu}_e$$

$$e^+ \bar{\mu} \rightarrow e^+ (\bar{e} \bar{\nu}_e \nu_\mu) = e^+ (\bar{e} \bar{\nu}_e \nu_e \nu_e \bar{\nu}_e) = (\bar{e} \bar{\nu}_e)(\bar{e} \nu_\mu) = \pi^- e^+ \nu_e$$

CP violation due to $\nu_e \bar{\nu}_\mu \leftrightarrow \bar{\nu}_e \nu_\mu$. \nearrow in both?

- electric dipole moment violates T, magnetic dipole moment not, because under T E does not change, but B does.

$e^+ e^- \rightarrow \mu^+ \mu^-$ ✓ calculate also $e^+ e^- \rightarrow \tau^+ \tau^-$

*) $\mathcal{L}^{\mu\text{-decay}} = \frac{-ig^2}{8(q^2 - M_W^2)} \bar{\mu} \gamma_\mu (1 - \gamma_5) \gamma_\mu \bar{e} \gamma_\mu (1 - \gamma_5) \nu_e$

$$q^2 \ll M_W^2 \rightarrow \frac{GF}{\sqrt{2}} = \frac{g^2}{8M_W^2}$$

„Nuclearites“: (uds) probably more tightly bound than (uud), (udd)

in my model: $(uud) \rightarrow (\nu e \bar{e})$
 $(udd) \rightarrow (\nu e \bar{e})$
 but $(uds) \rightarrow (\nu e \mu)$?

Schröd. Eq. in first order Matrix form

$$\Psi = \begin{pmatrix} \psi(x) \\ \psi'(x) \end{pmatrix} \rightarrow \Psi' = M \Psi, M = \begin{pmatrix} 0 & 1 \\ -k^2 & 0 \end{pmatrix}, k^2 = 2m(E-V)/\hbar^2$$

(analogy with transmission line see J. Rosner, Chicago EFI 92-07 / 4017/92)

June 28

- History of Skyrme Model (25 years):

Sov. Phys. Uspekhi, 35, 55 (1992)

- Radiation in electrodynamics and in Yang-Mills Theory

Sov. Phys. Uspekhi, 35, 135 (1992)

- Pair production in Strong E-fields,

J.M. Eisenberg et al Acta Phys. Pol. 23B, 577 (1992)

June 30

J. Schwinger, Casimir effect in source theory, Lett. Math. Phys. 24, 227 (1992)

$$y = x^5 - 5x^3 + 5x \quad \text{For } x = -2, -1, 0, 1, 2 \\ \downarrow y = -2, -1, 0, 1, 2. \quad \text{If an experimentalist had measured only these points!}$$

On Bell's inequality

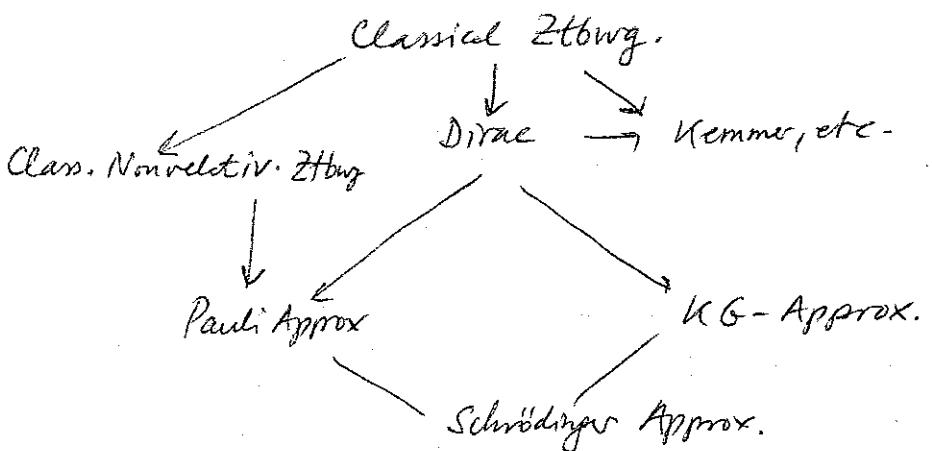
$$E(a, b) - E(a, b') = \int d\lambda \left\{ A(a\lambda) B(b\lambda) [1 \pm A(a'\lambda) B(b'\lambda)] - A(a,\lambda) B(b'\lambda) [1 \pm A(a',\lambda) B(b\lambda)] \right\}$$

Now relax the condition $|A(a,\lambda)| \leq 1, |B(b,\lambda)| \leq 1$, $\int d\lambda = 1$
to $|A(a,\lambda)| \leq \sqrt{2}$ $\int \sqrt{2}$

$$\rightarrow -2\sqrt{2} \leq B(A, B) \leq 2\sqrt{2}. \quad \checkmark$$

- "Photballs" decaying into $\gamma\gamma$.
The polarization of 2 photons are correlated. Both the same helicity,
 $\leftarrow \vec{J} \quad \rightarrow \vec{J}$ or $\uparrow^E \rightarrow E$
This is true for $\pi^0 \rightarrow \gamma\gamma$ and positronium $\rightarrow \gamma\gamma$.

- Revive discrete Kepler problem for the electron, 4-dimensional non-commutative geometry of Barut-Bracken



July 1st in train from Konstanz to Lausanne reading about the botanist Richard Evans Schultes (1915 -), Harvard, in the footsteps of Richard Spruce (1817-1893), both Amazon explorers (Columbia) (New Yorker, June 1, 1992)

July 3rd at lunch 1½ hrs defend my QED with Račzka, Budinić, Demkowshi
Strong points of SEOED:

- (1) $pS \rightarrow 3\gamma$ check the value of wave fn at the origin
- (2) positronium Lambshift, etc... all positronium problems
- (3) No zero point energy
- (4) More accurate spontaneous emission rates
- (5) easier next order ($g-2$) .

July 5

P. Kraster, Solar 2's in twisting magnetic fields
CERN-TH. 6468/92

D.H. Wilkinson (Proc. S.S. Hanna Symposium, 4253/92). The Atomic Nucleus

"No evidence that quarks (or QCD) have shown themselves in nuclear structure proper". (But he says "we know that quarks are there! (?)")
(Note: Quarks must be small, 10^{-20} cm. like electron).

E-D. Cooper et al Relat. 2-body Eq. etc. - (4249/92)

→ Problem for us: Form factors of our 2-body positronium eq.

M.M. Nieto ; Coherent States -- (J. Klauder's 60th Festschrift)
LA-UR-92-1284

Note: Squeezed states use the algebra: $K_+ = \frac{1}{2} \alpha a^\dagger a^\dagger$, $K_- = \frac{1}{2} \alpha^* a a$, $K_0 = \frac{1}{2} (\alpha a^\dagger + \alpha^* a)$

$$S(z) = \exp\left[\frac{1}{2} z a^\dagger a^\dagger - \frac{1}{2} z^* a a\right], \quad D(\alpha) = \exp(\alpha a^\dagger - \alpha^* a).$$

$$D(\alpha) S(z) |0\rangle \equiv |\alpha; z\rangle$$

Z. Habur (Wroclaw; ITP UWr, 802/92; 4196/92); Coherent States, Reproducing kernels, Field quantization, --

Z. Hariewicz et al Quantum particle on a group manifold. (4195/92)
G as the configuration space -- Lagrangian quadratic
function of $P = \dot{\phi}(t)$, $\phi(t)$ curving

J. Lopuszanski (4192/92)

1) If $f_{\mu\nu} = \Lambda_\mu^{\mu'} \Lambda_\nu^{\nu'} f_{\mu'\nu'}$, i.e. form invariant under Lorentz
transf's (isotropic tensor), then $f = 0$.
(obvious; there is no isotropic antisymmetric two index tensor)

2) ibid. (4185/92). Galilei transf's: $x' = g(t, x) = Rx - vt + a$
 $t' = t + b$

Let $x = f(t = \tau) \rightarrow$ Lagrangian

$$\mathcal{L} = \frac{m}{2} (f'(t))^2$$

This \mathcal{L} is not invariant under Galilean transfs;

$$\mathcal{L}' = \mathcal{L} + W, \quad W = m \left\{ \frac{1}{2} \int_0^t (\dot{f}(t+\tau))^2 d\tau - v R f(t) + \frac{1}{2} t + c \right\}$$

But we can find a central extension of the Galilean group. Define new Lagrangian $\tilde{\mathcal{L}} = \mathcal{L} - m s$, s = new addition variable.

now require

$$\tilde{\mathcal{L}}' = \tilde{\mathcal{L}} \quad \text{invariance. Hence } s \text{ must transform}$$

$$s \rightarrow s' = s + \frac{1}{m} W$$

\rightarrow extended Galilean group. (as in Schröd. case)

P V Landshoff, The structure of pionium (CERN-TH 6462/92)-4172/92

Raising $p\bar{p}, \bar{p}\bar{p}$... cross-sections, Forward peak in $p\bar{p}, \bar{p}\bar{p}$...
Pionium exchange is a non-perturbative effect

J. Sakamoto : N-Body Bound state solutions of Dirac particles in
1+1 dim. space-time (with δ -function potentials)

(\rightarrow see W. Glöckle et al PR D35, 584 (1987)
2-Body with δ -function pot. in 1+1-dim)

$$H = \sum \vec{\alpha} \cdot \vec{p}_i + m \sum \beta_i - \frac{g}{2} \sum_{i \neq j} (1 - \vec{\alpha}_i \cdot \vec{\alpha}_j) \delta(\vec{x}_i - \vec{x}_j)$$

J. N. NG, Introduction to symmetry breaking and spin (4254/92)
(Lake Louise Winter Inst.)

Standard Model : the whole symmetry breaking mechanism is rather ad hoc.

t-quark is yet to be found. Why it is so heavy?

No predictive power for quark masses

quarks mix because weak interactions eigenstates are misaligned with mass eigenstates

Higgs doublet has 4 degrees of freedom : 3 W^\pm, Z^0 , one scalar Higgs.

$$\mathcal{L}_{\text{electr.}} = (D_\mu \phi - \frac{i g'}{2} B_\mu \phi - \frac{i g}{2} W_\mu^\alpha \epsilon^\alpha \phi)^2 - V(\phi^\dagger \phi); \quad V = \mu^2 \phi^\dagger \phi + \frac{\lambda}{2} (\phi^\dagger \phi)^2$$

for some unknown reasons μ^2 -term has negative sign.

$$\mathcal{L}_f = \bar{e}_R \delta^{\mu} (i\partial_\mu - g' B_\mu) e_R + \bar{q}_L \delta^\mu (i\partial_\mu + \frac{g}{2} \tau^a W_\mu^a + \frac{g'}{2} B_\mu) q_L \\ + \bar{Q}_L \delta^\mu (i\partial_\mu + \frac{g}{2} \tau^a W_\mu^a + \frac{g'}{6} B_\mu) Q_L + \bar{u}_R \delta^\mu (i\partial_\mu + \frac{2}{3} g' B_\mu) u_R + \bar{d} \delta^\mu (i\partial_\mu - \frac{1}{3} g' B_\mu) d_R$$

$\Psi_L = (r\bar{e})_L, Q_L = (u\bar{d})_L.$ For each generation.

- Study Banerji-Zhangi theory from the point of view of noncommutative Minkowski space. (Durul)
- Generalize spin polarizer to Dirac case and to neutrino; only 1-component passes through!
- Tunnelling of spin $1/2$ particles through magnetic potentials -
- Two-body problem in linearized gravity of spinning particles (M. Couz)
- QED in the field of a (Aharanov-Bohm) solenoid

R. Jackiw, S-Y Pi : Symmetries of (2+1)-dim. Field Theory
4207/92

R. Bhandari, Must a fermion change sign under 2π -rotations? 4206/92

"Wentzel - Method" of summing over all modes to calculate vacuum pol.

$$\Delta E = \frac{1}{2V} \sum_n \left(\omega_n^2 / \Phi_N(r) / 2 + (\nabla \phi_n - ie A \Phi_N / 2 + n^2 / \Phi_N)^2 / 2 \right. \\ \left. + e^2 A_0^2 / \Phi_N / 2 \right); \Phi_N = \text{exact solution}$$

cf. C. Goebel, N. Thomas, Phys. Rev. D 30, 823 (1984)

VACUUM POLARIZ. Cf also R. Jost + T.M. Luttinger, Helv. Phys. Acta
23, 201 (1950)

P. Garbaczewski, "Stochastic Mechanics and Spin 1/2" -- 4184/92

\times J. Math. Phys. 33, 3393 (1992) \times Rotating spinor functions?

• 1+1- QED:

1) What is $(g-2)$?

2) " " Spontaneous emission.

Gauge I and gauge II both lead to $\nabla A_p = j_p$

hence $A_p = \int dy D(x-y) j_p(y)$.

In gauge I: $\partial A_0 / \partial t = 0, \partial A_1 / \partial x = 0 \Rightarrow$ either $\frac{\partial D}{\partial t} = 0, \frac{\partial D}{\partial x} = 0$

or $\int dy D(x-y) \frac{\partial j_0}{\partial t} = 0, \int dy D(x-y) \frac{\partial j_1}{\partial x} = 0$

→ This is too strong — use only $\partial A_i / \partial x^i = 0$
Green's function by the method of contour-integr.

$$G(x-y) = -\frac{1}{(2\pi)^2} \int dk e^{ikx} \int \frac{e^{-iky}}{k^2 - k_0^2} dk$$
$$= \int dk \frac{e^{ik(x-t)}}{2k}$$

Review : "Supersymmetry in Quantum Mechanics"
 Int. J. Mod. Phys. A 5, 1383-1456 (1990)

July 10.

R. Schrieffer,

1)



Ferrolayer

Magnetoresistance changes by a factor 2 behv. ↑↑ or ↓↓ spins !

- 2) Order parameter (pairing of electrons) $\Delta = \langle C_{k\sigma} C_{k\bar{\sigma}} \rangle$ is usually taken instantaneous, at equal times, there is actually a retardation effect

3) $\begin{array}{c} \uparrow \quad \uparrow \\ S=1, l=1 \\ \text{time reversal odd} \end{array}$

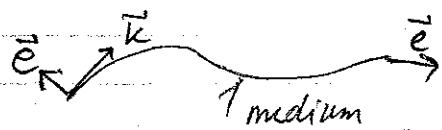
$\begin{array}{c} \uparrow \quad \downarrow \\ S=0 \quad l=1 \\ \text{time reversal even?} \end{array}$

Lecture by M. Berry.

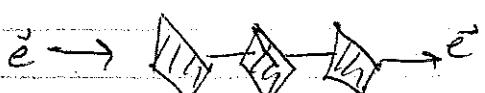
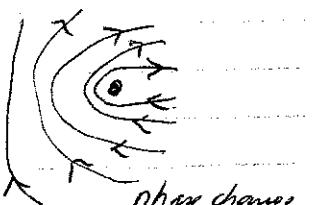
"wave" is the universal mathematical concept
 "Anholonomy" is the more general concept. Special cases.

Gauss' "parallel transport", Pancharatnam, - - -

Dislocations, Disclinations - - Singularities.



polarization vector \vec{e} does not rotate around \vec{k} but is only parallel transported.



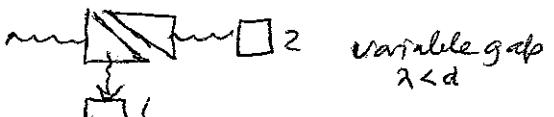
several polarizers.
 \vec{e} traces spherical triangle (Pancharatnam)

forward scattering amplitude.

