Quantum computing, the early days & Effect of scalar scaling field on physics, geometry

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Talk has two parts

Discuss beginnings of quantum computing

Basis of my interest in Hamiltonian models

Problems in developing these as models of Quantum Turing machines.

Describe effects of scalar scaling field on physics and geometry.

Based on:

Localization of mathematical structures as in gauge theory.

Separation of concepts of number and number value

Overall framework: Interest in relations between foundations of mathematics and physics.

Quantum Computers

Why quantum mechanical models of computers

Computers are complex physical systems

Should be possible to describe quantum mechanically.

Description necessary if any progress is to be made in

Describing intelligent beings quantum mechanically

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Then it should describe its own validation.

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In particular, the computation process should be described by the dynamics of a complicated, isolated quantum mechanical system.

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In particular, the computation process should be described by the dynamics of a complicated, isolated quantum mechanical system.

This implies the need of a Hamiltonian description of the dynamics of computation.

Problem: Hamiltonian descriptions are restricted to
processes that are reversible.

Computations have many irreversible steps,
These steps dissipate energy.

Heat generated by energy dissipation is large problem in computers
Problem becomes more acute as computer elements become smaller.
Fraction of heat due to irreversible computation steps

Landauer: "Information is Physical"
kTln2 energy dissipated as heat per bit erased.
At room temperature, about 2.6×10^{-14}
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To proceed, a specific model of computers is needed.
Chose Turing machines.

Turing machines are slow but very powerful.

Any computation can be done on a Turing machine.

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Turing machines consist of a tape divided into cells,

each cell contains a 0 or a 1.

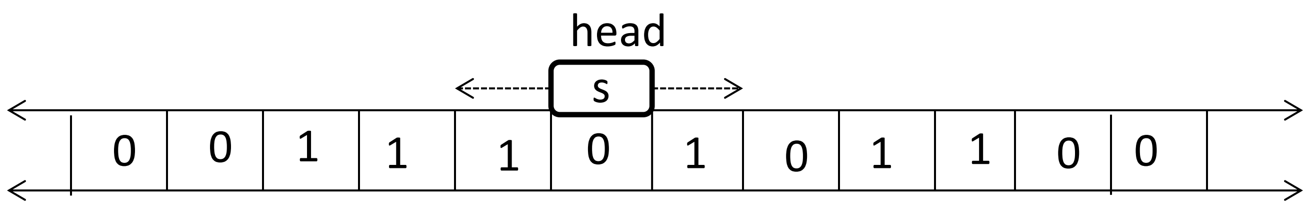
A head reads tape cell contents.

Possible head operations are

change cell contents,

move one cell to left or right.

Head operation determined by state of head.



Each computation defined by set of quadruples of form (s,a,b,t)

examples: (s,0,1,t), (t,1,r,v), (v,1,0,y), (s,1,l,x),

reversibility problem, (w,0,1,t)

Reversibility problem and Hamiltonian, what to do?

Reversibility problem solved by Bennett's reversible Turing machines
with history tape

Bennett showed that for each Turing machine there exists a
reversible machine that does the same computation.

My solution, Construct a Hamiltonian model of a Turing machine
with history tape that erases its own history.

Show no energy dissipated in the model.

Did this in several steps:

First paper used simplified dynamics,
created and saved history tape.

Journal of Statistical Physics
The computer as a physical system: A microscopic quantum mechanical Hamiltonian model of computers as represented by Turing machines
Paul Benioff
May 1980, Volume 22, Issue 5, pp 563-591

In this paper a microscopic quantum mechanical model of computers as represented by Turing machines is constructed. It is shown that for each number N and Turing machine Q there exists a Hamiltonian H_N^Q and a class of appropriate initial states such that if $\Psi_N^Q(0)$ is such an initial state, then Ψ_N^Q (t) =exp($-iH_N^Q$t)$\Psi_N^Q(0)$ correctly describes at times t 3,t 6,⋯,t 3N model states that correspond to the completion of the first, second, ⋯, Nth computation step of Q. The model parameters can be adjusted so that for an arbitrary time interval Δ around t 3,t 6,⋯,t 3N, the "machine" part of Ψ_N^Q(t) is stationary.

Irreversibility and energy dissipation was big problem in computation process.
Some argued that it was essential part of computation.

Examples of papers supporting this:

Energy Cost of Information Transfer
Jacob D. Bekenstein
Phys. Rev. Lett. 46, 623 (1981) – Published 9 March 1981
From thermodynamic and causality considerations a general upper bound on the rate at which information can be transferred in terms of the message energy is inferred. This bound is consistent with Shannon's bounds for a band-limited channel. It prescribes the minimum energy cost for information transferred over a given time interval. As an application, a fundamental upper bound of 10^{15} operations/sec on the speed of an ideal digital computer is established.

