Barabasi "Bose-Einstein Condensation in (so called) 'Complex'-Networks" ***Re***discovery of Siegel Artificial-Neural-Networks "EUREKA" + "SHAZAM" Optimizing Optimization-Problems Optimally (OOPO) Automatic-Mathematical-Catastrophe ("AUTMATHCAT") Crossover from Slow Memory-Hogging "Simulated-Annealing" + "Boltzmann-Machine" to "Bose-Einstein CONDENSATION Machine"

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Fuzzy-Logic/Physics "FUZZYICS"' "Fuzzycity" Optimizing Optimization-Problems Optimally (OOPO) of Neural-Networks (N-N's) Via *Quantum-Statistics* Crossover Equivalence to Switching-Function Sigmoidal→***Anti***-Sigmoidal Crossover Equivalence to "Noise" Power-Spectrum Crossover "Noise-'Induced'/ 'Driven'-Phase-Transitions (NIT's) ***Vast-Acceleration*** *Control* Via "NIT-Picking: "Eureka" and "Shazam" N-N *Bose-Einstein* ***Condensation*** ***Automatic Optimality***

Horsthemke-Lefever-Moss-McClintock-Hongler-Siegel-...) "'noise'-'induced'/'driven'/ concomitance phase-transition" ("NIT") between power-spectrum critical-exponents: $P(\omega)=[\text{"1"}/\omega^{n=0}$-White]–to→$P(\omega)=(\ldots\text{"1"}/\omega^{1.000\ldots}$-***Hyperbolicity***...), with *control* ("NIT-picking") implementation *two-step* application ***vastly-accelerates*** neural-network (N-N) inefficiency. "Eureka": by-rote sigmoid switching-function $1/[1+e^{-E/T}]=1/[+1+e^{-E/T}]$ (Lipmann-Siegel) identification as *Fermi-Dirac* (*F-D*):$1/[e^{\hbar\omega/kT}+1]= 1/[e^{E/T}+1]$ *quantum-statistics* ***exactly-wrong*** (Pauli exclusion-principle/Hund's-rule) ***automatic*** *non*-optimal *local*-minima *trapping* (a.k.a. "chemical-elements"). *Sign-change*/crossover to ***exact-opposite Bose-Einstein*** (***B-E***) *quantum-statistics* (*F-D*):$1/[e^{\hbar\omega/kT}+1]=1/[1+e^{-E/T}]=1/[+1+e^{-E/T}]$–crossover→ (***B-E***): $1/[e^{\hbar\omega/kT}-1]=1/[e^{E/T}-1]$ equivalence to *anti*-sigmoidal switching-function $1/[+1+e^{-E/T}]$–crossover→$1/[-1+e^{-E/T}]$ *completely-avoids* such inefficiency via Siegel quantum-statistics low-argument/infra-red-(E<<T)-limit $e^{E/T}$ Taylor/power-series-expansion: (*F-D*):$1/[e^{\hbar\omega/kT}+1]=1/[+1+e^{-E/T}]\cong 1/[1+[1+(E/T)+\ldots]]\cong 1/[2+(E/T)]\cong 1/2\cong [\text{"1"}/\omega^{n=0}$-White]–crossover→(***B-E***):$1/[e^{\hbar\omega/kT}-1]=1/[-1+e^{-E/T}]\cong 1/[\cancel{1}+[\cancel{1}+(E/T)+\ldots]]\cong 1/(E/T)\cong\text{"1"}/E= (\ldots\text{"1"}/\omega^{1.000\ldots}$-***Hyperbolicity***...). "Shazam": *infinite*-numerator-limit: $\lim_{\#\to\infty}\{\#/[e^{\hbar\omega/kT}-1]\}= \lim_{\#\to\infty}\{\#/[-1+e^{-E/T}]\}\cong \lim_{\#\to\infty}\{\#/E\}= \lim_{\#\to\infty}\{(\ldots\#/\omega^{1.000\ldots}$-***Hyperbolicity***...)$\equiv d(w-\mathbf{0})$ effects N-N *Bose-Einstein* ***Condensation automatic optimality***! (versus both Hsu's long-predicted/never-implemented accidentally/partially Demuth-Beale/Matlab-NN-toolbox (only $5\text{x}10^3$) Gaussian-$2^{-x\cdot x}$!)