July 11 - Sunday . After a stormy-night (tempora) . (Tosa Act 2)

- M. Sakai et al ... Confirmation of 330 keV electron line in $e^+ + Th$ interaction ---
(4458/92)
- M. Znojil , Nexto harmonic oscil. potentials --- $r^2 + r^3 + r^4$ ---
(4421/92)

- P. Ghose , D. Hume , G.S. Agarwal , Phys. Lett. A 153 (1991) 403 ; New Scientist 132 (1991) 30
Exp. Y. Mizobuchi --- , Phys. Lett. A (4417/92)



" discrete localized detection events pose (e.g. counts) do not necessarily imply particle-like propagation of the detected entities ; They can be regarded as due to the quantized energy levels of the detector . "

" The anticoincidence (12) for single photon in this state cannot be explained by classical wave-like propagation of the detected entity . It is only compatible with indivisible particle-like entity propagation " (I do not agree !)

Conclusion : Not mutual exclusiveness of particle and wave , but you need both . (OK !)

K. F. Nees --- Boltzmann Eq.

4401/92

$$(\partial_t + \vec{C} \cdot \nabla_{\vec{r}} + (\vec{\alpha} + \vec{C} \times \vec{\omega}) \cdot \nabla_{\vec{C}}) f(\vec{r}, \vec{C}, t) = -J(f)$$

$$\vec{\alpha} = e\vec{E}/m, \vec{\omega} = e\vec{B}/m. \text{ Identity } (\vec{C} \times \vec{\omega}) \cdot \nabla_{\vec{C}} = -\vec{\omega} \cdot \vec{L}, \vec{L} = \vec{C} \times \vec{V}_{\vec{C}}$$

$$\text{Expand. } f(\vec{r}, \vec{C}, t) = \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} f_m^{\ell}(\vec{r}, \vec{C}, t) Y_m^{\ell}(\vec{C})$$

$$\sum_{\ell'm'} \langle \ell m | \partial_t + \vec{C} \cdot \partial_{\vec{r}} + \vec{\alpha} \cdot \partial_{\vec{C}} - \vec{\omega} \cdot \vec{L} | \ell'm' \rangle f_{m'}^{\ell'}(\vec{r}, \vec{C}, t) = - \sum_{\ell'm'} \langle \ell m | J | \ell'm' \rangle f_{m'}^{\ell'}(\vec{r}, \vec{C}, t)$$

$$\text{Identify } \langle \ell m | \hat{O} | \ell'm' \rangle = \int Y_{m'}^{\ell'}(\vec{C}) \hat{O} Y_m^{\ell}(\vec{C}) d\vec{C} \quad \text{for any of the operators } \hat{O}$$

$$\langle \ell m | \vec{\omega} \cdot \vec{L} | \ell'm' \rangle = \sum_{\mu=-1}^{+1} \omega_{\mu}^l \langle \ell m | L_{\mu}^l | \ell'm' \rangle = \sum_{\mu=-1}^{+1} \omega_{\mu}^l \langle \ell m' | \mu | \ell m \rangle \sqrt{\ell(\ell+1)} \delta_{\ell\ell'}^l$$

$$L_{\mu}^l = \sum_{m_1, m_2} \langle 1m_1 1m_2 | \mu | \ell m \rangle C_{m_1}^l \otimes C_{m_2}^l$$

tensor coupling rule

$$[a^{\ell_1}, b^{\ell_2}]_m^l = \sum_{m_1, m_2} \langle l_1 m_1 l_2 m_2 | lm \rangle a_{m_1}^{l_1} b_{m_2}^{l_2}$$

July 18.

Table Talk in Münster: "Field or Matter: That's the question?"

- 1) we can eliminate A_μ in terms of matter current j_μ
i.e. make fields from particles (?)

- 2) Conversely make particles from fields; wavelets

Every light has a source. If there is no matter, there is no light \rightarrow no vacuum fluctuations, no zero point energy.
Support for this proposition: QED can be fully formulated in terms of sources and detectors alone.

But then what is the matter?

Positronium Hydride (PsH). D. M. Schrader et al., PRL 69, 57 (1992)

Binding energy $1.1 \pm 0.2 (see history)$

\rightarrow Positronium molecule (estimate $\pm \frac{1}{2}$) Ps_2, Ps_3, \dots

2+1 - dimensions.

Chern-Simons $L = (D_\mu \phi)^* (D^\mu \phi) + \frac{\theta}{4\pi^2} \epsilon^{\mu\nu\lambda} A_\mu \partial_\nu A_\lambda$

$$iD_\mu = i\partial_\mu - eA_\mu, \quad \epsilon^{012} = 1, \quad g_{\mu\nu} = (t, --)$$

$$\phi \rightarrow e^{i\chi} \phi, \quad A_\mu \rightarrow A_\mu - \partial_\mu \chi. \quad \rightarrow \text{Dirac}$$

$$j_\mu = i[(D_\mu \phi)^* \phi - \phi^* (D_\mu \phi)]$$

\rightarrow What is the corresponding particle theory - spinless and with spin

$$L = \int m \sqrt{\dot{x}^2} + \int e \dot{x}_\mu A^\mu \delta(x - x(s)) + \frac{\theta}{4\pi^2} \epsilon^{\mu\nu\lambda} A_\mu \partial_\nu A_\lambda$$

$$\frac{\theta}{4\pi^2} \left(\frac{\partial}{\partial x^\nu} (\epsilon^{\mu\nu\lambda} A_\mu) + \epsilon^{\mu\nu\lambda} \partial_\nu A_\mu \right) - e \dot{x}_\mu \delta(x - x(s)) = 0$$

$$\frac{d}{dt} \left(m \frac{\dot{x}_\mu}{\sqrt{\dot{x}^2}} + e A_\mu \right) = e A_{\nu, \mu} \dot{x}^\nu \quad \Rightarrow \frac{d}{dt} \ln \frac{\dot{x}_\mu}{\sqrt{\dot{x}^2}} = e f_{\mu\nu} \dot{x}^\nu$$

$$\underbrace{\epsilon^{\mu\nu\lambda} A_{\mu,\nu} + \epsilon^{\mu\nu\lambda} A_{\mu,\lambda}}_{2\epsilon^{\mu\nu\lambda} A_{\mu,\nu}} = \frac{4\pi^2}{\theta} e \dot{x}_\mu \delta(x - x(s)) ds$$

July 14.

- 1) The "H-atom as an antenna" calculation should implicitly contain (g-2)
look at the B-field produced by \vec{s} .
- 2) Do the same calculation for Landau-level: calculate B^{self} . (Havare, A)
- 3) look at the $nnnn$ -term in self energy!

e^+e^- Resonances:

J.R. Spence, J.P. Vary, Phys. Lett. B 254, 1 (1991)
" " " B 271, 27 (1991)

More References see M. Horbatsch preprint "Are there resonances - - - ?
H. Dohmen & H. Shahin, Int. J. Mod. Phys. A 6 (1991) 1031 - spikes

Localized solutions of $\Box g = 0$, wave equation on $S^3 \times S^1$.
then "boost" \rightarrow wavelets on $S^3 \times S^1$.

Geber (Freiburg i.Br.): Colloquium: Femtosecond Spectroscopy.
produce localized wave packets in excited states & then ionize them.

Chem. Phys. Letters 191 (1991) 639
Phys. Rev. Lett. 67, (1991) 3753

Pauli principle - Leibnitz principle (PIRON) - New book

Pauli principle for individual events, for wavelets of identical particles.

Dirac.

$$\psi_0(0) = e^{i \frac{mc^2}{\hbar} t} \mathbf{1}, \quad \psi(t) = e^{i \vec{p} \cdot \vec{x}} \psi_0(0) = U \psi_0(0)$$
$$i \hbar \partial_t \psi_0 = m \psi_0 \rightarrow (\gamma^\mu p_\mu - m) \psi(t) = 0$$
$$x' = U \times(0) U^{-1} = e^{i \vec{m} \cdot \vec{x}} x(0) e^{-i \vec{m} \cdot \vec{x}} \stackrel{?}{=} \vec{x} + \vec{\omega} t$$

equation $i \hbar \frac{\partial}{\partial t} f = \vec{v} \cdot \vec{\nabla} f + \lambda x^2 f$ can be solved

$$f \sim f(0) e^{i \omega t} e^{\frac{1}{3} (\vec{\omega} \cdot \vec{x} - \lambda_i x_i^3)}$$
$$\omega_i = \omega/v, \lambda_i = \lambda/v$$

$$i \hbar \dot{\psi}_{,t} = -\frac{\hbar^2}{2m} \Delta \psi + U \psi$$

Define $X_\mu = \begin{pmatrix} -i \hbar \dot{\psi}_{,t} \\ -\frac{\hbar^2}{2m} \psi_{,ii} \end{pmatrix}$

then $X_\mu{}^\mu = -i \hbar \dot{\psi}_{,t} \neq \frac{\hbar^2}{2m} \psi_{,ii}$

$$X_\mu{}^\mu + V_\mu X^\mu = 0 \quad V_\mu = (U, 0, 0, 0)$$

$\int dx \psi^\dagger i \partial_t \psi$ is invariant under a global $\psi \rightarrow e^{iS} \psi$

Now make $S = S(t)$: To preserve invariance we add an H

$$\psi \rightarrow e^{iS(t)} \psi, H \rightarrow e^{iS} H e^{-iS} + i U \partial_t U^{-1}, U = e^{iS}$$

so $\int dx \psi^\dagger (i \partial_t - H) \psi$ is now invariant under $\psi \rightarrow U \psi$
 $H \rightarrow U H U^{-1} + i U \partial_t U^{-1}$

In particular, find U such that $H' = 0$

$$U H U^{-1} + i U \partial_t U^{-1} = 0 \quad \text{special case } [U, H] = 0 \Rightarrow H + \frac{\partial S}{\partial t} = 0$$

Hamiltonian

$p \dot{q} - H$ is not invariant under $p \rightarrow p, q \rightarrow q + vt$.

So add H_P such that $p \dot{q} - H$ is when $H \rightarrow H + p v = H + \frac{p^2}{m}$ (factor $\frac{1}{2}$?)

$$p \dot{q} - H \rightarrow p \dot{q} + p v - H - p v = p \dot{q} - H$$

$$\bar{\psi} \gamma^\mu i\partial_\mu \psi$$

$$\psi \rightarrow \gamma_2 \psi, \quad \psi^t \rightarrow \psi^t \gamma_2^t, \quad \bar{\psi} = \bar{\psi}^t C$$

$$\begin{aligned}\psi^t \gamma_2^t C \gamma^\mu i\partial_\mu (\gamma_2 \psi) &= \bar{\psi}^t C \underbrace{\gamma_2^t \gamma_2}_{\gamma_2^{-1}} C \gamma^\mu i\partial_\mu \psi + \gamma_2 i\partial_\mu \psi \\ &= \bar{\psi} \underbrace{\gamma_2^{-1} \gamma^\mu \gamma_2}_{\cancel{\gamma_2}} i\partial_\mu \psi + \bar{\psi} (\gamma_2^{-1} \gamma^\mu i\partial_\mu \gamma_2) \psi\end{aligned}$$

Now take

$$\begin{aligned}\bar{\psi} \gamma^\mu (i\partial_\mu - A_\mu) \psi &\quad , A_\mu \rightarrow A_\mu + \theta_{,\mu} \\ \rightarrow \bar{\psi} (\gamma_2^{-1} \gamma^\mu \gamma_2 i\partial_\mu + \gamma_2^{-1} \gamma^\mu (i\partial_\mu \gamma_2)) \psi - \bar{\psi} \gamma_2^{-1} \gamma^\mu (A_\mu + \theta_{,\mu}) \gamma_2 \psi\end{aligned}$$

July 19.

- EB Berdnikov et al ... Rigid string, passage to ∞ -comp. wave Eq.
Hamiltonian, etc... 4486/92, 4487/92
cf. also Sov. J. Nucl. Phys. 54 (1991) 763; 55 (1992) 203
- TH Cho, KL Ng --- 2-component spinors for graviton (spin 2) diagrams. 4493/92
- C. Latourre et al. 4539/92; For an $su(2)$ triplet massive vector boson \tilde{W}^μ
with
$$\mathcal{L}_0 = -\frac{1}{4}(\tilde{W}_{\mu\nu})^2 + \frac{1}{2}(m_W W^\mu)^2$$
$$\mathcal{L}_{int} = \frac{1}{2}g_1 \tilde{W}_{\mu\nu} \cdot (\tilde{W}^\mu \times \tilde{W}^\nu) - \frac{1}{4}g_2 (\tilde{W}^\mu \times \tilde{W}^\nu)^2 + \frac{1}{4}g_3 (\tilde{W}_\mu \cdot \tilde{W}_\nu)^2$$
Schrödinger invariance of the S-matrix implies $g_1^2 = g_2, g_3 = 0$, i.e. Yang Mills.
Note: massive vector meson propagator
- Rajan Gupta, Scaling, Renormalization group--- (Los Alamos) 4558/92
- (2+1)-dim. QED : T. Appelquist et al ... PRD 29, 2423 (1984)
,, 33, 3774 (1986)
- Arnold's cat :
$$(x'_1, x'_2) = (x_1 + x_2, x_1 + 2x_2) \pmod{1}$$
 (2-torus)
What is the quantum analogue ? J. Ford et al Physica D 50, 493 (1991)
St. Bergot, Z. Phys. B 80, 3 (1990)
R. V. Mendes, J. Phys. A 24 (1991) 4349 --- (4589/92)
- GN Afanastiev ... Electrical solenoids (subm. J. Phys. A) 4606/92
(earlier work, J. Phys. A 23, 5755 (1990)) ---
- S.V. Shabanov, Gauge invariant classical ED, (subm. J. Phys. A) 4608/92
- LV. Prokhorov, ... String-like excitations in QED 4616/92
(Modern Phys. Letters A)
they are unstable ...
→ construct (string-like wavelets) →
$$Q(\vec{x}, t) = \int dy \tilde{D}(\vec{x}-\vec{y}, t) \tilde{J}(y), D = \frac{\epsilon(t-t')}{2\pi} \delta((\vec{x}-\vec{y})^2)$$

22 July, Wednesday, Trieste

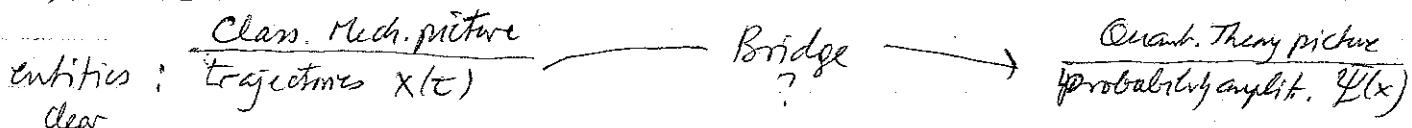
Talk on workshop "From Classical to Quantum Chaos" or
"New Method of Classical - Quantum Chaos Correspondence".

24 July, Friday, München.

Talk at the MPQ - Summer Festival on
"There are two quantum Mechanics - Not one!"

- 100 years ago e has been introduced in cathode rays as a particle. Had it been introduced as a wave we wouldn't have the problem of quantization - it would be just a classical wave theory. Ever since we are forcing in our minds the electron to be a particle, which is not, and see that it doesn't work, e.g. uncertainty principle, etc. But ~~of~~ the problem is really what is an electron?
If it is a wave it must be a special kind of wave because of its localization and extraordinary stability.

Thus we have



A bridge is missing, because the passage from $\Psi(x)$ to $x(t)$ is subtle, and not just to $\rightarrow 0$.
A clear bridge is provided by ~~the~~

The (original) Wave Mechanics (Quant. Theory of Single) Events

The entities here are :

"wavelets"

localized real oscillating

nonspreading solutions of wave Eq's

which move like massive particles

with v/c .

We will do mechanics with these wavelets, bouncing them back and forth like billiard balls, hence the name wave mechanics, but not according to the laws of Newton, but according to the laws of wave equations.

Now the bridge is clear. Class. picture appears immediately as the motion of the center of mass of the wavelets (Newton's equations derived from wave Eq.) or the limit $S \rightarrow \infty$.

And the probability amplitudes arise as averages over the parameters of the wavelets.