Irreversibility, Uncertainty, Relativity and Computer Limitations.
D. Mundici,
Nuovo Cimento 61B, 297, 1981
Any computer M is subject to such laws as irreversibility and uncertainty of time-energy and maximality of the speed of light. This imposes fundamental limitations on the performance of M and, more generally, on the power of algorithmic methods for several important logic operations; this also has an impact on the problem of what is knowable in mathematics.

Minimum energy requirements of information transfer and computing
Hans J. Bremermann
International Journal of Theoretical Physics
April 1982, Volume 21, Issue 3, pp 203-217
The minimum energy requirements of information transfer and computing are estimated from the time-energy uncertainty relation.

These positions were challenged in other papers,

Is There a Fundamental Bound on the Rate at Which Information Can Be Processed?
David Deutsch
Phys. Rev. Lett. 48, 286 (1982) – Published 25 January 1982
It is shown that the laws of physics impose no fundamental bound on the rate at which information can be processed. Recent claims that quantum effects impose such bounds are discussed and shown to be erroneous.

Uncertainty principle and minimal energy dissipation in the computer
Rolf Landauer
International Journal of Theoretical Physics
April 1982, Volume 21, Issue 3, pp 283-297
Reversible computation is briefly reviewed, utilizing a refined version of the Bennett-Fredkin-Turing machine, invoked in an earlier paper. A dissipationless classical version of this machine, which has no internal friction, and where the computational velocity is determined by the initial kinetic energy, is also described. Such a machine requires perfect parts and also requires the unrealistic assumption that the many extraneous degrees of freedom, which contribute to the physical structure, do not couple to the information-bearing degrees of freedom, and thus cause no friction.
Quantum mechanical computation is discussed at two levels. First of all we deplore the assertion. repeatedly found in the literature, that the uncertainty principle. $\Delta E \Delta t \approx h$, with Δt equated to a switching time, yields any information about energy dissipation. Similarly we point out that computation is not an iterated transmission and receiving process, and that considerations, which avoid the uncertainty principle, and instead use quantum mechanical channel capacity considerations, are equally unfounded. At a more constructive level we ask whether there is a quantum mechanical version of the disispationless computer. Benioff has proposed one possible answer Quantum mechanical versions of dissipationless computers may suffer from the problems found in electron transport in disordered one-dimensional periodic potentials. The buildup of internal reflections may give a transmission coefficient. through the whole computation, which decreases exponentially with the length of the computation.

Presented at conference at Endicott house, MIT in May, 1981

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No energy dissipation was present.

Landauer: This delays the inevitable.

The history tapes have to be erased sometime.

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My talk at the conference took care of this problem

Quantum mechanical Hamiltonian models of discrete processes that erase their own histories: Application to Turing machines

Paul A. Benioff

International Journal of Theoretical Physics

April 1982, Volume 21, Issue 3, pp 177-201

Work done before on the construction of quantum mechanical Hamiltonian models of Turing machines and general discrete processes is extended here to include processes which erase their own histories. The models consist of three phases: the forward process phase in which a map T is iterated and a history of iterations is generated, a copy phase, which is activated if and only if T reaches a fix point, and an erase phase, which erases the iteration history, undoes the iterations of T, and recovers the initial state except for the copy system. A ballast system is used to stop the evolution at the desired state. The general model so constructed is applied to Turing machines. The main changes are that the system undergoing the evolution corresponding to T iterations becomes three systems corresponding to the internal machine, the computation tape, and computation head. Also the copy phase becomes more complex since it is desired that this correspond also to a copying Turing machine.

Physics of Computation Conference Endicott House MIT May 6-8, 1981

1 Freeman Dyson
2 Gregory Chaitin
3 James Crutchfield
4 Norman Packard
5 Panos Ligomenides
6 Jerome Rothstein
7 Carl Hewitt
8 Norman Hardy
9 Edward Fredkin
10 Tom Toffoli
11 Rolf Landauer
12 John Wheeler
13 Frederick Kantor
14 David Leinweber
15 Konrad Zuse
16 Bernard Zeigler
17 Carl Adam Petri
18 Anatol Holt
19 Roland Vollmar
20 Hans Bremerman
21 Donald Greenspan
22 Markus Buettiker
23 Otto Floberth
24 Robert Lewis
25 Robert Suaya
26 Stan Kugell
27 Bill Gosper
28 Lutz Priese
39 Madhu Gupta
30 Paul Benioff
31 Hans Moravec
32 Ian Richards
33 Marian Pour-El
34 Danny Hillis
35 Arthur Burks
36 John Cocke
37 George Michaels
38 Richard Feynman
39 Laurie Lingham
40 Thiagarajan
41 ?
42 Gerard Vichniac
43 Leonid Levin
44 Lev Levitin
45 Peter Gacs
46 Dan Greenberger

In the meantime Landauer encouraged me to publish another paper to make the notion of quantum computers more visible. The result was this paper.