Barabasi-Bianconi[Phys. Rev. Lett. 86, 24, 5632 (2001)] (BB) "Bose-Einstein Condensation in (so called) 'Complex'-Networks" is manifestly-demonstrated to be a ***re***discovery of Siegel "EUREKA" + "SHAZAM" ***purposeful*** Bose-Einstein Condensation ***of*** artificial neural-networks (ANNs) via a Horsthemke-Lefever[Noise Induced Phase-Transitions, Springer (1983)]-Moss-McClintock[Noise in Physical-Systems, (1990)]-Hongler[Chaotic and Stochastic Behavior in Automatic Production Lines, Springer (1994)]-Siegel[Symp. on Fractals,..., M.R.S. Fall Mtg., Boston (1989)-5 papers!] "(so called) 'noise'-induced/driven phase-transition" ("NIT") via *control* "NIT-***picking***" to replace slow cumbersome "simulated-annealing" + "Boltzmann-machine" with a "Bose-Einstein Condensation (BEC)-machine" to force ANN from local nonoptimal-minima to the global optimum-minimum (if one exists), to optimize optimization-problems optimally (OOPO).

Subsequently, the Demuth-Beale Mathworks Matlab ANN-Toolbox achieved same by

Barabasi-Bianconi (BB) "Bose-Einstein Condensation ***in*** (so called) 'Complex'-Networks"/Random-Graphs Summary and Metamorphosis to Siegel "Bose-Einstein Condensation ***of*** (so called) 'Complex'-Networks"

Barabasi-Bianconi[Phys. Rev. Lett. 86, 24, 5632 (2001)] (BB) "Bose-Einstein Condensation *in* (so called) 'Complex'-Networks" is summarized and its metamorphosis to a ***re***discovery of Siegel "Bose-Einstein Condensation ***of*** (so called) 'Complex'-Networks" detailed.

Barabasi-Bianconi[Phys. Rev. Lett. 86, 24, 5632 (2001)] (BB) "Bose-Einstein Condensation ***in*** (so called) 'Complex'-Networks" Summary

In detail, Barabasi-Bianconi[Phys. Rev. Lett. 86, 24, 5632 (2001)] (BB) "Bose-Einstein Condensation *in* (so called) 'Complex'-Networks" is both summarized, critiqued, and identified as a metamorphosis of/ relative to/ vis a vis much-earlier original Siegel[Symp. on Fractals..., M. R. S. Fall Mtg., Boston (19***89***)-5-papers!; Schrodinger Centenary Symp., Imperial College, London (19***87***); I. B. M. (a.k.a. "Reich-III") Conf. On Computers and Mathematics, Stanford (19***86***)] "Bose-Einstein condensation ***of*** (so called) 'Complex'-Networks".

BB abstract emphasizes for their object of study, (so called) "complex"-networks/random-graphs, hence their results, universality:

- Lawrence-Giles[Nature (London) 400, 107 (1999)] World Wide Web (www) site competition for URLs to enhance their visibility,
- Kermin[J. Evol. Econ. 4, 339 (1997)] business world company competition for links to consumers,
- Redner[Euro. Phys. J. B, 4, 131 (1998)] scientific-community scientists and publications competition for citations as a (false!) measure of their impact on "the" field (typical B. U. - B. S.!),