24 July, München.

Talks with Jabs and Jan Seide.

J. Winter

Reischhauer / ↗ 2-body problem on S^3 . PRD 32, 1871 (1985)

self field QED and Bell's inequalities.

Party at MPQ : Mulser, Becker, ~~Mash~~ Hilary, Khalatnikov, Glauber, ...

23 July ; Party chez Walter : Schwinger's, Lamb, Harry Paul, Scully, Schleich, Agarwall, Lorenzo , Birula

Wünsche, TOSA A, Sept. or Oct. 1989

Group theory of Paraxial Approx. of wave Eq.

M. J. Duncan, The Cosmological Constant Mystery. Univ. Minnesota-74-105, 92
(to be published in Electroweak Int's and Unified Theories, ed. J. Tran Than Van
Editions frontières (1992))

Exp. energy density $< 10^{-47} \text{ GeV}^4$. Theories give 54, 110, 123 orders larger.

"We are in serious need of some understanding why the vacuum is so empty"

-- we do not have a firm grasp of how gravity and quant mechanics
relate to each other.

• either need a deeper theory of both GR and QFT in which $\Lambda = 0$
automatically

→ • or, "we have missed something quite obvious. The cosmological constant
is telling us that in developing our theories this century we inadvertently
imposed too many conditions on them, some of which are too restrictive"

Poincaré group in 2+1-dim's. Wave Eqs for Anyons

R. Jackiw et al PR D 43, 1933 (1991)

M.S Plyushchay, Phys. Lett. B 273, 250 (1991)

Y. Ohnuki

Chang G. Han (Korea); 4641/92.

Wehrhahn, Cooper, DESY 92-072 (4565/92)

$$(-r\frac{d^2}{dr^2} + \frac{\ell(\ell+1)}{r} + \frac{z^2}{n^2}r^2)\psi = z\psi.$$

$$W_1 = (\frac{z}{n})r, W_3 = (\frac{z}{n})^{-1} \left(-r\frac{d^2}{dr^2} + \frac{\ell(\ell+1)}{r} \right), [W_1, W_3] = 2iW_2 = 2r\frac{d}{dr}$$

$$T_1 = \frac{1}{2}(W_3 - W_1), T_2 = W_2, T_3 = \frac{1}{2}(W_3 + W_1)$$

$$[T_1, T_2] = -iT_3, [T_2, T_3] = iT_1, [T_3, T_1] = iT_2$$

$$C_2 = T_3^2 - T_1^2 - T_2^2 = \ell(\ell+1), T_3\psi = n\psi = (n_r + \ell+1)\psi$$

$$A^\dagger(\ell) = \frac{d}{dr} - \frac{(\ell+1)}{r} + \frac{2}{\ell+1}, A(\ell) = \frac{d}{dr} - \frac{\ell(\ell+1)}{r} + \frac{2}{\ell+1}$$

$$A(\ell)\psi_{0,\ell} = 0, A(\ell)A^\dagger(\ell) = -\frac{d^2}{dr^2} + \frac{(\ell+1)(\ell+2)}{r^2} - \frac{2\ell}{r} + \frac{2\ell}{(\ell+1)^2} = A^\dagger(\ell+1)A(\ell+1) + 2\Delta E_{1,\ell}$$

$$A^\dagger(\ell)A(\ell)\psi_{n_r+1,\ell} = 2(E_{n_r,\ell} - E_{0,\ell})\psi_{n_r,\ell}$$

→ Supersymmetry of the full H , not just the radial one!

$$\text{Morse: } (-\frac{d^2}{dr^2} + \lambda^2 e^{-2y} - 2\lambda^2 e^{-y} + (\lambda - v - \frac{1}{2})^2) \psi_{v,\lambda} = 0$$

$$(e^{-y}\frac{d^2}{dy^2} + (\lambda - v - \frac{1}{2})^2 e^y + \lambda^2 e^{-y}) \psi_{v,\lambda} = 2\lambda^2 \psi_{v,\lambda}$$

$$W_1 = \lambda e^{-y}, W_3 = \lambda^{-1} \left(-e^{-y}\frac{d^2}{dy^2} + (\lambda - v - \frac{1}{2})^2 e^y \right), [W_1, W_3] = 2iW_2 = 1 - 2\frac{d}{dy}$$

$$T_3 \text{ as above. } \rightarrow T_3 \psi_{v,\lambda} = \lambda \psi_{v,\lambda}. C_2 = (\lambda - v - \frac{1}{2})^2 - (\frac{1}{2})^2.$$

$$r \rightarrow e^{-y} \Rightarrow \left[-\frac{d^2}{dr^2} + \frac{(\lambda - v)(\lambda - v - 1)}{r^2} - \frac{2\lambda^2}{r} + \lambda^2 \right] \psi_{v,\lambda} = 0. \text{ Radial Coulomb-like}$$

J.H. Robbins, M.V. Berry, The geometric phase for chaotic systems

Proc. R. Soc. London (A) 1992, 438, 631 ff

T. Sawada, Bound-states of the Nucleon-Monopole system

$$H = \frac{1}{2M} (\vec{p} - e\vec{z}\vec{A})^2 + V(r) - K_{\text{tot}} \frac{eq}{2M_p} \frac{\sigma \cdot \hat{r}}{r^2}$$

Dipole form factor corresponds to a potential $\tilde{G}(r) = K_{\text{tot}} \frac{a^3}{8\pi} e^{-ar} \cdot \delta(r)$ limit

replace last term by $-\frac{1}{r^2} \frac{b(r)}{2M_p} (\vec{\sigma} \cdot \hat{r})$, $b(r) = b(1 - e^{-ar}(1 + ar + \frac{a^2 r^2}{2}))$

Monopole harmonics are related to Wigner-Racah-Letts functions D^l_j
the system is like a rigid body.