Quantum Mechanical Models of Turing machines That Dissipate No Energy,
Paul Benioff
Phys. Rev. Lett. **48**, 1581 (1982) – Published 7 June 1982
Quantum mechanical Hamiltonian models of Turing machines are constructed here on a finite lattice of spin-½ systems. The models do not dissipate any energy and they operate at the quantum limit in that the system (energy uncertainty)/(computation speed) is close to the limit given by the time-energy uncertainty principle.

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This was not the end of controversy. In 1984 the following paper appeared.

Dissipation in Computation
W. Porod, R. O. Grondin, D. K. Ferry, and G. Porod
Phys. Rev. Lett. **52**, 232 (1984) – Published 16 January 1984
The question of the energy dissipation in the computational process is considered. Contrary to previous studies, dissipation is found to be an integral part of computation. A complementarity is suggested between systems that are describable in thermodynamic terms and systems that can be used for computation.

In response, comments section of Phys. Rev. Lett. Of Sept, 17,1984 was taken over with criticisms of paper by Bennett, Benioff, Toffoli, and Landauer.

Porod et al responded in same PRL section with a criticism of our criticisms. Their response ended with the following:

> "In summary, much of the above commentary concerns various Gedankenexperimente which are claimed to demonstrate dissipationless computation. The fact that these machines are carefully designed to be logically invertible is irrelevant for the question of dissipation. We further argue with these constructions on physical grounds. In designing a valid experiment one must retain, and not a priori discard, the possibility of dissipation and broken time-reversal symmetry. "

This was essentially the end of criticism, as far as I was aware.

Next phase in development of quantum computation.

My models were limited to strings of single qubit states as in $\psi_s = |s_1\rangle|s_2\rangle, \cdots, |s_n\rangle$ where $s_j = 0, 1$. Did not realize power of quantum computation in acting on state that is linear superposition, of single string states as in

$$\psi = \frac{1}{2^{n/2}} \sum_s \psi_s.$$

Hamiltonian acts on all 2^n input string states similtaneously. This is referred to as exponentially fast computation.

If one calculates values of a function, f, final state has form

$$\psi_f = \frac{1}{2^{n/2}} \sum_s \psi_{f(s)}.$$

If one is interested in a specific value, $f(s)$ for a given s speedup is lost. About 2^n repetitions of computation needed.

If one is interested in a property of the values as a whole, speedup in determining value of property may be preserved.

Shors Algorithm for finding prime factors of large numbers is example.

Proposed in 1994 by Peter Shor.

Algorithm caused explosion of interest in quantum computing.

Finding prime factors of large numbers basis of RSA coding.

Used by security agencies, banks for encryption.

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As shown by presentations at this symposium, there is much work towards goal of creating a quantum computer.

Work consists of creating physical models of groups of qubits in entangled states that evolve under some type of interaction and are stable against decoherence or errors for a sufficient period.

Wikipedia: As of 4/2016, largest integer factored is 200,099 by D-wave quantum processor.

Would like to change topic and discuss briefly recent work.

Background

Interested in relationship between foundations of mathematics, physics.
Influenced by Wigner's 1960 paper, "The unreasonable effectiveness of mathematics in the natural sciences".

If mathematical systems have an ideal existence outside of space and time, physical systems exist in space time, no reason they should be related.

Led me to consider possible existence of a coherent theory of physics and mathematics together as a coherent whole rather than as separate entities.

Work in last decades has been with a goal of developing and understanding aspects of such a theory

Approach to coherent theory taken here:

Based on mathematical framework used in gauge theories,

Extending framework to other areas of physics and geometry.

Framework is that of local vector spaces:

A vector space is associated with each point of space time.

Vector spaces are closely associated with scalars,

Closed under scalar vector multiplication, Norms

Seemed strange that local sets of scalars were not included.

One global set of scalars for local vector spaces.

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Framework extension:: Associate a set of scalars for the vector space with each point of space time.

Real vector spaces $\bar{R}_x \times \bar{V}_x$

Complex vector spaces (Hilbert spaces) $\bar{C}_x \times \bar{V}_x$.