Common-feature identified is Lawrence-Giles-Redner- Adamic-Huberman[Science 287, 2115 (2000)]-Albert-Jeong-Barabasi [Nature (London) 401, 130 (1999)]-Watts-Strogatz[Nature (London) 393, 440 (1998)] "nodes (so called) 'self-organization' (media-hype P. R. spin-doctoring "bushwaaah!) into (so called) 'complex'-networks/random-graphs, whose 'topology and evolution 'reflect' the dynamics (dynamics = time-dependence *is* evolution!) and outcome of this 'competition' (a.k.a. (so called) 'frustration' (another trendy Irlon-Anderson-Pines-Laughlin-Frauenfelder-...-'ICAM' [New Scientist 32 (6/11/2001)] buzzword media-hype P.R. spin-doctoring bushwaaah!; known long ago by so very many: Cohen[in Transition-Metal Magnetism, Fermi School in Physics, T. Moriya ed., Academic (19*67*)]-Moriya[ibid]-Penn[Phys. Rev. ??? (~19*66*)]-Siegel-Kemeny[Doctoral Dissertation, M. S. U. (19*70*); Phys. Stat. Sol.: (b) 50, 593 (19*72*) ; (b) 55, 817 (19*73*); J. Mag. Mag. Mtls. (19*76*-19*80*) - many-papers; Mag. Lett. (19*80*) -2-papers!;...]".

BB claim to show, despite nonequilibriumness and irreversibility, that evolving/dynamic networks/random-graphs can be "*1:1-mapped*" onto an equilibrium ((so called) "complex"/evolving-network/random-graph *nodes/vertices/entities corresponding to quantum* energy-levels, *with links corresponding to particles*) ***Bose***-gas, and in doing so, are actually ***re***deriving a central portion of Siegel[Symp. on Fractals..., M. R. S. Fall Mtg., Boston (19***89***)-5-papers!; Schrodinger Centenary Symp., Imperial College, London (19***87***); I. B. M. (a.k.a. "Reich-III") Conf. On Computers and Mathematics, Stanford (19***86***)] "Synergetics Paradigm & Dichotomy" (S.P.D.) "**FUZZYICS**" **INEVITABILITY -WEB**, and Siegel[(1998); Am. Math. Soc. Mtgs. (1998-2000); SIAM Ann. Mtg., San Diego (2001); Am. Math. Soc. Ann. Mtg., San Diego (2002)] ostensibly "pure-mathematics" DIGITS' "NeWBe"-law inter-digit (*on average*) *statistical* logarithmic-correlations INVERSION to ***only Bose-Einstein*** *quantum-statistics* **physics!**, (DIGITS in decimal-number (so called) "complex"/evolving-network/random-graph *nodes/vertices/entities corresponding to quantum* energy-levels 'spin(***e***)less-boZos' (SoBs)", *with links* ((*on average*) inter-digit *statistical* logarithmic-interactions) *corresponding to particles*), wherein decimal-numbers are a DIGIT-gas with (*on average*) inter-digit *statistical* logarithmic-correlations caused by (*on average*) inter-digit *statistical* logarithmic-interactions, necessarily in the dual-integral-transform-space inverse (k, ω)-space(s) Hubbard-like Hamiltonian.

BB's "1:1-mapping" predicts common-sense epithets characterizing competition/(so called)"frustration": "winner takes all", "fit get rich" (FGR), "first mover advantage" "emerging"(another/still more media-hype P.R. spin-doctoring buzzword bushwaaah!) naturally as topologically and thermodynamically distinct-phases of underlying (so called)"complex"/evolving-network/random-graph.

BB in particular predict (so called)"complex"/evolving-network/random-graph ***Bose-Einstein CONDENSATION*** (BEC), in which a single-node/vertex/entity captures a macroscopic-fraction of links.

BB, falling back upon "specificity-of-(so called)'complexity'" (SoC)-tactics:..., models,..., here their fitness-model[Barabasi-Bianconi, Europhys. Lett. - to be pub.] of a (so called) "complex"/evolving-network/random-graph growing by new nodes/ vertices/ entities acquisition, their generic (SoC)-tactics:..., model,... of:

- new webpages creation, or
- new companies emergence,

or

- new papers publication.