$$\vec{L} = \vec{r} \times (\vec{p} - e\vec{z}\vec{A}) - \mu \hat{r}$$

~~~~~

1) Take ground-state wave  $f_h$ ; e.g.  $\chi = r^{l+1} e^{-\alpha r} = e^{-W/h}$

2) hence  $W = \alpha r - (l+1)\ln r$ ,  $W' = \alpha - \frac{l+1}{r}$ ,  $W'' = \frac{l+1}{r^2}$   
 $\frac{1}{2m}(W'^2) - \frac{\hbar^2}{2m}W'' - \frac{1}{2}\alpha^2 = -\alpha \frac{(l+1)}{r}$

But take  $V = \frac{1}{2m}(W'^2)$  alone, and use B-Sommerfeld  $\int dx \sqrt{2m(E_n - \frac{1}{2m}W'^2)} = n_r \pi \hbar$   
You get no exact spectrum for shape  
indep. potentials

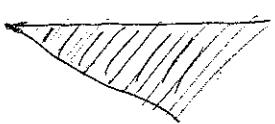
M. Kibler et al ... H-oscillate-connection ..  
J Math Phys 27, 154 (1986)

R W Ziolkowski, A path-integral-Riemann space Approach to  
electromagnetic wedge diffraction

J. Math. Phys. 27, 2271 (1986)

field point

• source point



Double the space with  
image ~~source~~ point (Riemann  
surface)

L'équation de Augustin Fresnel.

Thèse de diplôme de C. Piron (1955) : La formule de Fresnel est fausse  
diffraction de demi-plane

Coordinate-free diffusion eq. on a manifold. J. Math. Phys. 27, 1646 (1992)

$$\frac{\partial \rho}{\partial t} = \partial_\mu \left\{ \left[ -F_\mu - kT \left( \frac{1}{\sqrt{g}} \right) \partial_\nu (\sqrt{g} g^{\mu\nu}) \right] \rho \right\} + \partial_\mu \partial_\nu (kT g^{\mu\nu} \rho)$$

drift force.

H. Rumpf, Grassmannian path integral of the Dirac propagator  
J Math Phys 27, 1649 (1992)

E.G. Kalnins, W. Miller, Jr. Separation of variables on  $S^n$  --- Proc. Roy. Soc.  
J Math Phys 27, 1721 (1986); also 1893. ~~NOV. 1992~~

$$\text{for Helmholtz Eq. } \Delta_n \Psi = \frac{1}{\sqrt{g}} \frac{\partial}{\partial x^\mu} (\sqrt{g} g^{\mu\nu} \frac{\partial \Psi}{\partial x^\nu}) = \lambda \Psi$$

K. Takayama, JMP 27, 1747 (1986)

$$X'' + (q_1(t) + \lambda q_2(t)) X = 0 \rightarrow \text{transform into class of solvable eq's -}$$

(Zero eigenvalue eq.)

G. Emch, G.C. Hegerfeldt, JMP 27, 2731 (1981)

Thm: If 2-particles C.o.m. is in a coherent state, then each particle is also in a coherent state, centred around positions in phase space predicted by the classical theory. ("Thermal coherent states")

B. Cordani, JMP 27, 2921 (1986)

→ Rederivation of the Barut-Bornzin Refor. for Monopole-dyn.

L. Chetouani, T.F. Hammam, Coulomb's Green f.n. (N-dim)  
JMP 27, 2945 (1986)

→ John Rawlsley, Lett. math. Physics

Plan d'un livre "Physique Théorique" avec PIRON.

Longitudinal and transverse potentials:  $\vec{A} = \vec{A}_T + \vec{A}_L$  (is it corr?)

Can you write it in covariant 4-component notation?

Poincaré (voir Oeuvres Complètes --)

For the motion of two magnetic dipoles interacting total momentum

$\vec{P}$  = const., but the center of mass  $\vec{R} = \frac{m_1 \vec{r}_1 + m_2 \vec{r}_2}{m_1 + m_2}$  does not move  
on a straight line!

I can write the motion of Dirac dipoles,

$$H = \alpha_1 \cdot (\vec{p}_1 - e_1 \vec{A}_{21}) + \frac{1}{2} e_1 (A_{21}^0)$$

$$H = \alpha_2 \cdot (\vec{p}_2 - e_2 \vec{A}_{12}) + \frac{1}{2} e_2 (A_{12}^0)$$

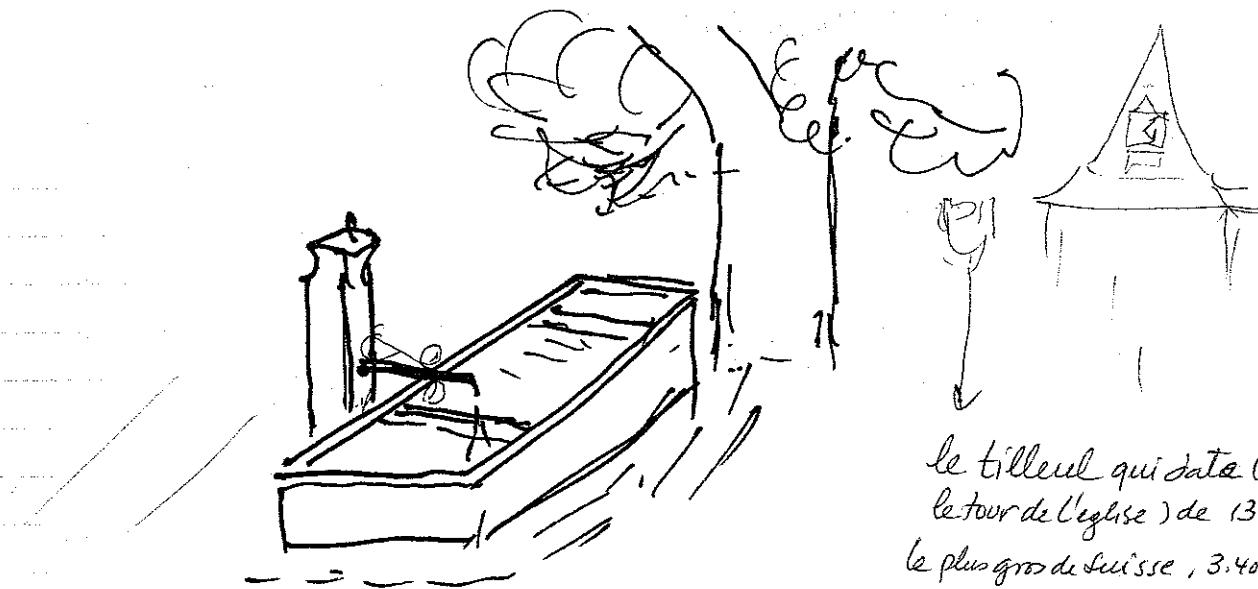
$$\vec{A}_{21} = e_2 \frac{\vec{\alpha}_2}{r}, \quad \vec{A}_{12} = e_1 \frac{\vec{\alpha}_1}{r}, \quad A_{21}^0 = \frac{e_2}{r}, \quad A_{12}^0 = \frac{e_1}{r}$$

+ plus anomalous magnetic terms - -

→ Now take the Schrödinger and classical limits.

"velocity" is not an observable in the sense of a property at a given time, like position or momentum; velocity measures the change of a quantity on average between two Hilbert spaces at  $t_1$  and  $t_2$ . Then it is not surprising that Dirac velocity  $\vec{\alpha}$  has eigenvalues  $\pm c$ , or magnitude  $\sqrt{3}c$ .

$$x(t) = x(0) + \frac{1}{m} p(0) t \quad \rightarrow x(t_1), x(t_2) \text{ do not commute!}$$



le tilleul qui date (comme  
la tour de l'église) de 1380.

le plus gros de Suisse, 3.40m = d  
 $2\pi r \approx 10.20\text{ m.}$

### Marchissy . Hôtel de Commune . La nuit de 28 Juillet .

Les cloches des vaches le matin - - - (35 Frs. avec déjeuner)

29 Juillet : Marcher de Marchissy à Begnac (1hr.)

Plage de Partenouex(?) avec Piron's - Nage dans le lac de Léman  
déjeuner -

### Misadventures with trains.

1) Going to Münich from Mestre. I take the Münich car on the next platform. Put my baggage in a first class car, looking for the Couchette - man back and forth when I am outside the train starts to leave, I run to open the door. The conductor on the platform pull me back shouting "in coda, in coda" - I says "ma il n'a valigge time in treno" - he shouts back "in coda, in coda" finally I understand that another Münich car will be attached at the back "in coda" Then I ask "Non sapere che ci sono due treni per Monaco" "No, lui mi dice, solo uno" and then I understand that my baggage will be back "in coda" -- No need to go to the 'lost and found' in Münich tomorrow morning in Münich, as I had quickly thought.

2) 29 July in Geneva waiting to take the 10<sup>58</sup>-Symphon express to Trieste. Decide to go to Airport to take train a bit earlier there. There I hear a loudspeaker that something will be 1h hr. late, and stupidly conclude that it is my train, confirmed by another conductor. Decide to return to Geneva, indecision... In Geneva, no sign for a delay. Return to Airport. Unfortunately the 22<sup>40</sup> arrives in Airport, ~~arrives~~ a bit late, as the Symphon Express leaves - Return to Geneva. Hotel Astoria, Str. 80 - not much sleep or what stupidity, indecision! mad at myself -

Next morning up 6<sup>15</sup>. Stupid Receptionist says train is at 638. It was 648 miss coffee. What a night and day. Wore travel still not used to travelling

$$\text{in } \mathbb{R}^3: \quad A = A_1 + A_2 \quad \exists \quad dA = dA_1, \quad dA_2 = 0 \quad (\text{curl } A_2 = 0), \quad A_2 \parallel$$

$$*A = *A_1 + *A_2 \quad \exists \quad d^*A = \delta A = \delta A_2, \quad \delta A_1 = 0 \quad (\text{div } A_1 = 0), \quad A_1 \perp$$

$$\text{in } \mathbb{R}^4: \quad A = A_1 + A_2, \quad dA = dA_1, \quad dA_2 = 0 \Rightarrow A_2 = d\lambda \quad (\text{pure gauge field})$$

$$*A = *A_1 + *A_2, \quad d^*A = \delta A = \delta A_2, \quad \delta A_1 = 0 : \quad \epsilon_{\mu\nu\lambda\sigma} A_{\lambda\sigma} \stackrel{\downarrow}{=} A_{\mu}^{\lambda} \quad = A_{\mu}^{\lambda} = 0$$

$$\delta d\lambda = 0 \Rightarrow D\lambda = 0$$

$\therefore A_1$  is a potential satisfying  $A_{\lambda}^{\mu} = 0$  and  $A_2$  is a pure gauge.

$$A_\mu = \int dy D(x-y) j_\mu, \quad A_\mu^{\lambda\mu} = \int dy \partial_\mu D(x-y) j_\mu = - \int dy D(x-y) j_\mu^{\lambda\mu} = 0$$

that was already used in writing the first eq.

$$A_\mu = (A \cdot n) n_\mu + A_\mu^T, \quad A_\mu^T \cdot n^\mu = 0, \quad A_\mu^T = A_\mu - (A \cdot n) n_\mu$$

$$A_\mu A^\mu = (A \cdot n)^2 + A_\mu^T A^\mu_T$$

$$A_\mu^T = \int dy D(x-y) j_\mu^T, \quad j_\mu^T = \bar{\psi} \gamma^T \psi = - \bar{\psi} \gamma_n \psi + \bar{\psi} \gamma_\mu \psi = - \psi^\dagger \psi + \bar{\psi} \gamma_\mu \psi$$

$$n = (1000) \rightarrow j_\mu^T = 0, \quad A_\mu^T \text{ is pure longitudinal.}$$

$$j_\mu^T = \bar{\psi} \gamma_\mu \psi \quad j_\mu \parallel = \psi^\dagger \psi = \psi^\dagger \psi (1000)$$

Lienard-Wiechert pot.  $A_\mu = e \frac{u_\mu}{R}$ ,  $n_\mu = u_\mu$ , pure longitudinal if  $n$  is chosen to be in the direction of velocity  $u_\mu$  at  $s = s_0$

If we choose a different  $n$ :

$$A \cdot n = e \frac{u \cdot n}{R}, \quad \cancel{u} \cdot u^\mu = (u \cdot n) n^\mu + u_T^\mu$$

$$u^2 = (u \cdot n)^2 + u_T^2$$

$$F = dA = d(A \cdot n)n + A_T$$

$$= \cancel{e}((A \cdot n)_\nu n_\mu - (A \cdot n)_\mu n_\nu) + F_{\mu\nu}^T \quad \left| \begin{array}{l} \text{one can also make } n \text{-x-dependent} \\ n = n(x) \end{array} \right.$$

$$= A_{\lambda\nu}^\lambda n_\lambda n_\mu - A_{\mu\nu}^\lambda n_\lambda n_\nu + F_{\mu\nu}^T$$

A Chakrabarti, N.C. 56A, 604 (1968)

(squared) Dirac-Pauli Eq. in extn. plane waves.

- The Quantum C. Neumann problem: AJ Macfarlane, DAMTP 92-38. 4791/92  
particle confined on  $S^{N-1}$ :  $(-\frac{1}{2}\Delta + U_1 + U_2)\Psi = 0$

$$U_1 = \frac{1}{2} \sum_k \alpha_k x_k^2, \quad U_2 = \frac{1}{2} \sum_k \alpha_k^2 \left( \frac{1}{x_k^2} - 1 \right).$$

Classically:  $H = \frac{1}{4} \sum_{k \neq l} J_{kl}^2 + U_1 + U_2, \quad J_{kl} = x_k y_l - x_l y_k$   
integrable!

O. Yu. Meklin, Non-topological solitons - Review ITEP 92-43. (4777/92)

- B. Holstein, Electromagnetic polarizabilities of Nucleus:  
(Univ. Mass., Amherst, MA 01003) — Non-relat. quark model fails

$$\bar{\alpha}_E^n = (12.3 \pm 1.5 \pm 2.0) 10^{-4} \text{ fm}^3 \quad \bar{\beta}_M^n = (3.5 \pm 1.5 \pm 2.0)$$

$$\bar{\alpha}_E^P = (10.9 \pm 2.2 \pm 1.4) \quad \bar{\beta}_M^P = (3.3 \pm 2.2 \pm 1.4)$$

c.f. PR D13, 2075 (1976)      Comments Nucl. Part. Phys. 20, 301 (1992)

$$\Box u = 4u(1-u^2). \quad \text{B.C.:} \quad u(r,t) = 0, r \rightarrow \infty$$

$$|u(r,t)| < \infty, r \rightarrow 0$$

$$\text{initial cond. } u(r,0) = \tanh(\sqrt{2}(r-r_0))$$

$$u'(r,0) = 0. \quad \mathcal{L}(u) = \frac{1}{2} (\partial u)^2 - (u^2 - 1)^2$$

If it is regarded as an effective  $\mathcal{L}$  for  $R(t)$ :  $\mathcal{L}(R) = -4\pi \mu R^2 (1 - \dot{R}^2)^{1/2}$

$$\therefore \ddot{R} = -2(1 - \dot{R}^2)/R$$

oscillating bubble.

$$\text{solution } R(t) = R_0 \operatorname{ch}(\sqrt{2}t/R_0, 1/2)$$

$$C_n(x, 1/2) = \text{ellipt. funct. } n^2 = 1/2.$$

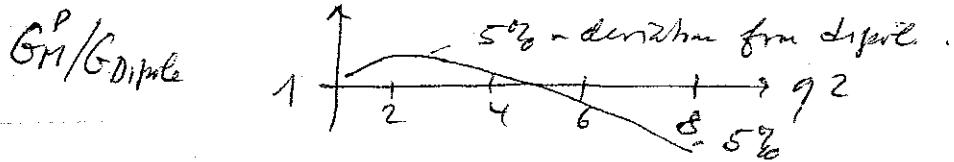
Aug. 2

Supersymmetry of Ztbmp.

How to factorize  $\mathcal{H} = \bar{Z}g\gamma^2\pi_\mu = Q\bar{Q} + \bar{\Phi}\Phi$  ?

PROTON Form Factors ; SLAC-PUB-5744 , Febr. 1992  
from  $Q^2 = 1.75 - 8.83 (\text{GeV}/c)^2$ .

$G_E^{\text{Prot}}$  fits very well with dipole form factor



Unruh effect : F. Hinterleitner , Wien preprint 1991

The information for double-slit interference is already  
in the Green's function for double-slit !

$$\psi(f) = \int K(f, i) \psi(i)$$

$$\sum_a \psi(f, a) = \int K(f, i) \sum_a \psi(i, a)$$

$$\therefore \psi(f, a) = \int K(f, i) \psi(i, a)$$

M. Baker, Ball, F. Zachariasen , QCD based spin-orbit potentials between  
heavy quarks  
Phys. Lett. 283B , 360 (1992)

$\gamma$ -magnetic Moment ; Phys. Lett. 285B , 364 (1992)  
 $\leq (5.4 \pm 1.4) 10^{-10} \mu_0 \}$  " " 376 " GALLEX  
390 " Results

## Aug. 8. Getting Ready to Lectures at ICTP on Aug. 17-18 "Surprises in Physics"

Surprise 1. Can light travel with velocity  $v < c$  ? (or  $v > c$ )  
(wavelets)

# 'far-reaching Unexpected Consequences : Origin of mass ; Origin of quantum phenomenon AND BOUND-STATES OF LIGHT WITH MATTER

## AND BOUND-STATES OF LIGHT WITH MATTER

Surprise 2. Can you make a fermion out of 2 bosons ?

(Dyons)

Origin of spin, Symmetric QED, No new coupling constant!

Surprise 3. Does electromagnetism become strong at short distances ?

1st generation )

Unexpected consequences: New Resonance states

} Clausius interaction  
 } Charge-dipole system

## Surprise 4. The $\mu$ -meson (and $\tau$ )

Surprise 5. Can you have an extended electron with finite self-energy?

(shell)

and no new ~~topping~~ cost size parameter.

Surprise 6 . Will a tachyon leave a track in the bubble chamber ?

(thickm)

Surprise 7 . Can you model spin as a top ?

(Magnetic top)

Surprise 8 . Can you build all matter out of e and ν ?

→ Realization of quark model and standard model by physical particles.

Surprise 9 : Is parity and T conserved after all ?

Aug. 10,

Maryland prep. 92-241

O. W. Greenberg : "Color: From baryon spectroscopy to QCD" (history)

(I conclude by emphasizing that a full understanding of hadrons based directly on the Lagrangian of QCD is still lacking...")

Surprise 10: Can a uniformly moving charge radiate?

In medium, yes. (Cronin). Singularity of the L-W-potential!

$$A_p = c \frac{u_p}{R}, R = (x - x(t_0)) \cdot \dot{x}(t_0) = (t - x^0(t_0)) u^0 - (\vec{x} - \vec{x}(t_0)) \cdot \vec{u}$$

→ Radiation Reaction for Pauli-Coupling - see A. ALAN's thesis --- (?)

Surprise 11. The Dirac Eq. Itself!

→ cf. F. Salzmann, The gravit. field of a freely moving charge  
N.C. 24B, 157 (1974)

Surprise 12. Are there photons?

Do you have to quantize the EM-field?

Surprise 13. Schrödinger eq. without  $\hbar, e, m$

Aug. 11

"Cold fusion" alive in JAPAN, ... Akito Takashashi, Osaka, Eng.  
cf. SCIENCE, 257, 24 July, 474 ; 24 April, p. 438