Basic aspect of gauge theories is gauge freedom:

Corresponds to freedom of basis choice in different vector spaces.

States in $\bar{V}_y$ related to those in $\bar{V}_x$ by unitary operator $U(x,y)$

In group for standard model of elementary particles.

What corresponds to gauge freedom for the scalars?

Mathematical systems

To answer this question must have some idea of
what mathematical systems are.

Take description from mathematical logic that mathematical
systems of different types are structures or models.

A structure or model for a system of a given type consists of a base set, a few basic operations, relations, and constants. Axioms relevant for the structure type must be true.

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Examples of structures

$$\text{Natural numbers: } \bar{N} = \{N, +, \times, <, 0, 1\}$$
$$\text{Real numbers: } \bar{R} = \{R, \pm, \times, \div, <, 0, 1\}$$
$$\text{Complex numbers: } \bar{C} = \{C, \pm, \times, \div, 0, 1\}$$
$$\text{Vector space: } \bar{V} = \{V, \pm, \cdot, |-|, \phi\}$$

Structures for many other types of mathematical systems

Number and number value.

These are two distinct concepts that are usually identified.

Numbers are elements of the base set of structures.

A number acquires a value as a base set element of a structure.

$\bar{N} = \{N, +, \times, <, 0, 1\}$
$\bar{R} = \{R, \pm, \times, \div, <, 0, 1\}.$

By themselves numbers in N, R have no intrinsic value.

They acquire value only as elements of a base set of a structure.

Values are different in different structures of same number type.

Shall see that there are many different structures of each number type.

Each structure must satisfy axioms relevant to number type.

Natural number model:

Set, N that is discretely well ordered
with no maximal element.

Elements of N are numbers.

Value determined by position in well ordering.

First element, value 0, second element, value 1, etc.

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N_2, subset of N with every other element of N.

Inherits well ordering of N.

First element of N_2 value 0, second element value 1, etc.

Number with value 1 in N_2 has value 2 in N.

Number with value n in N_2 has value $2n$ in N.

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Values of numbers in $\bar{N}_n = \{N_n, +_n, \times_n, <_n, 0_n, 1_n\}$

Scaled by factor of $1/n$ relative to values of numbers N_n in $\bar{N}$

where $\bar{N} = \{N, +, \times, <, 0, 1\}$.

Shows numbers as base set elements have no intrinsic value

Value determined by mathematical environment

Concepts of number and number value are distinct.

This distinctness extends to other number types.

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This distinctness and number scaling extends to other number types.

Structures for real numbers scaled by r, s

$\bar{R}^r = \{R, \pm_r, \times_r, \div_r, <_r, 0_r, 1_r\}$

$\bar{R}^s = \{R, \pm_s, \times_s, \div_s, <_s, 0_s, 1_s\}$

a_r and a_s are numbers in R

with value a in $\bar{R}^r$ and $\bar{R}^s$

a_r is different number in R from a_s.

value of a_r in $\bar{R}^s$ is $\frac{r}{s}a$.

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Structure $\bar{R}^r_s$: Components of $\bar{R}^r$ in terms of those in $\bar{R}^s$.

$$\bar{R}^r_s = \{R, \pm_s, \frac{s_s}{r_s}\times_s, \frac{r_s}{s_s}\div_s, <_s, 0_s, \frac{r_s}{s_s}1_s\}.$$

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Structure $\bar{C}^r_s$: Components of $\bar{C}^r$ in terms of those in $\bar{C}^s$.

$$\bar{C}^r_s = \{C, \pm_s, \frac{s_s}{r_s}\times_s, \frac{r_s}{s_s}\div_s, 0_s, \frac{r_s}{s_s}1_s\}.$$

Scaling of analytic functions:

$$f_r(a_r) \rightarrow \frac{r_s}{s_s} f_s(a_s).$$

Scaling with numbers extends to other types of mathematical structures,

Those that include numbers in their axiomatic description.

Vector spaces:

$\bar{V}^r = \{V, \pm_r, \circ_r, |\psi_r|_r, \psi_r\}$

$\bar{V}^s = \{V, \pm_s, \circ_s, |\psi_s|_s, \psi_s\}$

ψ_r, ψ_s vectors in V with vector value, ψ in $\bar{V}^r$, $\bar{V}^s$.

ψ_r differs from ψ_s by scaling factor ratio.

$\bar{V}^r_s$: representation of components of $\bar{V}^r$ in terms of those of $\bar{V}^s$.

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Effect of scaling: multiply vectors by numerical scaling factor.

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Effect of scaling: multiply vectors by numerical scaling factor.