Nodes acquisition of links rate can vary widely, as Adamic-Huberman[Science 287, 2115 (2000)] www-network, and Redner [Euro. Phys. J. B, 4, 131 (1998)] citation-networks and economic-networks measurements ascertain.

BB assign a fitness-parameter h , representing nodes'/vertices'/entities' different-ability to compete for/capture links, from a fitness-parameter distribution $r(h)$, to account for differences in, generically:

- webpages' contents
- products' quality
- companies' marketing,
- a publications' findings importance.

New-node'/vertex'/entity's interconnection one of its m links to a network's/graph's already-present node/vertex/entity i probability Π_i depends on links-number k_i and node/vertex/entity-fitness h_i via $\Pi_i = \frac{h_i}{\sum_l h_l k_l}$, summarizing Barabasi-Albert-Jeong [Science 286, 509 (1999); Physica 281A, 69 (2000)] tendency for new-nodes/vertices/entities to preferentially link to higher-k (links-number) nodes/vertices/entities, most simply possible:

- connecting to more-visible websites,
- favoring more-established companies,
- citing more-cited papers,

and with larger node/vertex/entity-fitness h_i:

- connecting to better-content websites,
- favoring better-products and better-sales-practices companies,
- citing more-novel-results papers.

Node/vertex/entity-fitness h_i and links-number k_i jointly determine node/vertex/entity attractiveness and evolution/dynamics.

Crucial "*1:1-mapping*" to ***only Bose***-gas dominated by ***only Bose-Einstein*** *quantum-statistics* is in several steps:

- (1) assign to each node/vertex/entity an energy e_i determined by its node/vertex/entity-fitness h_i via $e_i = -\frac{1}{b}\log h_i$,

inter-nodes i and j, with respectively: energies e_i and e_j, and fitnesses h_i and h_j, link corresponds to two non-interacting-particles on energy-levels e_i and e_j. Adding a new node/vertex/entity to a network/random-graph corresponds to adding a new energy-level e_i and 2m particles. Of these 2m, m occupy energy-level e_i (corresponding to m outgoing links possessed by node i) versus the other m being distributed among the other energy-levels (representing links pointing to existing m-nodes/vertices/entities), with particle landing on level i probability $\Pi_i = \frac{h_i}{\sum_l h_l k_l}$. [deposited particles, forbidden to jump to other energy-levels, are inert].

Each-node/vertex/entity/energy-level added at time t_i with energy e_i is characterized by occupation-number $k_i(e_i, t, t_i)$ denoting links-number/particles a node/vertex/entity/energy-level occupies at time t.

Rate at which energy-level/node/vertex/entity e_i acquires new particles/links-number k_i is $\frac{¶\ k_i(e_i,t,t_i)}{¶t} = m\frac{e^{-be_i}k_i(e_i,t,t_i)}{Z_t}$ in terms of partition-function $Z_t \equiv \sum_{j=1}^{t} e^{-be_j} k_j(e_j, t, t_j)$.

BB assume each-node/vertex/entity "***increases its connectivity***" [meaning its ***topological-connectivity dimension*** $d_T^C \equiv (2\cdot genus+1) \equiv (2\cdot g+1)$ lower-bound on upper-bounded by geometric-embedding dimension $d_G^E \equiv d^{st} = (d^s + d^t) = (d^s + 1)$ ***lower-bound increase*** $\Delta d_T^C \equiv (2\cdot \Delta genus + 1) \equiv (2\cdot \Delta g + 1) \le D_{FRACTAL} \le d^{st} \equiv (d^s + d^t) = (d^s + 1)$] by a power-law $k_i(e_i, t, t_i) = m\left(\frac{t}{t_i}\right)^{f(e_i)}$ in terms on an energy-dependent dynamic-exponent $f(e)$.