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P. Hillion, -- Courant-Hilbert Solutions of wave Eq. in 2 and 3-dim.  
J Math Phys. 33, 2749 (1992).

YD Han et al -- Aharonov-Casher effect, Phys. Letters A 167, 341 (92)

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R-Lenz Vector:

Class. Mech.  $\vec{A} = \frac{1}{m} \vec{p} \times \vec{L} - \frac{e^2}{r} \vec{r}$

Proof:  $\vec{A} = \frac{1}{m} (\vec{p} \wedge \vec{L} + \vec{p} \wedge \vec{L}) + \frac{e^2}{r^2} \vec{r} \times \vec{r} - \frac{e^2}{r} \vec{r}$   
 $= \frac{1}{m} \left( -\frac{e^2}{r^3} \vec{r} \wedge (\vec{r} \wedge \vec{p}) \right) + \frac{e^2}{r^3} (\vec{r} \cdot \vec{r}) \vec{r} - \frac{e^2}{r} \vec{r}$   
 $= -\frac{e^2}{r^3} (\vec{r} \wedge \vec{r} \wedge \vec{r}) + \frac{e^2}{r^3} (\vec{r} \cdot \vec{r}) \vec{r} - \frac{e^2}{r^3} (\vec{r} \cdot \vec{r}) \vec{r}$

Quant. Mech  $\vec{A} = \frac{1}{2m} (\vec{p} \times \vec{L} - \vec{L} \times \vec{p}) - \frac{e^2}{r} \vec{r}$

$$\vec{A} \cdot \vec{L} = \vec{L} \cdot \vec{A} = 0, \quad A^2 = e^4 + \frac{24(L^2 + \hbar^2)}{m}$$

$$[A_i, A_j] = i\hbar \left( -\frac{2\hbar}{m} \right) \epsilon_{ijk} L_k$$

$$\vec{K} \equiv \sqrt{\frac{m}{24}} \vec{A} \quad \text{then} \quad [K_i, K_j] = i\hbar \epsilon_{ijk} L_k$$
$$[K_i, L_j] = i\hbar \epsilon_{ijk} K_k$$
$$[L_i, L_j] = i\hbar \epsilon_{ijk} L_k$$

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Books: E. Collett, Polarized Light, 1992, Marcel Dekker, Inc.

V. L. Ginzburg, Applications of electrodynamics & Theor. Physics 8A  
Gordon & Breach, 1989

M. Abe, N. Nakanishi : (Perturbative) solution of operator equations  
of QED in Heisenberg picture.

(cf. Progr. Theor. Phys. 87, 495, 757 (1992) & earlier papers)

$$\mathcal{L} = -\frac{1}{4g^2} F_{\mu\nu} F_{\mu\nu} + B \partial^\mu A_\mu + \bar{\psi}(iD-m)\psi \quad ; \quad D = \partial^\mu (\partial_\mu - iA_\mu)$$

Landau gauge.

$$\rightarrow \square A_\mu = g^2(\partial_\mu B + j_\mu), \quad j_\mu = -\bar{\psi}\gamma_\mu\psi$$

$$\partial^\mu A_\mu = 0, \quad \square B = 0, \quad (iD-m)\psi = 0$$

+ Equal time commut. relations..

Pauli-Jordan D-function is defined by the Cauchy problem:

$$\square_x D(x-y) = 0, \quad D(x-y)|_0 = 0, \quad \partial_x D(x-y)|_0 = -\delta^3(x-y)$$

Solution:  $D(x-y) = -(2\pi)^{-1} \epsilon(x^0-y^0) \delta((x-y)^2).$   $|_0$  means  $x^0=y^0$

$S(x,y)$  is defined by the following Cauchy problem

$$(iD-m)_x S(x,y) = 0, \quad S(x,y)|_0 = -i\delta^0 \delta^3(x-y)$$

$$\text{or } (i\partial^\mu \partial_\mu - m)_x S(x-y) = 0$$

Relativistic form of  $\omega$  for spinless particle.

$$\omega = p \dot{q} - \sqrt{p^2 + m^2} - V(q)$$

$$\dot{p} = -\nabla V$$

$$\dot{q} = \frac{p}{\sqrt{p^2 + m^2}}$$

is equivalent to  $L = -m\sqrt{1-v^2} - V$

$$\frac{d}{dt} \left( \frac{mv}{\sqrt{1-v^2}} \right) = -\nabla V$$

$$H = \frac{mv^2}{\sqrt{1-v^2}} + m\sqrt{1-v^2} + V$$

$$= \frac{m}{\sqrt{1-v^2}} + V, \quad v = \frac{p}{\sqrt{p^2 + q^2}}$$

Aug. 15 (Ferragosto!) lost one shoe on the rocks after swim Aug. 13)

With Ray:

Rep's of conformal group on the 8-dim. homog. space  $\mathcal{D}$

$f(X, Y; Z) -$  special cases  $f_a(\text{const. const. } Z)$  or  $f(XY, Z = \infty)$

Identify  $Z$  with the spacetime  $S^3 \times S^1$

$X, Y$  dynamical spin variables

Together space + internal variables.

\* Study reduction of Lie algebra to special cases.

\* Relation betw. the Lab-algebra<sup>basis</sup> and  $E_{ij}$ -basis.  
Check the  $SO(8) \rightarrow SU(4)$  isomorphism on the Lie algebra level.

### Questions

1) On action of the conformal group on  $S^3 \times S^1 / \mathbb{Z}_2$ ,

What is the action of  $e^{iP_0\theta}$  and  $e^{iL_{56}\theta}$ ?

There are two "times" (legal).  $\theta$  is periodic,  $S^1$ .

Is time corresponding to  $P_0$  periodic? probably no

2) Two ways of introducing  $S^3 \times R$

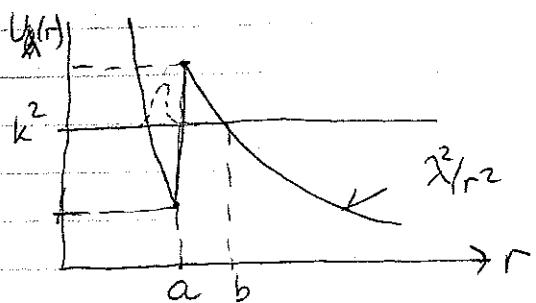
a)  $R$  as a covering group of  $S^1$

b) directly from the  $R^{4,1}$  subgroup of the cone  $\eta^a \eta_a = 0$

3) How does the conformal group act on  $\mathfrak{so}(S^3 \times R)$

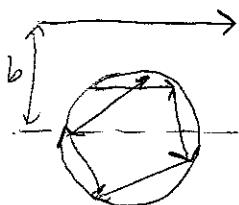
Aug. 16 Sunday

Reading H.M. Nussenzweig. Mie Scattering.



partial wave potential.

$\frac{2r}{r^2}$  + squarewell  
attractive



Complex angular momentum.

→ Do the same thing for spin  $1/2$ -particles, or for neutrinos

H.M. Nussenzweig, Causality and Disp. relations, Academic 1972

" Diffraction effects in semi-class. Scatt., Cambridge 1992,

→ Approximate magnetic interactions by a square-well, instead of  $\delta(r^2)$ !

Flux tubes (strings - em) in superconductors

F. Kusmatcu Phys. lett. A 169 Sept. 1992

J.C. Varille, et al The Moyal repr. for spin

Ann. of Physics 190, 107 (1989)

Nature, Aug 1992

(observed)

Positive energy bound state in periodic lattice.

J.V. Neumann, E.Piaggio, potential, Phys. Zeit. 30, 465 (1929). (Collected papers)

Ex. 1):  $V = \frac{2}{r^2} - 9r^4$ . There is a discrete eigenvalue  $E=0$ , with  $\psi_0 = \frac{\sin(r^2)}{r^2}$

2)  $V = -1 - 32 \cos r \frac{A^2 - 3(\cos r + \sin r)^2}{[A^2 + (\cos r + \sin r)^2]^2}$ ,  $\psi = \frac{\sin r}{r(A^2 + (2r\cos r)^2)}$ ,  $E=0$ . discrete spectrum in position

Are there surprises in physics?

Not only

The biggest surprise is physics itself: that there are objective laws and regularities in Nature but that we can also understand, know, unravel, unify them. (In spite of some very recent & apparent indications that there are no objective realities in quantum theory - for some) we have come a long way from observing the regularities.

Part I: S 1, 2, 3.

Part II: S 3, 13, 8

## Lecture at the Conference "H-atom in Strong Laser fields"

"QED in Strong-Fields": New tests of QED in new environment.

No field quantization

Unified treatment

in principle nonperturbative

Applicable to bound-state problems

" to cavity QED: Replace D by Dcavity -

" to strong fields

Work in immediate progress:

Ann. F. L. de Broglie ✓

✓ → Encyclop. Italiana (soft.) ✓

Symmetry in Science (soft.) ✓

→ Hertzs Volume ✓

→ G.Zijino chaos (Trieste)?

N. Parisic ✓

F. Saradjiev ✓

N. UNAL

Z. Akgöz ✓

A. Harare

C. ONEA

B. OGUZ

→ Chandola ✓

Bardinich et al

Nieto

→ Rajzka

Cruz

Craig

Aug. 28, 31.

Avinash Khare (Bhubaneswar) on Supersymmetric QM and Anyons.

- Anyons have a chiral, directional property,  $\Theta$ , (circulation or vortex)  
hence are not eigenstates of parity (and T)  $\rightarrow$  P,T violation, unless  
we can also introduce their mirror image — A.O.B"
- Cf. S. M. Girvin, Anyons and T-violation . . . . Science, 257, 1354 (92)
- A one-parameter family of potentials, all with oscillator spectrum; but  
the wave functions are different.
- Generalize supersymmetry to parafermions, . . . (J Phys A June 1992)
- "With anyons you give up the single-valuedness of the wave function!"

---

H. Tsuka, "Wave packet Motion in a Magnetic Field"

J. Phys. Soc. Japan, 61, 2246 (1992)  
(Green's function is also given here)

George Temple, obituary, Bull. Inst. Maths. Appl., 26, 121 (1992) —

— Y. Güler et al. . . . Tr. J. Phys. 16, 297 (1992)

L. J. Challis, Physics in less than 3 dimensions,  
Contemp. phys. 33, 111 (1992)

L. Hardy, E. J. Squires, Phys. Lett. A 168, 169 (1992)

• Quantum Pendulum : S. Kar, Phys. Lett. A 168, 179 (1992)

• Orbitally excited Hadrons — Rydberg Trajectories  
Sov. Phys. Usp. 35, 257 (1992)



- Poincaré group in 1+1-dimensions.
- ref K. Baumann, Lett. Math. Phys. 25, 61 (1992)
- Heisenberg, collected papers.

Thought: Eliminate  $\psi$  in QED

$$(\delta^{\mu}_{\nu} \partial_{\mu} - m) \psi = e A^{\mu} \delta_{\mu} \psi \quad \square A_{\mu} = e \bar{\psi} \gamma_5 \psi$$

$$\psi = \overset{(0)}{\psi} + \int dy S(x-y) e A^{\mu} \delta_{\mu} \psi$$

→ Series solution by iteration --

$$\psi = \overset{(0)}{\psi} + \int dy S(x-y) e A^{\mu} \delta_{\mu} \overset{(0)}{\psi} + \dots$$

Insert into the action

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} - e A^{\mu} \square A_{\mu} + \bar{\psi} e A^{\mu} \delta_{\mu} \psi$$

↓  
 Higher order  
 term derivative  
 ←

↓  
 Iteration  
 solution  
 ↓  
 Iteration  
 solution

$$e \overset{(0)}{\bar{\psi}} \delta^{\mu} \overset{(0)}{\psi} A_{\mu} + e \int dy S(x-y) A^{\mu} \overset{(0)}{\bar{\psi}} \overset{(0)}{\psi} \underset{..}{\overset{(0)}{\bar{\psi}}} \overset{(0)}{\psi}$$

+ -----

→ Modified Maxwell's equations

$$F_{\mu\nu}{}^{\nu} = \square A_{\mu} + e \overset{(0)}{\bar{\psi}} \overset{(0)}{\psi} + e \int dy S(x-y) \overset{(0)}{\bar{\psi}} \overset{(0)}{\psi} + \dots$$

+

Cf. Ruedi Am. J. Phys.

D N Voshresenskii, Zero charge or asymptotic freedom in QED?  
Sov. J. Nucl. Phys. 55, 1090 (1992)

V V Nestorenko et al Casimir Energy of the Rigid String with massive ends  
Ibid. 1112

$$\mathcal{L} = \sqrt{-g} R$$

The RHS of Einstein's eq's is

$$\frac{-2}{\sqrt{g}} \left\{ \frac{\partial(\sqrt{-g}R)}{\partial g^{\mu\nu}} - \partial_\lambda \frac{\partial(\sqrt{-g}R)}{\partial(\partial_\lambda g^{\mu\nu})} \right\} = G_{\mu\nu}$$

Is this  $T_{\mu\nu}$  gravitation?

The LHS is  $T_{\mu\nu}$  of  $\mathcal{L}_{\text{matter}}$ .

Scalar wave Equation:

$$\text{For a scalar } \nabla_\mu \phi = \partial_\mu \phi$$

$$\partial_\mu \phi \text{ is a vector, hence } \nabla^\mu (\partial_\mu \phi) = \partial^\mu \partial_\mu \phi - \Gamma^\lambda_{\mu\nu} g^{\nu\mu} \partial_\lambda \phi$$

Where do we get the connection  $\Gamma^\lambda_{\mu\nu}$  from?

Sept. 7 - Labor Day. — Wavelets 1

- 1). Study polarization correlations ( $\tilde{E}, \tilde{B}$ -fields) in the decay of an electromagnetic wavelet.
- 2). The total energy of the sum of two wavelets contains interaction energy !!!

$$(E^2 = (E_1 + E_2)^2 = E_1^2 + 2E_1 \cdot E_2 + E_2^2)$$

$$\int E^2 dV = \int E_1^2 dV + \int E_2^2 dV + 2 \int \tilde{E}_1 \cdot \tilde{E}_2 dV$$

Is this zero?

- 3). Solve Helmholtz Eq. in a box  $(\Delta F + (\omega/c)^2 F) = 0$

How do you apply Lorentz transf. in a box? Boundary conditions are not Lorentz invariant!

- 4) "Tempered wavelet solutions" do not violate causality (cf. Hugfeldt theorem)

- 5) Electromagnetic wavelet with an angle ( $\theta/4$ ) for the orientation of the  $\tilde{E}$ -field (or  $\tilde{B}$ ): Boost and rotate the rest frame solution.

- 6) Pauli principle for two identical wavelets?

The system of two-wavelets is given by the sum  $\Psi_1 + \Psi_2 = \Psi$

But  $L$  or current is quadratic in  $\Psi$ .

If wavelets are far separated, the cross terms vanish, otherwise not

- 7) Energy fluctuations in Black-Body Radiation (Einstein formula)

2 terms :  $\frac{1}{N} + \frac{1}{W}$        $N = \# \text{of photons}$   
 $W = \# \text{of wave-modes}$

for TRANI - Meeting:

The "fallacy" is this:

one tries to eliminate a wide class of local hidden variables, supposedly without making any assumption about  $\lambda$  --

But one does actually make a model of  $\lambda$ , a model of an individual event, and a very big assumption: The argument goes as follows:

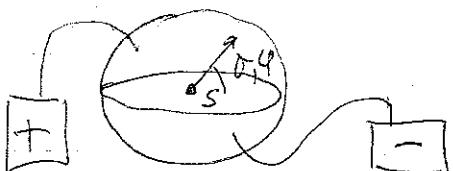
"If we lower the intensity of light more and more, we end up with "photons", the individual events; each one of them is either detected or not with certain probabilities — the individual events themselves are ~~still~~ probabilistic or quantized.

Or, we know that in quantum mechanics of spins a beam of atoms can be in a superposition state  $(|+\rangle + |-\rangle)$  and that ~~averaged~~ in repeated experiments the expectation values of spin components are  $\pm \frac{1}{2}$ . But then one extrapolates that if one has ~~a~~ at single individual atom, the spin component is also quantized and can only have the values  $\pm \frac{1}{2}$ .

The discussion in hidden variables looks like model-independent, any  $\lambda$  (within a den). However, one does make every drastic assumptions about individual events which lead then to contradictions.

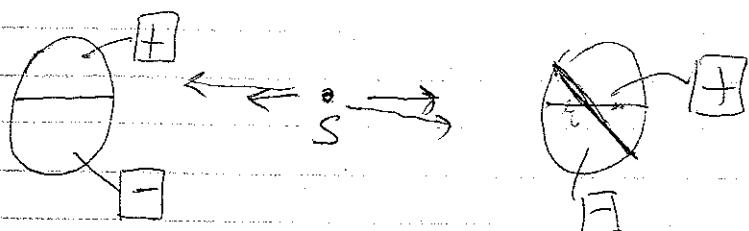
"Photon" is a statistical concept, comes from field quantization. And in QED or quantum optics anybody that uses photon always takes expectation values — An use of photons, or photon number, etc. always refer to ensembles.

Now we extrapolate this to single events.