This completes summary of number scaling

Explore effects on some physical and geometric quantities

Gauge theories

What corresponds to gauge freedom for the scalars?

Freedom of choice of scaling factors at different space time points.

Introduce complex scalar scaling field, g,
where $g(x)$ complex number value.
Purpose of g: to give complex number scaling factor,
$g(x)$, for each point x of space time.

Let ϕ be vector field where for each x,
$\phi(x)$ is a vector value in $\bar{V}_x^{g(x)}$.

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Follow ususal steps in gauge theory to get covariant derivative,

$$D_{\mu,x}\phi = (\partial_{\mu,x} + \frac{\partial_{\mu,x} g(x)}{g(x)})\phi(x).$$

Replace $g(x)$ by its equivalent expression

$$g(x) = e^{\gamma(x)} = e^{\alpha(x)+i\beta(x)}$$

$\alpha(x)$, $\beta(x)$ real valued scalar fields.

$D_{\mu,x}$ becomes

$$D_{\mu,x} = (\partial_{\mu,x} + A_\mu(x) + iB_\mu(x))\phi.$$

$\vec{A}$, $\vec{B}$ gradients of α, β.

Abelian gauge theory, QED

Covariant derivative with photon field P included is

$$D_{\mu,x}\phi = (\partial_{\mu,x} + c_a A_\mu(x) + ic_b B_\mu(x) + ic_p P_\mu(x))\phi.$$

c_a, c_b, c_p are coupling constants.

Invariance of terms in QED Lagrangian
under local $U(1) = e^{i\theta(x)}$ gauge transformations
places no mass restrictions on $\vec{A}$.
Mass of $\vec{B}$ must be 0 if it shares with $\vec{P}$
some of invariance breaking term, $\partial_{\mu,x}\theta(x)$.
Otherwise any mass is possible.

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Physical properties, restrictions on α, β fields.
Both are scalar, spin 0 fields.
Great accuracy of QED without α, β fields
requires coupling constants, c_a, and probably c_b
to be very small relative to fine structure constant,
or $\vec{A}$, $\vec{B} \simeq 0$ in local region of space and time.

Extensions of number scaling by g field to other areas of physics and geometry.

Based on:

- Use of mathematical framework of local scalar, vector space structures in other areas of physics, geometry.
- Freedom of choice of scaling factors as shown in scaling g field.
- Treatment of integrands of integrals over space, time, or space time as fields as in gauge theory.

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Quantum mechanics, nonrelativistic

Wave packet $\psi = \int \psi(y)|y\rangle dy = \int \lambda(y) dy$.

Integral is over Euclidean 3 space.