Randomly-chosen node/vertex/entity-fitness h from node/vertex/entity-fitness - distribution $r(h)$ causes energy-levels/ nodes/ vertices/entities to be chosen from a causes energy-levels/ nodes/ vertices/entities - distribution $g(e) = br(e^{-be})e^{-be}$, averaging over which determines partition-function $Z_t \equiv \sum_{j=1}^{t} e^{-be_j} k_j\left(e_j, t, t_j\right)$ as average partition-function

$\left\langle Z_t \right\rangle = \int deg(e) \int_1^t dt_0 e^{-be_i} k\left(e, t, t_0\right) = \frac{m}{z} t\left[1 + O\left(t^{-a}\right)\right]$ in terms of inverse-fugacity $\frac{1}{z} = \int de \;\; g(e) \frac{e^{-be}}{1 - f(e)}$ and

$a = \min_e\left[1 - f(e)\right] > 0$.

Since fugacity $z = \frac{1}{\int de \;\; g(e) \frac{e^{-be}}{1 - f(e)}} > 0$ is positive, for any finite-temperature $b \neq 0$, BB introduce a *chemical-potential*

m as $e^{bm} \equiv z = \frac{1}{\int de \;\; g(e) \frac{e^{-be}}{1 - f(e)}} > 0$, i.e. as $m \equiv \frac{1}{b} \ln z = \frac{1}{b} \ln\left[\frac{1}{\int de \;\; g(e) \frac{e^{-be}}{1 - f(e)}}\right] > 0$ permitting rewriting of

average partition-function $\left\langle Z_t \right\rangle = \int deg(e) \int_1^t dt_0 e^{-be_i} k\left(e, t, t_0\right) = \frac{m}{z} t\left[1 + O\left(t^{-a}\right)\right]$ and inverse-fugacity

$\frac{1}{z} = \int de \;\; g(e) \frac{e^{-be}}{1 - f(e)}$ together as $e^{-bm} = \lim_{t \to \infty} \frac{\left\langle Z_t \right\rangle}{mt}$, which self-consistently solves energy-level/node/vertex/entity e_i

acquires new particles/links-number k_i acquisition-rate continuum-equation $\frac{¶ \;\; k_i\left(e_i, t, t_i\right)}{¶ t} = m \frac{e^{-be_i} k_i\left(e_i, t, t_i\right)}{Z_t}$ yielding solution

of assumed each-node/vertex/entity/ energy-level "*connectivity-increase*" [meaning its ***topological-connectivity dimension***

$d_T^C \equiv (2 \cdot genus + 1) \equiv (2 \cdot g + 1)$ lower-bound on upper-bounded by geometric-embedding dimension $d_G^E \equiv d^{st} = \left(d^s + d^t\right) = \left(d^s + 1\right)$]

power-law form $k_i\left(e_i, t, t_i\right) = m\left(\frac{t}{t_i}\right)^{f(e_i)}$ with dynamical-exponent $f(e) = e^{-b(e-m)}$, which combined with

$\frac{1}{z} = \int de \;\; g(e) \frac{e^{-be}}{1 - f(e)}$ yields chemical-potential as solution of $I(b, m) = \int de \;\; g(e) \frac{e^{-be}}{e^{b(e-m)} - 1} = 1$.

BB stress the properties of just-above system that make it unsuitable to be an equilibrium Bose-gas:

- particles'/links'-number inertness is a nonequilibrium-feature,

versus quantum-gas particles' inter-level/node/vertex/entity jumps causing a temperature-driven equilibrium,

- both eligible energy-levels/nodes/vertices/entities and populating particles/links-number increase *linearly* in time ["**FUZZYICS**" (relative)-1=time-(...GLOBALITY...) asymptotic-limit antipode],

versus quantum-system fixed system-size ["**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode].

Yet $I(b, m) = \int de \;\; g(e) \frac{e^{-be}}{e^{b(e-m)} - 1} = 1$ indicates that in ($t \to \infty$) thermodynamic-limit their BB "fitness-model" SoC-tactics "*1:1-maps*" onto an ***only Bose***-gas obeying ***only Bose-Einstein*** *quantum-statistics*!