Suppose we count particles coming from the source  $S$  and upper half plane goes to a counter + lower half to a counter -- .

The probabilities  $P_{\pm}$  can be accounted either (a) individual events are indeterministic each goes with prob.  $\pm \frac{1}{2}$  to  $(+)$  or  $(-)$ , or (b) individual events are deterministic, and  $P_{\pm}$  are calculated by integrating over  $(\theta)$  and  $(\phi)$



J. Krause, L. Michel, Classification of the symmetries of ODE  
Lecture Notes in Physics 382, 251 (1991)  
see also O. Gan, J. Math. Phys. 33, 2966 (1992)

E. Marshalek, a new boson realization of 3-dim. oscill.  
J Math Phys. 33, 2972 (1992)

YS Kim et al  $O(2,1)$ -like little group for space-like momenta and localized  
light waves in continuous media

*ibid.*, p. 3190

M. Ban :  $SU(1,1)$  Lie algebra approach to dissipative processes in quantum optics  
*ibid.*, p. 3213

### - Geometry of Conformal Transf's .

R L Ingraham, N.C. 46 B, 16 (1978)  
I II III, IV

Propagation of Light in moving media :

S. Komatsu, N.C. 46, 98 (1978)

H Kröger, Time-depend. Methods in Scattering Theory  
Phys. Reports, ~~220~~ 210, 47-109 (1992)

M. Skalsey, Testing CP, CPT with polarized positronium  
Mod. Phys. Lett. A 7, 2251 (1992)

### pt. 18. J. Dowling visiting:

A) Thermal + cavity corrections to Lamb shift (Walter's experiment)  
they are of the same order of magnitude .

B) Blackbody formula for a small cavity  
Derivation from the oscillators : (cf. Plunien, Phys. Reports 1986)

C) Selffield QED in Medium.

A single photon, or a single individual spin, cannot be in an entangled state. The latter is only for statistical, ensemble states.

So cannot a macroscopic state; the Schrödinger's cat.

So cannot the universe, or a black hole!

The limit of applicability of entangled states to macroscopic system is:

If we a macroscopic system (many-body) with classical parameters, the system may have a localized wave function, but it cannot be a superposition of states (without parameters).

Schrödinger tried to describe a crystal (length, angle) from an N-body Schrödinger eq. However, a crystal is an individual, with the positions of the nuclei (almost) classical parameters. Then we can apply entangled states to the electrons only, not to the crystal as a whole!

Crystal growth:

We should not assume (take it for granted, ingrained!) that a single individual photon is a "photon" (already known), but actually know, make a theory of what it is? an electron = leave it open, let it to our intuition

For me the crucial question is not just the debate about "realism or not" but "What is an 'electron'? What is a 'photon'? Having given a name, it does not mean that we understand it! And such a question must have a deterministic answer, otherwise it would be the end inquiry + the end of our ability to know ... And some people would like to put a limit on human knowledge:

Sept. 22. Up 4<sup>50</sup>, 5<sup>15</sup>... 8<sup>00</sup> Bus - beautiful clear boulder sky.

TWA 10<sup>00</sup> in time - first class; 6<sup>20</sup> - Ambassador class in N.Y. 2 hrs delay  
arrive Rome 10<sup>30</sup> → 13<sup>30</sup> BAII -

"Tachyonic Wavelet" solution: plan ready. Read Ziff, Read Sknir.

Reading George Lochack's "Loris de Broglie" -

TRANI Meeting: Sept. 24 - leave on 29.

Sellei, Garuccio, Lepore, Croca, Etchard, Costa de Beauregard (Chateau de Beauregard  
pris de Genève - à present à Fontainebleau) et Madame; Euan Squires (his suitcase  
stolen in Naples); T. Cushing, Rimini, Ghirardi, Jean Legrée, B. Home,  
Simon Prokhorov, Ranch, Boudet, Salmon, (E. Siegel (!)), H. Bozic, Chris  
Dewolfe, L. Hardy, Kostas, Ignatovich, Khalfin, Hasagawa, Balykin, Mezei  
Cornille, Dorda, Hara, Hunter, Rugar-Schäffer — People I talked to.

Sept. 29. Return fine - uneventful, on time. First class (both ways)

Relative coordinates as "hidden variables" — since are integrate  
over them!

Books: Krieger's Electromagnetics and Optics

World Scientific 1992 , QC673.E464, 1992

Oct. 3.

Phys. Rev. Lett. 69, (1992)

- 1) No 5% force: Pisa Exp.  $\frac{4g}{g} = 7.2 \times 10^{-10}$ : p. 1722
  - 2) No low  $e^+ e^-$  resonances ..... p. 1729, 1733
  - 3) First observation of Smith-Purcell leochiation p. 1761
  - 4) Gallex and solar  $\nu$  problem p. 1864
  - 5) Stueckelberg oscill's in multiphoton excitations p. 1919
- 6) T. Hänsch et al. Absolute frequency measurement 15-25 Å H

New Rydberg:  $R = 109737.315684(42) \text{ cm}^{-1}$ .

- 7) Photonic bands, Taynes-Linnum model, Schröd. eqs...? p. 1927
- 8) Laser induced localization of an electron in a double-well quantum structure p. 1986
- 9) Aharonov-Bohm effect in a Coulomb blockade regime p. 1989
- 10) Comment on "Scalar-A-B-effect" M. Peshkin p. 2017.

Y. Ohnuki et al. Mod. Phys. Lett. A 7, 2477 (1992)  
Non relativistic Q.M. on  $S^3 \rightarrow$  spin ?

AKT Assis, Deriving gravitation from EM, Can. J. Phys. 70, 330 (1992)  
Instit. Phys. State Univ of Campinas, C.P. 6165, 13081 Campinas, São Paulo, Brazil

•  $e^+ e^- \rightarrow p\bar{p}$ ,  $e^+ e^- \rightarrow t\bar{t}$  at  $\sqrt{s} = 52-61.4$  charge asymmetry  
Phys. Lett. B 291, 206 (1992)

CERN-Delphi coll.

|                                                   |       |
|---------------------------------------------------|-------|
| $\tau^- \rightarrow \mu^- \bar{\nu}_\mu \nu_\tau$ | 17.4% |
| $\rightarrow e^- \bar{\nu}_e \nu_\tau$            | 18.6% |
| $\rightarrow \pi^- \bar{\nu}_\tau$                | 11.9% |
| $\rightarrow \bar{g} \bar{\nu}_\tau$              | 22.4% |

Gauges:  $f^\mu A_\mu = 0$ ,  $f^\mu = \partial^\mu$  (Lorentz),  $f^\mu = n^\mu$  (axial)  
 $f^\mu = x^\mu$  (Fock-Schwinger) - FS

- FS is obtainable by a gauge transf.  $A_\mu \rightarrow A'_\mu = U A_\mu U^{-1} - \frac{i}{g} (\partial_\mu U) U^{-1}$   
 with

$$U = P \{ \exp [-ig \int_0^1 d\alpha x^\mu A_\mu(\alpha)] \} U(0)$$

Inverse formula

$$A_\mu(x) = - \int_0^1 d\alpha x^\nu F_{\mu\nu}(\alpha x)$$

$$A_0(x) = - \int_0^1 d\alpha x^\nu E(\alpha x), \quad \vec{A}(x) = - \int_0^1 d\alpha x^\nu [x_0 \vec{E}(\alpha x) + \vec{\Gamma}_\lambda B(\alpha x)]$$

Examples see R. Delbourgo et al., Int. J. Mod. Phys. A 7, 5833 (1992)

M. Komachiya --- QED  $\rightarrow$  H, He-atoms; ibid p. 5585

J. Seke, ... Nonrelativistic Lamb shift

Physica A, 187, 625 (1992)

→ and J. of Phys. A, 25, 5415 (1992)

S. Sasabe, Virtual size of the electron caused by its self-field

J. Phys. Soc. JAP. 61, 2606 (1992)

I. E. Segal et al ...  $S^3 \times R^4$ : q<sup>4</sup>-theory  
 Ann. of Phys. 218, 279 (1992)

R. Gottlieb, M. Kiefer ... Tunnelling ---  
 Ann. der Phys. 1, 369 (1992)

A. Turbiner, Lie Algebras and Polynomials ... J. of Phys. A 25, L1087 (1992)

R. Damoiseau et al ... 2-level systems, Berry's phase, Gutzwiller etc  
 J. Phys. A 25, L1105 (1992)

H. Huber et al ... Constraint system ...  
 J. Phys. A 25, L1111 (1992)

(e.g. Sundermeyer, Constraint Dynamics, Lecture Notes in Phys. 169  
 (Böhr, Springer 1982))

Feynman : "Cargo cult science"  
(to ignore minority opinions)

OCT. 14 :

L. Pearce Williams (Cornell) on Josef-Marie Ampère (1775-1836)

Né à Lyon. Autodidact, phenomenal memory, intelligence, --- Philosophy.  
Adhered to Kant: Not just observation, but make also models to give observations!  
Main contribution (1820) after Oersted: Magnetism is due to rotating  
charges (currents); even permanent magnets.

OCT. 16. FOKAS - Colloquium.

Integrable Eqs. are compatibility conditions of a pair of linear eq's.  
Linearization by inverse-scattering transformation.

OCT. 19. PRL : 69, (1992) Oct. 12

- |     |                                                   |         |
|-----|---------------------------------------------------|---------|
| 1.) | quantum phase measurement ... (C.M.Caves, et al.) | p. 2153 |
| 2)  | limits on $\nu$ masses and $\mu$                  | 2157    |
| 3)  | First observation of bound state $\beta$ -decay   | 2164    |

OCT. 19. Ilya Prigogine : "Laws of Nature, Laws of Chaos". (Reception after)

'Laws of nature' - a western notion (not chinese, hindu...), a certain legal connotation.

'Laws of chaos' - seems paradoxical. The Arrow of Time - not completely explained!

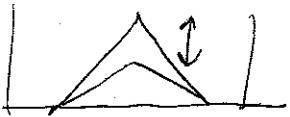
Boltzmann. Critique of Boltzmann

Chaos started with Poincaré and Kolmogoroff. Classical Mechanics is not deterministic (Lyapunov) - Nonintegrable systems - Lyapunov exponents. Individual trajectories difficult, but probabilities have simple laws and regularities.  
e.g. Bernoulli process:  $X_{n+1} = 2X_n \text{ (mod. 1)}$

References

PRL : 69, (19 Oct.

- 1) Thermal potential barrier crossing over a fluctuating barrier



C. R. Doering et al., p. 2318

- 2) New value of Rydberg F. Nez et al (France), p. 2327

$$R_\infty = 109\ 737.\ 315\ 6830(31)\text{ cm}^{-1} \quad (\text{compare Oct. 3 entry})$$

--- --- --- --- 684(42) cm<sup>-1</sup> Hinsch.

- 3) Observation of the  $'P_1$  State of Charmonium --- p. 2337

(a statistically significant enhancement in  $\bar{p}p \rightarrow J/4 + \pi^0$  at  
 $\sqrt{s} = 3526.2$  MeV consistent with  $'P_1$ )

- 4)  $^{128}\text{Te}$  half-life :  $7.7 \times 10^{24}$  yr - the longest T ever measured!

p. 2341

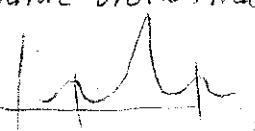
((Major mode mass of  $\nu < 1.1-1.5$  eV; right handed current  $|m| < 5.3 \times 10^{-8}$ )

XT.21. Lectures by P. Lett and S. Parkins

"Quantized motion of atoms in 1-D optical (standing) field"

center of mass motion  $\rightarrow$  harmonic vibrational levels

Two side bands seen,



Not yet superposition of vibrational levels!

PRL 64, 49 (1992)

B DeFacio, "Wavelets in Inverse Optics" in QA 370, I 58, 1992  
Dept Phys Univ Missouri, Columbia, MO 65211

Tables of Fourier, ..., Hankel, ... Transforms

A. J. Jerri, "Integral and Discrete Transforms with Applications"

QA 601, J 45, 1992

Massless Dirac Eq. Localized solutions

$$\delta^{\mu\nu} \partial_\mu \psi = 0 \rightarrow \psi = e^{-i\omega t} \begin{pmatrix} F \\ G \end{pmatrix} \xrightarrow{\text{Lorentz trans}} \psi = e^{i(kx-\omega t)} \begin{pmatrix} F \\ G \end{pmatrix} e^{ik(x-vt)}$$

$$\psi = e^{-i\omega t} \tilde{\psi} \rightarrow (\delta^{\mu\nu} - \vec{\partial} \cdot \vec{\nabla} + i\omega) \tilde{\psi} = 0$$

↓ generate a mass term? ?

OCT. 30. Peter D. Lax (Courant Inst.)

Irreversibility : Heat energy (Carnot)  
 Entropy (R. Clausius)  
 H-Theorem (Boltzmann)

Information as negative entropy (Szilard)  
 Information theory (Shannon)

Formation of shocks  $\rightarrow$  increase of entropy  $\sim$  loss of information.

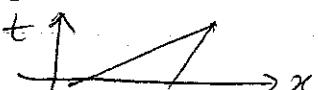
Conservation Laws :  $U_t + \operatorname{div} f = 0$   $\Rightarrow U_t + f(u)_x = 0$  in 1-dim  
 density  $\quad \quad \quad$  flux  $\quad \quad \quad$   $U_t + a(u)u_x = 0, a = \frac{\partial f}{\partial u}$

Several functions:  $U_t^i + f'(u)_x = 0$ , or,  $U_t + A(u)u_x = 0$   
 $U(x, 0) = U_0(x)$ .

A has real eigenvalues  $\approx$  discrete speeds.

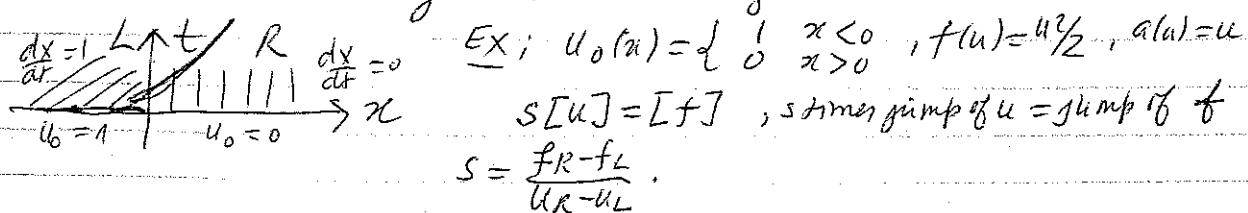
- (i) No classical solutions exist for all times
- (ii) Solution in integral sense of conservation laws (neoclassical)
- (iii) But we loose uniqueness — How to pick up the right solution

(i)  $U_t + a(u)u_x = 0$  can be written as  $\frac{du}{dt} = 0, \frac{dx}{dt} = a(u), \frac{d}{dt}(u) = \frac{\partial u}{\partial t} + \frac{\partial u}{\partial x} \frac{dx}{dt}$



(ii) Solution in integral sense :  $\frac{d}{dt} \int_U f u ds = - \int_D f u ds$  (Riemann)

This eq. leads to discontinuous solutions. So we need some jump conditions at the discontinuity : Rankine - Hugoniot conditions



(iii) Solutions are not unique

Negative Entropy  $H(u)$  is convex function  $\Rightarrow$

$$H_u A = F_u \quad F = \text{entropy flux}.$$

$$\frac{d}{dt} \int H(u) dx < 0 \quad \text{decreasing function.}$$

How much information is contained in the solution at time  $t$ ?

For any set  $M$  in metric space:

Capacity  $C(M, \epsilon) = \text{largest } \# \text{ of points in } M \text{ whose distance is } \geq \epsilon$

(information you can place on  $M$ )

Entropy  $E(M, \epsilon) = \text{smallest } \# \text{ of } \epsilon\text{-balls needed to cover } M$

(compact sets have small capacity).

Thermodynamics: 1)  $S, T, P, C = \text{speed}$  (palpable quantities)