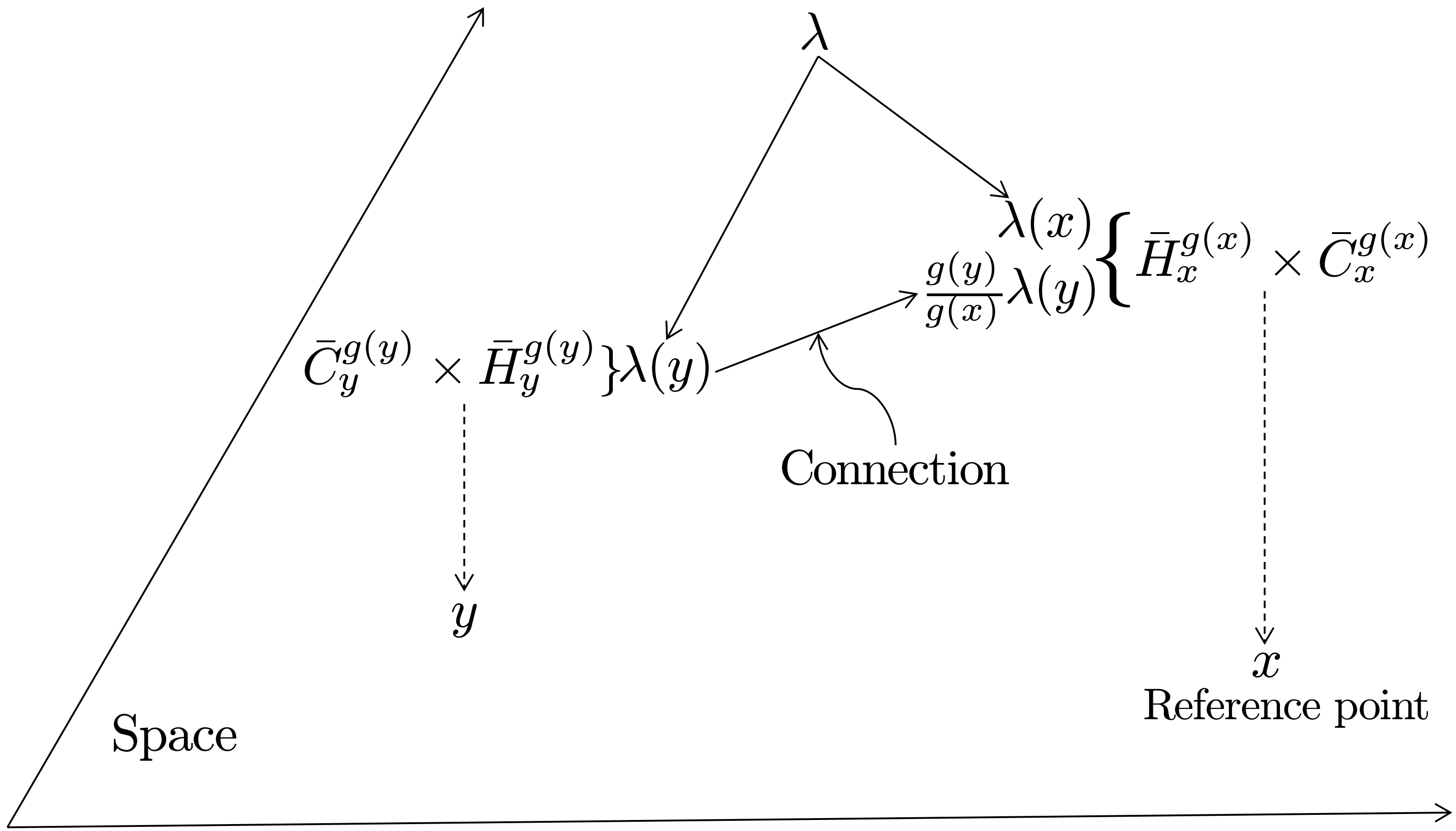
λ is a field of vector values, $\lambda(y)_{g(y)}$ is a vector in $\bar{H}_y^{g(y)}$.

$\bar{H}_y^{g(y)}$ is a separable Hilbert space scaled by $g(y)$.

Integral not defined:

Implies sum of vectors in different Hilbert spaces.

Remedied by use of connection to map field values to vector values in $\bar{H}_x^{g(x)}$ at reference location, x.


λ
$\lambda(x)$
$\frac{g(y)}{g(x)}\lambda(y)$
$\bar{H}_x^{g(x)} \times \bar{C}_x^{g(x)}$
$\bar{C}_y^{g(y)} \times \bar{H}_y^{g(y)}$
$\lambda(y)$
Connection
y
x
Reference point
Space

Resulting expression:

$$\psi_g = \int_x \lambda_{g,x}(y)dy = \frac{1}{g(x)} \int_x g(y)\psi(y)|y\rangle dy.$$

Expression with scaling results from treating integrand in ψ like a vector field in gauge theory. For each location y

$\lambda(y) = \psi(y)|y\rangle$ is a vector value in $\bar{H}_y^{g(y)}$.

λ is globally valued field.

Usual expression with no scaling is obtained by letting $\lambda(y)$ be vector value in $\bar{H}_x^{g(x)}$.

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Momentum of scaled field given by

$$\tilde{p}\lambda_{g,x}(y) = i\hbar g(y) \textstyle\sum_j (\Gamma_j(y) + \partial_{j,y})\lambda(y).$$

$\vec{\Gamma} = \vec{A} + \vec{i}B$ gradient field of γ where

$$g(y) = e^{\gamma(y)} = e^{\alpha(y)+i\beta(y)}.$$

Path lengths in geometry

Base space: Euclidean or Minkowski:

Associate $\bar{R}_x, \bar{T}_x$ with each point x of space.

$\bar{T}_x$ vector space model of base space,

$\bar{R}_x$ associated real scalars.

In presence of real valued scaling function, g,

$\bar{R}_x, \bar{T}_x$ becomes $\bar{R}_x^{g(x)}, \bar{T}_x^{g(x)}$.

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Let p be a timelike path on the base space:

$p(\gamma)$ a point in base space $p(0)$, $p(1)$ initial, final points.

Let $\nabla_\gamma p$ be slope of p at point $p(\gamma)$.