2) internal energy  $e$ , enthalpy  $H$ , entropy. (thermial constants)

Carnot's theorem:  $\eta \leq \frac{T_h - T_c}{T_h} \cdot (\eta = \frac{Q_h - Q_c}{W})$

Proof:  $W = Q_h - Q_{\text{coll}}$ . cyclic process and  $de = TdS - pdV$

$$V = \text{Const.} \Rightarrow S = Q_h / T_h$$

At low temp: you dump entropy  $S = Q_c / T_c$ . The two are equal for cyclic process  $\text{QED}$

However, if you have shock waves you create entropy,

hence you decrease  $\eta$ . The reason is the loss of ~~information~~ information.

Szilard: Maxwell's demon decreases entropy, but needs information to do this - this negentropy compensates the decrease of  $S$ .

Oct. 31

A.G. Kyurkchan, Solving eq's of math. physics by reducing them to ODE with operator coefficients

Sov. Phys. Doklady, 37, 70 (1992)

Xavier Roqué, Möller scattering --

Arxi. History of Exact Sciences, 44, 197 (1992)

Seminari d'Història de les Ciències

Univ. Autònoma de Barcelona, E-08193 Barcelona

PRL 26 October 1992

- R.F. Sawyer, Slowing of Decay Processes by interaction with a medium. (Space periodic external potential) p. 2457

$\Rightarrow$  Idea : Atom in a periodic potential. Center of mass moves in an external potential. Now use selffield OED to calculate spontaneous emission.

First spontaneous emission of a freely moving atom  $\rightarrow$   
Nothing happens  $\rightarrow$  Lorentz transf.  
etc.

- P. Herczeg and R.N. Mohapatra : Muonium  $\leftrightarrow$  antimuonium p. 2475

Send my paper / Los Alamos Physics, Maryland, College Park  
Theory, 87540 Conversion, ant  $\mu^+ \rightarrow e^+ \bar{\nu}_e \bar{\nu}_\mu$   
~~8/25~~ 20.742 (exotic).

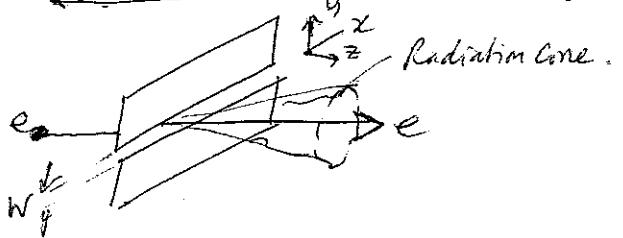
- J.M. Rost et al. ( $Ps^-$ ) : Molecule or atom? p. 2499

$(Ps^-)$  resonances can be classified with  $H_2^+$  quant. numbers.  
(predicted J.A. Wheeler (1946), expt. prof. A.P. Mills (1981))

- Tilo Blasberg - (Zürich ETH) Displacement of a laser beam by a precessing mag. Dipole (Ang. mom. transfer to light), p. 2507

- X-ray generation by the Smith-Ducell Effect p. 2522  
(See Oct. 3 entry)

## Electron radiation by a single slit.



M. L. Ter-Mikaelian

"High energy EM-processes in Media  
(Wiley, N.Y. 1972), p. 382

$$\frac{d^2N}{d\omega d\Omega} = 2\pi^2 \left[ \frac{\omega}{\hbar c} \right] (|E_x|^2 + |E_y|^2)$$

= # of photons

$$E_x = iK \left[ \frac{k_x}{f} \right] \left( \frac{e^{-y_-(f-iky)}}{f-iky} + \frac{e^{-y_+(f+iky)}}{f+iky} \right)$$

$$K = e/4\pi c$$

$$E_y = K \left[ \frac{e^{-y_-(f-iky)}}{f-iky} - \frac{e^{-y_+(f+iky)}}{f+iky} \right]$$

$$k = \frac{\omega}{c}$$

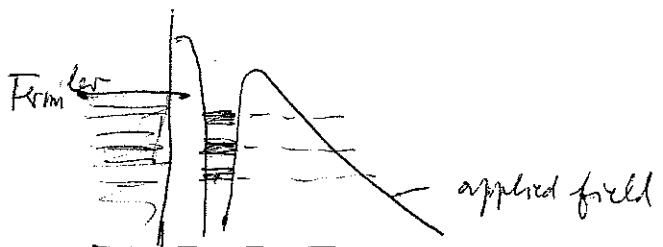
$$k_x = k \sin \theta \cos \varphi, k_y = k \sin \theta \sin \varphi, f = (k_x^2 + \eta^2)^{1/2}, \eta = \frac{\omega}{fc}$$

$y_+$ ,  $y_-$  - distances of the electron from the top and bottom of the slit

$$y_+ + y_- = w_s$$

$$\vec{E} = E_x \hat{x} + E_y \hat{y}$$

- Vu Thien Binh et al. Field emission electron spectroscopy of Single-Atom Tips. p. 2527



Bound state  
bands →  
hence  
peaks in the  
energy spectrum

$$x' = a(t)x \quad \text{Moving frame in expanding universe}$$

$$\dot{x}' = \dot{a}x + a\dot{x}$$

$$\begin{aligned} \ddot{x}' &= \ddot{a}x + 2\dot{a}\dot{x} + a\ddot{x} = \frac{1}{a}\ddot{x}' + 2\dot{a}\left(\frac{1}{a}\dot{x}' - \frac{1}{a}\dot{a}\dot{x}'\right) + a\ddot{x}' \\ &= 2\frac{1}{a}\dot{a}\dot{x}' + \left(\frac{1}{a}a'' - 2\frac{\dot{a}^2}{a^2}\right)x' + a\ddot{x}' \end{aligned}$$

- Anomalous magn. moment in spinor-dynamics  $a \in [g, g] \otimes F_{\mu\nu}$
- Bhabha's radiation reaction w/ massive photons  $\xrightarrow{\text{add spin}}$
- Limit of Dirac-Heselberg Coulomb eq's to Schröd. Heselberg Eq's
- How do you formulate Bound-states (station. states) in Heselberg Rep?

.. K. Nakayama, H. Segur, M. Wadati, Integrability and motion of curves  
PRL 69, 2603 (1992)

My notdm! curve  $x^i(t, \sigma)$

$$g(t, \sigma) = \frac{\partial x^i}{\partial \sigma} \frac{\partial x^j}{\partial \sigma} \quad \left| \begin{array}{l} x^\mu(\tau, \sigma) = x^\mu(\xi) \\ g_{ab}(\xi) = \frac{\partial x^\mu}{\partial \xi^a} \frac{\partial x^\mu}{\partial \xi^b}, \quad d\xi^2 = g_{ab} d\xi^a d\xi^b \\ S = \int_0^\sigma \sqrt{g(t, \sigma')} d\sigma' \quad , \quad ds = \sqrt{g} d\sigma \\ \vec{t} = \frac{\partial x^i}{\partial s} \Big|_t = \frac{1}{\sqrt{g}} \frac{\partial x^i}{\partial \sigma} \quad \left| \begin{array}{l} t^\mu = \frac{\partial x^\mu}{\partial \sigma} = \frac{\partial x^\mu}{\partial \tau} \frac{\partial \tau}{\partial \sigma} + \frac{\partial x^\mu}{\partial \sigma} \frac{\partial \sigma}{\partial \sigma} = \frac{\partial x^\mu}{\partial \tau} \frac{ds}{d\sigma} \Big|_{(0,0)} \\ \tau \end{array} \right. \\ \vec{n} = \quad \left| \begin{array}{l} \text{For curves with fixed } \tau : S(\sigma) = \int_0^\sigma \sqrt{g_{ab}} d\sigma' \\ \text{vielen } e_\infty^\mu(\xi) : \text{two on sheet } \xi \\ \text{two } \perp \text{ sheet} \end{array} \right. \end{array} \right.$$

Serret-Frenet eq's

$$\frac{\partial t^i}{\partial s} \Big|_t = \kappa(s, t) n^i$$

$\kappa$  = curvature

$$\frac{\partial n^i}{\partial s} \Big|_t = -\kappa t^i + \tau b^i$$

$\tau$  = torsion

$$\frac{\partial b^i}{\partial s} \Big|_t = -\tau n^i$$

$$\frac{\partial t^\mu}{\partial s} = \kappa n^\mu$$

Motion of a point  $x^i(t, \sigma)$  on curve (vertically)

$$\dot{x}^i = \frac{\partial x^i}{\partial t} \Big|_0 = U n^i + V b^i + W t^i \quad \uparrow t \quad \left| \begin{array}{l} U = U(s) \\ V = V(s) \\ W = W(s) \end{array} \right.$$

$$\dot{t}^i = \frac{\partial t^i}{\partial t} \Big|_0 = \frac{\partial}{\partial t} \left( \frac{1}{\sqrt{g}} \frac{\partial x^i}{\partial \sigma} \right) = \frac{\partial}{\partial \tau} \left( \frac{1}{\sqrt{g}} \sqrt{g} \frac{\partial x^i}{\partial s} \right) = \frac{\partial}{\partial s} [U n^i + V b^i + W t^i]$$

$$\text{using } \frac{\partial}{\partial t} \left( \frac{\partial x^i}{\partial \sigma} \right) = \frac{\partial}{\partial t} \left( \frac{\partial x^i}{\partial t} \right) \text{ and } \frac{\partial ( )}{\partial \sigma} \Big|_t = \sqrt{g} \frac{\partial ( )}{\partial s} \Big|_t$$

$$= \frac{\partial U}{\partial s} n^i + \frac{\partial V}{\partial s} b^i + \frac{\partial W}{\partial s} t^i + U(-\kappa t + \tau b) + V(-\tau n) + W(-\kappa n)$$

H.O. Girotti et al Attractive Forces betw. electrons in (2+1)-dim. QED  
PRL 69, 2623 (1992).

ch of Nov. 9

\* Seminar K. Bartschat : Spin-dependant e- Atom Scattering

J. Kessler "Polarized Electrons", Book

Phys. Reports 180 (1988)

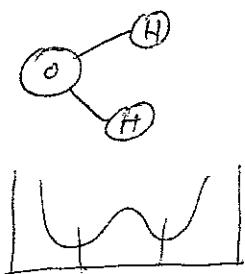
Comm. Atom. Mol. Phys. 27, 239 (1992)

1) Mott scattering

2) Exchange scattering.

e.g.  $e^-$ -H scattering : no total polarization, but  
individual levels have large polarizations.

Seminar : G. Blake (Caltech - Phys. Chem.)



two different  
equilibrium  
orientations.

Two molecule interactions  
2 different equilibria  
position of  $H_2O$  —  
Tunnelling behv. then  
→ doublet of levels

Seminar : J.C. Mather : Latest Results from COBE.

Earth moving against  $2.7^\circ K$  radiation  $\Rightarrow$  dipole form of Black  
body radiation  
+ small quadrupole ( $10^{-3}$  ?)

Seminar : V. Rokhlin (Yale)

Iterative solutions of the integral form of Helmholtz eq.  
for scattering theory

D.J. Griffiths, Am. J. Phys. 60, 979 (1992) Dipoles, monopoles -  
" " " " " 60, 1013 (1992) - Examples of renormalization  
(Reed College, Portland 97202)

Int. J. Modern Phys. A ; Vol. 7, Oct. (1992)

- 1) S K Lamoreaux, Review of Exp. Tests of Q.M. p. 6691  
(Univ. of Wash. Seattle, W 98195; Dept Phys. FM-15)  
→ 2) Rotating soliton ..... 6763  
3) N. Linden et al Path Integrals --- for Noncompact symmetric spaces 6871  
4) A P Balachandran et al Spin-Statistic Connection ---  
5) W. Lucha et al  $q-q$  bound states: Relativ. vs non-relat. 6431  
6) J. De La Laura F. .... Spinor Operators 6537  
7) P. S. Howe --- Conformal group, Point particles and Twisters 6639

A G Wagh --- Nonadiabatic geometric spinor phase in rotating  
magn. fields , Phys. Lett. A 1070, 71 (1992)

→ J M Dixon et al Nonlin. Schröd Eq - , ibid, 77

Physics Reports C 219, Nos 3-6 (1992) : Quantum Optics, Silvay 1991

S. Klama --- Green's function of electron in 2-dim. magn. field --  
Ann. der Phys. 1, 460 (1992)

C. Frøndal, What is a Covariant derivative?  
J. Geom. Phys. 7, 305 (1990)

M. Moretti, V-spin precession in magnetic field - Phys. Lett. B, 293, 378 (97)

Two-body Eq. with one Dirac one Kerner field; both linear in  $p^\mu$

(cf. Phys. Lett. B. 293, 265 (1992))

guess:

$$\{ [(\gamma \cdot p_1 - m_1) \otimes \beta^0 + \delta^0 \otimes (\beta \cdot p_2 - m_2) + \frac{e_1 e_2}{r} \gamma^\mu \otimes \beta_\mu] \phi = 0$$

$$\left[ \frac{1}{2} (\gamma^\mu \beta_0 + \delta^0 \beta^\mu) \cdot P^\mu + \frac{1}{2} (\gamma^\mu \beta^0 - \delta^0 \beta^\mu) \cdot p_\mu + \frac{e_1 e_2}{r} \gamma^\mu \otimes p_\mu \right] \phi = 0$$

$\downarrow$   
0<sup>th</sup> component:  $\delta^0 \cdot \beta^0 - \delta^0 \cdot \beta^0 = 0$

Comm. Math. Analysis, Vol. 26, (1972)

G. Daskalos, Wave packet realization of lightlike states, p. 15

R. Geroch, Einstein Algebras p. 271

← E. Novotny, H-Atom in the Friedman Univ. p. 321

G. A. Viano, - - - Harmonic Analysis of Scatt. Ampl. p. 290

ibid. Vol. 27, (1972)

E.J. Kansellopoulos et al. Solution of the Dirac Eq. p. 155

W. Rühl, - - - SU(2,2) - - - p. 53

Wigner C.R.

$$\dot{x} = i [p, H]$$

$$\dot{p} = -i [x, H]$$

General solution

$$p = -i \left( \frac{d}{dx} - \frac{C}{x} R \right)$$

$$H = \frac{1}{2} \left[ -\left( \frac{d}{dx} \right)^2 + \frac{C}{x^2} (C-R) + x^2 \right]$$

$$R \Psi(x) = \Psi(-x)$$

Y. Ohnishi et al JNP 33, 3653 (1992)

D. Basu, Clebsch-Gordan problem of the  $SL(2, \mathbb{C})$  coherent states ; ibid, 3826

J. Klauder, Affine coherent states

" , 3700

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G. Cincotti et al Self-Fourier functions JPhys A 25, L191 (1992)

$$\tilde{f}(v) = \int_{-\infty}^{+\infty} f(x) e^{-2\pi i vx} dx, \text{ SF-functn } \tilde{f}(v) = a f(v) \Rightarrow f(-x) = a^2 f(x) \quad a^2 = \pm 1.$$

Hermite-Gauß f's:

$$G_n(a) = \frac{(2)^{1/4}}{\sqrt{2^n n!}} H_n(\sqrt{2} \pi x) e^{-\pi x^2} \quad (n=0, 1, 2, \dots) \text{ Harmonic oscill. wave fms.}$$

$$\tilde{G}_n(v) = i^{-n} G_n(v) \quad \text{form a complete o.n. set in } L^2$$

From any function  $g(x)$  one can construct 4 SF-functions

---

J.E Gray, EM-waves with  $\vec{E} \parallel \vec{B}$ , J.Phys A 25, 5373 (1992)

↓  
not really free Maxwell's eqns. but with boundary conditions

---

R.J. Cook PR A 25, 2164 (1982) 526, 2754 (1982)

Photon Dynamics --

K. Baumann, Poincaré group in 1+1 dimensions

Lett. math Phys. 25, 61 (1992)

Reports Math. Phys. 30, 181 (1991)

Colloq. Robert Siemann (Stanford): Nov. 18.

1) Synchrotron radiation: energy loss per turn =  $\frac{4\pi}{3} \frac{re}{(mc^2)^3} \cdot \frac{E^4}{R}$   
 $E = \text{energy}, R = \text{radius}$

2) particles scatter from the (space-charge) field of the beam's cross section!  
 Huge  $E$  fields at the colliding beam  $\rightarrow$  can approach critical field  
 for pair production! Nonperturbative QED needed, like heavy-  
 ion collision.  $E/D \approx \frac{mc^2}{\lambda_{\text{cav}}}$

At what energy or acceleration you reach the critical field?

$$B^{\text{crit.}} = m^2/e, E^{\text{crit.}} = m^2$$

S.C. MacFarlane, Ang. Momentum and Heisenberg's correspondence principle  
 J Phys. B 25, 4045 (1992)

$$\langle n'l'm' | T_q^{(k)} | nlm \rangle \xrightarrow[\text{Corresp. prn.}]{} \frac{1}{(2\pi)^3} \int d\Omega_n d\Omega_l d\Omega_m e^{-i((l-n)\delta_n + (l'-l')\delta_l + (m'-m)\delta_m)} \\ \times T_q^k(\delta_n, \delta_l, \delta_m)$$

( $\Omega_n, \Omega_l, \Omega_m$   $\propto$   $\omega_n$ ) action angle variables.

AOB:  $T(\theta)$  individual values  $\rightarrow$  average over individuals  $\rightarrow$  O. Mod.

J-Q Liang, H-J W Müller-Krönlein, Time dependent gauge transform & Berry's phase  
 Ann. of Phys. 219, 42 (1992)

Torresani, .... wavelet packets ....

Ann. Inst. H. Poincaré, 56, 215 (1992)

CPT CNRS Luminy, case 907, 13288 Marseille (cedex 7)

E-Comay, Parity nonconservation in charge-monopole system  
 ??, Int. J. Theor. Phys. 31, 2035 (1992)