Distance element along path at point $p(\gamma)$ is

$$ds(p(\gamma)) = (\nabla_\gamma p \cdot \nabla_\gamma p)^{1/2} d\gamma = \sqrt{-\eta^{\mu,\mu}(\partial_{\mu,\gamma} p)^2} d\gamma$$

Usual expression for path length is

$$L(p) = \int_0^1 ds(p(\gamma)) = \int_0^1 (\nabla_\gamma p \cdot \nabla_\gamma p)^{1/2} d\gamma.$$

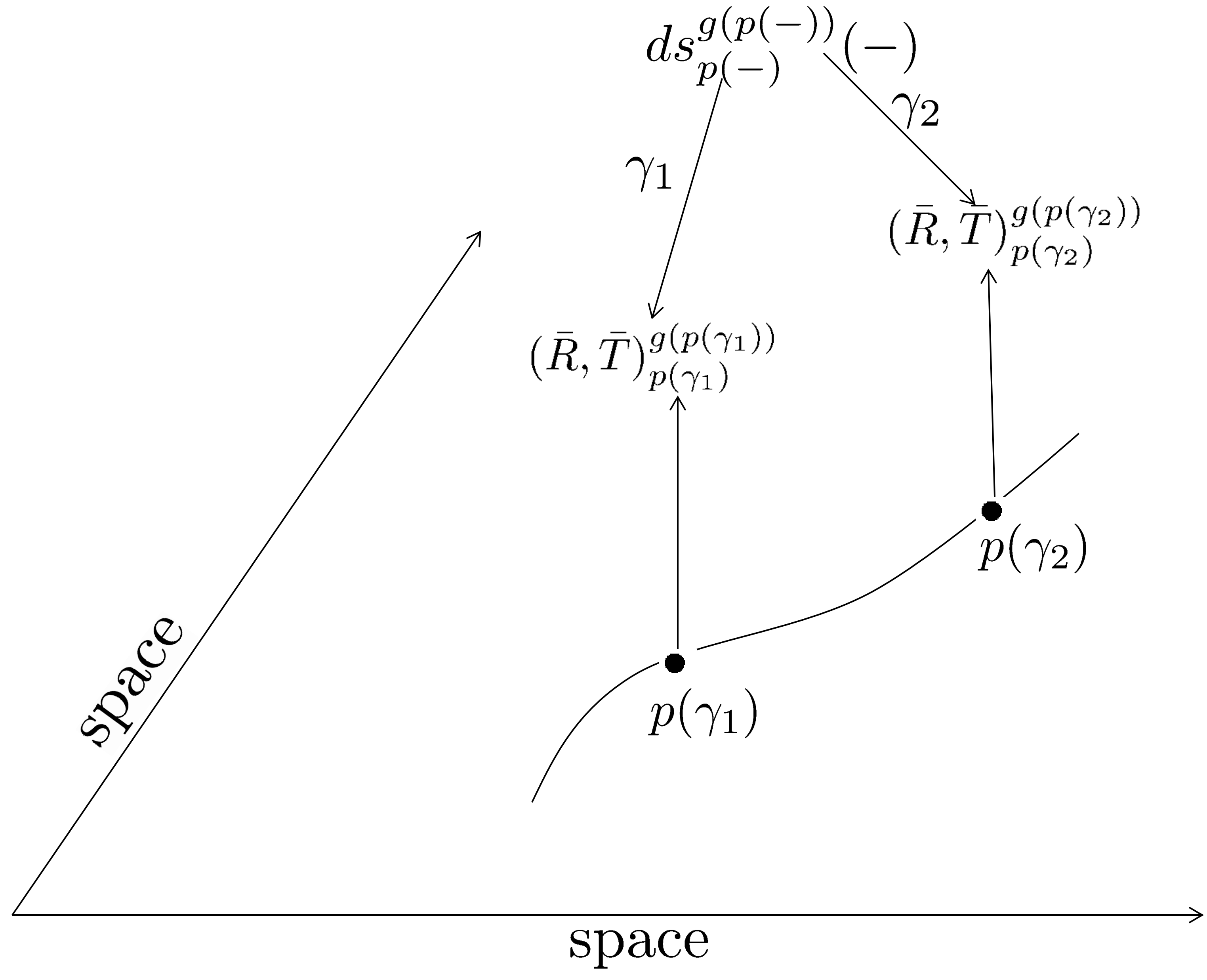
Treatment of path as a field, as in gauge theory

In the presence of scaling, $\nabla_{-\,-}p$ is a vector field
where $\nabla_{\gamma}p_{g(p(\gamma))}$ is a vector in $\bar{T}^{g(p(\gamma))}_{p(\gamma)}$.
$(\nabla_{-\,-}p\cdot\nabla_{-\,-}p)^{1/2}$ is a scalar field where $(\nabla_{\gamma}p\cdot\nabla_{\gamma}p)^{1/2}_{g(p(\gamma))}$
is a real number in $\bar{R}^{g(p(\gamma))}_{p(\gamma)}$.

Path length $L(p)=\int_0^1(\nabla_{\gamma}p\cdot\nabla_{\gamma}p)^{1/2}_{g(p(\gamma))}d\gamma$ does not make sense.
Remedy: Transfer integrand as numbers in $\bar{R}^{g(p(\gamma))}_{p(\gamma)}$
to the same numbers in $\bar{R}^{g(x)}_{x}$ at reference point, x.
Path length integral becomes,

$$L_{g,x}(p)_{g(x)}=\frac{1_{g(x)}}{g(x)_{g(x)}}\int_0^1 g(p(\gamma))_{g(x)}(\nabla_{\gamma}p\cdot\nabla_{\gamma}p)^{1/2}_{g(x)}d\gamma.$$

This is a number in base set of $\bar{R}^{g(x)}_{x}$.
Path length value is
$L_{g,x}(p)=\frac{1}{g(x)}\int_0^1 g(p(\gamma))(\nabla_{\gamma}p\cdot\nabla_{\gamma}p)^{1/2}d\gamma.$


$ds^{g(p(-))}_{p(-)}(-)$
γ_1
γ_2
$(\bar{R},\bar{T})^{g(p(\gamma_2))}_{p(\gamma_2)}$
$(\bar{R},\bar{T})^{g(p(\gamma_1))}_{p(\gamma_1)}$
$p(\gamma_2)$
$p(\gamma_1)$
space
space

Replacement of $g(x)$ with $e^{\alpha(x)}$ gives

$$L_{g,x}(p) = e^{-\alpha(x)} \int_0^1 e^{\alpha(p(\gamma))} \sqrt{-\eta^{\mu,\mu}(\partial_{\mu,\gamma} p)^2} d\gamma.$$

Scaled length of straight line path from z to y at reference point, x is

$$|y - z|(e^{\alpha(y)} - e^{\alpha(z)})e^{-\alpha(x)}.$$

Distance between points y and z, referenced to point x, obtained by use of geodesic equation.

Reconciliation of scaling field with experiment

Recall $g(x) = e^{\alpha(x)+i\beta(x)}$.

α, β are independent scalar fields.

Must reconcile use of g field with basic fact:

No direct physical evidence for field presence.

Imposes restrictions on α, β fields.

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From gauge theory, great accuracy of QED, one knows

coupling constants of α, β fields to matter fields must

be very small relative to fine structure constant.

or $\vec{A}, \vec{B} \simeq 0$ in local region of space and time.

α, β are spin 0 scalar fields.

Restrictions that are based on lack of evidence for scaling in geometry and quantum mechanics are based on following observations.

All measurements, observations done by us are local. Includes observations of cosmological systems,

Region of space, time accssible for us includes solar system, stars near enough for communication with civilizations on planets around stars.

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Restriction: Within region, fields α, β must be constant. Outside region, restrictions imposed by locality of measurements, observations do not apply.

Size of region: must be small compared to universe.
One literature estimate, must be region of about
500 light years radius.

H.A.Smith, "Alone in the Universe" Amer. Scientist, **99**(4),320, (2011)

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500 light years radius.

Candidates for α, β (spin 0 scalar) fields:
Higgs, inflaton, quintessence, dark matter, dark energy

Possibilities: Higgs, dark energy.
dark energy because α field affects
distances between points in space and time.
Higgs because, like Higgs, fields are spin 0 scalar.
Literature relating Higgs and dark energy.

H.A.Smith, "Alone in the Universe" Amer. Scientist, **99**(4),320, (2011)
M. Rinaldi, "Higgs, dark energy", arXiv:1404.0532v4
M. Czachor, "Dark energy as a manifestation of nontrivial arithmetic," arXiv:1604.05738

Summary

Described early days of quantum computing.

Showed existence of theoretical models of

Quantum Turing machines that do not dissipate energy..

Described reactions of those who did not believe that

dissipationless computing was possible

Noted explosion of interest when Shor's algorithm appeared.

Briefly described recent work on effect of scaling field on physics, geometry.

Based on separation of concepts of number and number value,

inclusion of local scalars with local vector spaces

Showed that freedom of choice of scaling factor for scalars could be

included as scalar scaling field.

Effects of scaling field on physical, geometric quantities determined by

treating quantities, such as integrands, paths,

like fields in gauge theory

Physical restrictions on scaling fields, α, β.

α, β spin 0, and any mass possible for α, maybe same for β.

Either coupling constants of fields very small or

Fields almost constant in local region of space, time.

Outside region, no restrictions on values.