I. M. Narodetskii et al Spin forces in QED, Sov. J. Nucl. Phys. 55, 1572 (1992)

$$V_{\text{spin}} = -\frac{2\pi}{3} \frac{\alpha s(r)}{m_i m_j} (F_i F_j) (\hat{\sigma}_i \cdot \hat{\sigma}_j) \hat{\delta}(r), \quad \hat{\delta}(r) = \frac{b^3}{\pi^3 r^2} e^{-b^2 r^2}$$

$$\lambda = m_i \int_0^\infty |V_{\text{spin}}| r dr, \text{ mean and. for bound state } \lambda \gg 1$$

V. V. Kozlov et al. Kepler's problem in constant curvature spaces  
Celestial Mechanics ... 54, 393 (1992)

$$S^2: \text{Laplace-Beltrami } \Delta V = \sin^2\vartheta \frac{\partial}{\partial\vartheta} \left( \sin^2\vartheta \frac{\partial V}{\partial\varphi} \right) = 0$$

$$V = -g \frac{\cos\vartheta}{\sin\vartheta} + \alpha$$

Bertrand's theorem hold. 2-center problem is integrable

D.G.C. McKeon, Can. J. Phys. 70, 388 (1992)

reviews  $n$ -dim. Sennet-Franet eq's.

$$[t^\mu, n_1^\mu, n_2^\mu, \dots, n_{n-1}^\mu]; \quad t^\mu = k_1 n_1^\mu, \quad \dot{n}_1^\mu = -k_1 t^\mu + k_2 n_2^\mu, \dots \\ \dot{n}_K^\mu = -k_K n_{K-1}^\mu + k_{K+1} n_{K+1}^\mu, \dots, \dot{n}_{n-1}^\mu = -k_{n-1} n_{n-2}^\mu$$

$$\text{calculate } k_1^2 =$$

$$k_2^2 = \dots$$

$$\text{let } e = \sqrt{\dot{x}^2}, \quad t^\mu = \frac{1}{e} \dot{x}^\mu, \quad k_1^2 = \left( \frac{\ddot{x}}{e^2} - \frac{\dot{e} \dot{x}}{e^3} \right)^2, \text{ etc}$$

A.Y. Shiekh, 'Does nature place a fund. limit of strength?

Can. J. Phys. 70, 458 (1992)

Spec. relat. + conserv. of energy  $\Rightarrow$  limit on stren/density of materials?

A. Grigorov, et al ibid. p. 467.

Solutions of 2-dim. sine-Gordon Eq.

M. M. Guzzo et al. On the 2-spin precession in magnetic fields

Phys. Lett. B 294, 243 (1992)

M.S Plyushchay, free relt. particle in 2+1-dim. with fractional spin

Int. J. Mod. Phys. A, 7, 7045 (1992)

# Origin of Magnetic fields in the Universe? Seminar T.D. Hanson

- Finn, Ott, ... Physics of Fluids 31, 2992 (1988)  
 32, 916 (1990)  
 PRA 39, 3660 (1989) 33, 1250 (1991)

1) Conducting fluid: Ampère + Faraday + Ohm ( $j = \sigma(E + \frac{v}{c} \times B)$ )

$$\Rightarrow \frac{\partial \vec{B}}{\partial t} + \vec{v} \cdot \nabla \vec{B} = \vec{B} \cdot \nabla \vec{v} + \frac{1}{\rho c} \nabla^2 \vec{B}, \quad \nabla \cdot \vec{B} = 0$$

Stretch-twist-fold  $\Rightarrow$  you can increase magnetic fields (flux contract)

2) Take  $\frac{d\vec{x}}{dt} = \vec{v}(\vec{x}, t)$ , test particle moving with fluid velocity

If  $\nabla \cdot \vec{v} = 0$ , this is Hamiltonian system.

let  $\vec{X} \rightarrow \vec{x} + \vec{\xi}(x)$ ,  $\frac{d}{dt}(\vec{x} + \vec{\xi}) = \vec{v}(\vec{x} + \vec{\xi}, t) = \vec{v} + \nabla \cdot \vec{v} \vec{\xi} + \dots$

$$\frac{d\vec{\xi}}{dt} + \nabla \vec{\xi} \cdot \vec{v} = \nabla \cdot \vec{v} \vec{\xi}$$

AOB: Two suggestions: Magn. field acts like going to a rotating frame  
 Earth's rotation and magnetic field are probably related (see also Schuster-Blackett effect)

Check:  $\nabla_n B = J$  (neglect displacement current)

$$\nabla_n E = -\frac{\partial B}{\partial t}$$

$J = \sigma(E + v_n B)$ , ~~neglect E~~? eliminate E

$$\nabla_n B = \sigma v_n B + \sigma E, \quad E = \frac{1}{\sigma} J - v_n B$$

$$\nabla_n E = \frac{1}{\sigma} \nabla_n J - \nabla_n(v_n B) = -\frac{\partial B}{\partial t}$$

$$\frac{\partial B}{\partial t} = \nabla_n(v_n B) - \underbrace{\frac{1}{\sigma} \nabla_n(\nabla_n B - \sigma v_n B + \sigma v_n B)}_{\nabla(\nabla \cdot B) - \nabla^2 B}$$

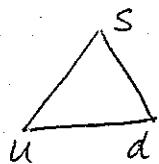
$$v_n(\nabla \cdot B) - B(\nabla \cdot v)$$

O.K.

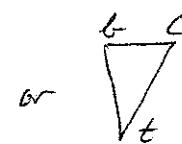
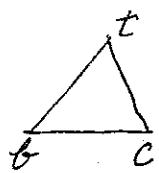
$$+ (B \cdot \nabla) v - (\nabla \cdot B) \vec{B}$$

Consequently:  $j^\mu = \sigma \mu \nu \lambda \rho F_{\nu \lambda} u^\rho$ ,  $F^{\mu \nu}_{\lambda \rho} = \sigma \mu \nu \lambda \rho F_{\nu \lambda} u^\rho$   
 inverse  $\sigma^{-1}_{\mu \nu \lambda \rho} j^\mu u^\rho = F_{\mu \nu}$ ?

The old SU(3) :



In place another for



This has been forgotten in lieu of 3 generations (u,d)(c,s)(b,t), ?

On Planck's derivation of his formula:

There are two steps : 1) relating  $\rho(\nu, T)$  of field to  $U = \text{average energy of a}$

$$\rho(\nu, T) = \frac{8\pi\nu^3}{c^3} U \quad \begin{matrix} & \\ & \text{individual oscillator} \\ & \text{source} \end{matrix}$$

→ This step needs radiation reaction term.

Energy in the field  $\sim$  energy of the source

2) Finding  $U$  : This needs the quantized levels of the source + equilibrium

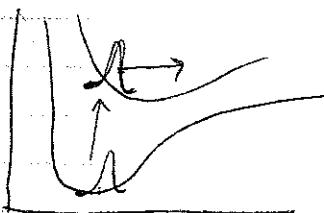
$N$  oscillators  $\rightarrow$  Entropy  $\sim \sim$

$$S_N = k \ln W_N, \quad W_N = \frac{(N+p)!}{(N-p)!} = \# \text{ of ways to distribute } P \text{ energy elements each } \epsilon \text{ to } N \text{ oscillators; } P = \frac{NU}{\epsilon}$$
$$\approx (N+p)^{N+p} / N^N p^p \Rightarrow S = k [(N+p) \ln(N+p) - N \ln N - p \ln p] \quad \begin{matrix} & \\ & \text{This agrees with} \\ & \boxed{S_N = kN \left[ \left(1 + \frac{U}{\epsilon}\right) \ln \left(1 + \frac{U}{\epsilon}\right) - \frac{U}{\epsilon} \ln \frac{U}{\epsilon} \right]} \quad \begin{matrix} & \\ & \text{on} \\ & \frac{dS}{dU} = \frac{1}{T} & \text{U=Plan} \end{matrix} \end{matrix}$$

M. Kobayashi et al On testing CPT symmetry in B decays, PRL 69, 3139 (1992)

Ahmed Zewail, Caltech, CONDON Lecture -

Femtosecond probing of chemical reactions



create a localized "wavepacket" and observe it move under various conditions.

Rotations of molecules, .

"Chemical Bond" CU Science, QD 461, C4222 1992

Steve Chu (Stanford) : Seminar

Measuring g by atomic interferometer -

See Review in Science 253

(Aug. 1991)

- Take H-atoms  $\Psi$  as the Debye-Brownish potential of a field

What are the corresponding fields  $\vec{E}$  and  $\vec{B}$ :

e.g. if it is of electric type  $\vec{E} = \vec{p}_1 \vec{L} \Psi$ ,  $\vec{B} = -\vec{L} p_0 \Psi$

If  $\Psi$  is a stationary state  $\vec{B}_z = -\omega m \Psi_{\text{hem}}$  etc --

$$\vec{E} = (\vec{p}_1 \vec{L}) \Psi_{\text{hem}}$$

- There is also a wavelet of magnetic type.

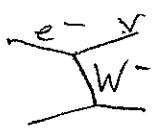
Wavelet with both-types.

N. Veltman, Colloq. Higgs & SSC. Do we need them. Dec. 2,

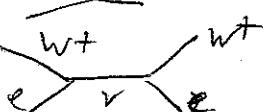
"Game":  ~~$p_n$~~  violates unitarity, conservation of prob. | maybe need nonpert-treatment.

OED:  ~~$e^- e^- \nu \bar{\nu}$~~   $\sim E^2$ , so add  ~~$e^- e^- \nu \bar{\nu}$~~  on  $E^2$  parts cancel.

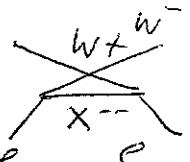
by this analogy introduce



But then there is



$E^4$  part cannot be cancelled by



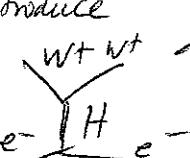
etc.

However introduce



cancel some

Introduce



and so on, and so on!

Then wild speculations about Higgs!! (Higgs  $\leftrightarrow$  gravity)

AOB: forgot to mention 24 parameters of the Standard model; even then Higgs mass cannot be calculated!!! So if you build SSC and  $M_H$  is higher, than you say "we need another Super-Super-Super-machinery!" Phenomenology is elevated to a fundamental theory.

Then you have to repeat the "game" of introduce new structure in the vertices, etc

M. RHOZ

$$\square^\alpha u = f$$

$$u = \square^{-\alpha} f = \frac{1}{H_d(\alpha)} \int f(x_1, \dots, x_{d-1}, t) \bar{P}_+^{d-\frac{\alpha}{2}} dx_1 \dots dx_{d-1} dt$$

$$H_d(\alpha) = \pi^{\frac{d-2}{2}} 2^{2d-1} \Gamma(1+\alpha - \frac{d}{2}) \Gamma(\alpha) \bar{P}_+^\lambda = \begin{cases} (t^2 - r^2)^\lambda, & t > r \\ 0 & \text{otherwise} \end{cases}$$

$$\alpha = 0 : 1 - \frac{d}{2} = 0, -1, -2, \dots \Rightarrow d \text{ even}$$

Gelfand-Shilov distributions: let  $Q_+^\lambda = \begin{cases} Q^\lambda & \text{if } x_1^2 + \dots + x_p^2 > x_{p+1}^2 + \dots + x_{p+q}^2 \\ 0 & \text{otherwise} \end{cases}$

analytic in  $\lambda$  except simple poles with

$$\text{Res } Q_+^\lambda |_{\lambda = -\frac{d}{2}} = (-1)^{\frac{d}{2}} \pi^{\frac{d}{2}} \frac{\delta(x)}{\Gamma(\frac{d}{2})}$$

$$\lim_{\lambda \rightarrow -1} \frac{Q_+^\lambda}{\Gamma(1+\lambda)} = \delta(Q) \cong \frac{\delta(t+r) + \delta(t-r)}{r}$$

Riesz's formula  $G_R^\alpha = \frac{Q_+ \theta(-t)}{\pi^{\frac{\alpha+2}{2}} 2^{2d-1} \Gamma(1+d-\frac{\alpha}{2}) \Gamma(\alpha)}$

$$\square^\alpha G_R^\alpha = \delta(x)$$

Dec. 6

For the Coulomb problem, the Schrödinger equation

is not the Casimir operator of ~~SO(2,2)~~  $SO(2,1)$ , but one of

the generators of  $SO(2,1)$ ;  $J_3$  for discrete states  
 $J_1$  for continuum states.

Group law  $g_1 g_2 = g_{12}$

If  $g$  has unit some coordinates  $z$  of a (homog.) space, then the decomposition of  $g_{12}$  into its  $z$  determines the left and right action of  $G$  on  $z$ -space. Example  $SU(2,2)$ ,  $z \in G/K$

Then if we have a representation space,  $\text{of } G \text{ and } K$  by functions over  $z$ ;  $f(z)$

then  $f(gz) = f_g'(z)$  some new function of  $z$ .

→ induced Rep's.

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R L Dawe et al The Physics of Tachyons I , Austr. J. Phys. 45, 591 (1992)

R. Delbourgo et al Fermi-Dirac eq's " " 45, 621 (1992)

$$(\delta^\mu_\nu p_\mu + \mu \delta_5^{\nu} \underbrace{q \cdot D - m}_{\text{new variables, intnd}}) \psi = 0 \rightarrow \text{have mass spectrum}$$

T D Lee, Y. PANG , NONTOPOLOGICAL SOLITONS , Phys. Reports 221, 251-350 (1992)

B. Bostw et al. . . . (Schrod. Transl. currents and multipole moments . . . ) JPP, 33, 4116 (1992)

A. Lakhtakia : Magnetic charges are useful (necessary?) for electrodynamics  
in chiral media . . . Physics Essays, 4, 105 (1991))

Anton Zeilinger, Sem. Dec. 8.

General EPR Correlations       $\begin{cases} 2 \text{ particles, each has } N \text{ states} \\ N \text{ particles, each has 2 states} \end{cases}$  -

by beam splitters realize unitary Matrix  $U (N \times N)$ .

Hans Frisch & Thomas Guhr : Spin-Orbit coupling in semidiamond Approx.  
(Lawrence Berkeley Lab., Berkeley, CA 94720)

(cf. B. Mielke, J. Reif, Z. Phys. A 339 (1991) 231)

T. Guhr, Fourier-Bessel Analysis of the space of  $2 \times 2$  matrices  
(J. Math. Phys. (to appear))

European J. Phys. 13, No. 6, Nov. 1992

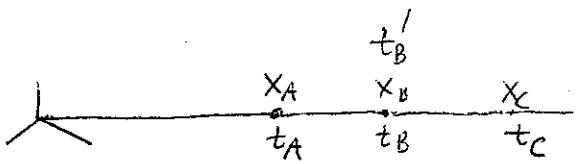
- 1) J. Paton, p. 280, Field energy-momentum, dropping self energy ?! p. 280
- 2) F. Nogueira et al. Exp. values of non-commut. operators ! p. 284
- 3) J. Frankel, Chemical spectrum of non-relat. Bremsstrahlung p. 286

$$\frac{dI(\omega)}{d\omega d\Omega} = \frac{e^2}{c^3} |\vec{n} \times \vec{a}_\omega|^2, \vec{a}(\omega) = \frac{1}{2\pi} \int_{-\infty}^{+\infty} dt \vec{a}(t) e^{i\omega t}, \vec{a}^\perp = -\frac{2e^2}{m} \frac{b}{(b^2 + v^2 t^2)^{3/2}}$$

use 
$$K_n(\omega t) = \frac{\Gamma(n+1/2)}{\Gamma(1/2)} \left(\frac{2\omega}{\omega}\right)^n \int_0^\infty dt \frac{\omega \omega t}{(b^2 + v^2 t^2)^{n+1/2}}$$

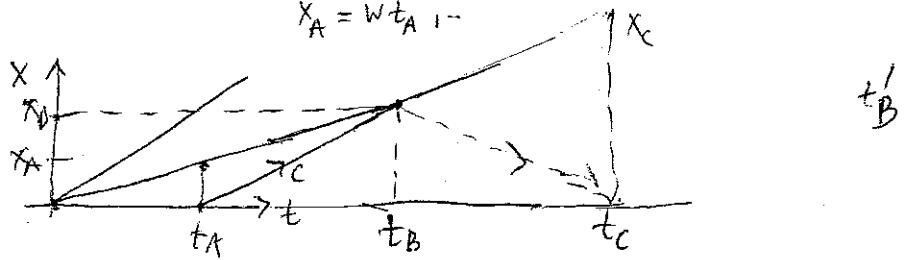
$$a'' = -\frac{2e^2}{m} \frac{v b}{(b^2 + v^2 t^2)^{3/2}}$$

$$|\vec{a}_\omega^\perp|^2 = \left(\frac{2e^2}{\pi m v^2}\right)^2 \omega^2 K_1(b\omega/v)$$
$$|\vec{a}_\omega''|^2 = \left(\frac{2e^2}{\pi m v^2}\right)^2 \omega^2 K_0(b\omega/v)$$



At  $(t_A, x_A)$  send a signal from origin :  $(x_B - x_A) = w(t_B - t_A)$ ,  $x_B = c(t_B - t_A)$

$$x_A = w t_A + \dots$$



Peter Bergmann in "Gravitation and Modern Cosmology", Plenum 1991

"My life" --- states "Einstein was convinced that <sup>eventually</sup> quantum <sup>phenomenon</sup> theory would ~~eventually~~ be recognized as something from <sup>the</sup> a classical physical field that ~~would~~ <sup>did</sup> not require the ministrations of a human observer!"

General relativity : Eq's of motion of particles follow from field equations

Note A05 ! So it is in the wavelet solutions !

Bergmann says : Quant. theory explains discrete angular momenta and energies -

So does the classical wavelet theory !

June 1993

1-5 : Köln

14-17 : Oak Ridge, Tenn. Coherent States ; FENG@DUVM.bitnet

July

19-21 Turkey.

August

Sept.

Meetings 1992-93

1992-Visits

Sept.

24-30 : TIRANI ✓

Oct.

Poznan

TRIESTE ✓ X JAN  
Konstanz ✓ X MAY-JULY  
FRANCE - MARSEILLE ✓ MAY  
MUNICH ✓ X JUNE-AUG  
ULM ✓ X AUG  
GENÈVE ✓ X JUNE-JULY  
BRAUNSCHWEIG ✓ X JUNE

AUSTRIA

BREGENZ ✓ X AUG  
JAPAN ✓ X MARCH  
NYC ✓ X APRIL  
WASH. D.C. ✓ X FEBR

TRAM ✓ SEPT  
TMI

Dec.

ISTANBUL

Jan

(8-8 SAN ANTONIO, TX,  
(8- MEXICO )

Febr.

March

2-5 TRIESTE

April

May 3-7 Deinze (Belgium)

June ERRNIE ?

1-5, Köln, S.Found.Mod.Phys 1993