Since in an ideal-gas of unit-volume ($v = 1$) Huang[Statistical-Mechanics, Wiley (1987)] states a normalization sum-rule

$\int deg(e) n(e)$ in terms of energy-level/node/vertex/entity occupation-number/density-of-states in energy/quantum-statistic $n(e)$,

BB's just-above derived fitness-model SoC-tactics inspired inert-gas $I(b, m) = \int de \;\; g(e) \frac{e^{-be}}{e^{b(e-m)} - 1} = 1$ yields

only Bose-Einstein *quantum-statistics* $n(e) = \frac{1}{e^{b(e-m)} - 1}$.

Thus BB conclude that their evolving/dynamic-network/random-graph "*1:1-maps*" onto ***only Bose-Einstein*** *quantum-statistics*, the evolving/dynamic-network/random-graph irreversibility and inertness are resolved by the asymptotic-distribution's stationarity, permitting in $t \longrightarrow \infty$ thermodynamic-limit occupation-numbers/link-numbers to obey ***only Bose-Einstein*** *quantum-statistics*.

Bose-Einstein *quantum-statistics* uniquely admit possibility of ***Bose-Einstein CONDENSATION***.

BB solutions: $k_i(e_i,t,t_i) = m\left(\frac{t}{t_i}\right)^{f(e_i)}$, $\langle Z_t \rangle = \int deg(e) \int_1^t dt_0 e^{-be_i} k(e,t,t_0) = \frac{m}{z} t\left[1 + O\left(t^{-a}\right)\right]$, and $f(e) = e^{-b(e-m)}$

can exist only when there exists a chemical-potential satisfying $I(b,m) = \int de \;\; g(e)\frac{e^{-be}}{e^{b(e-m)}-1} = 1$.

But this exhibits a maximum at $m = 0$, i. e. when $I(b,m) = \int de \;\; g(e)\frac{e^{-be}}{e^{b(e-m)}-1} < 1$ (for given b and $g(e)$) there is no solution, a well-known signature of ***Bose-Einstein CONDENSATION***, indicating finite-fraction $n_0(b)$ of particles/links condense into lowest energy-level/node/vertex/entity.

Due to mass-conservation at time t, there are t energy-levels/nodes/vertices/entities populated by 2mt particles/links, i. e.

$2mt = \sum_{t_0=1}^{t} k\left(e_{t_0}, t, t_0\right) = mt + mtI(b,m)$, such that, when $I(b,0) = I(b, m=0) = \int de \;\; g(e)\frac{e^{-be}}{e^{b(e-(m=0))}-1} < 1$,

$2mt = \sum_{t_0=1}^{t} k\left(e_{t_0}, t, t_0\right) = mt + mtI(b,m)$ is replaced by $2mt = mt + mtI(b,m) + n_0(b)$ with $\frac{n_0(b)}{mt} = 1 - I(b,0)$.

Lowest energy-level/node/vertex/entity occupancy corresponds to links-number/particles of energy-level/node/vertex/entity with maximal-fitness in their BB SoC-tactics fitness-model. Thus BB conclude that their ***Bose-Einstein CONDENSATION*** corresponds to non-zero $n_0(b)$ emergence represents their evolving/dynamical-networks/random-graphs "winner-takes-all" phenomenon, the fittest energy-level/node/vertex/entity/energy-level acquiring a finite-fraction of links/particles, ***in***dependent of network-*size/radius/extent/**scale***! ["**FUZZYICS**" (relative)-(...GLOBALITY...) asymptotic-limit antipode].

BB then predict existence of three "distinct" phases characterizing (so called) "complex"/random-graphs/networks-dynamics/evolution [***all equivalently identically*** "**FUZZYICS**" (relative)-(...GLOBALITY...) asymptotic-limit antipode**!**]:

- (a) ***Scale-free/Invariance***,

["**FUZZYICS**" (relative)-(...(***SCALE***-Invariance Symmetry-***RESTORING***...) asymptotic-limit antipode].

versus

- (b) "Fit-Get-Rich" (FGR),

["**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode].

"versus"

- (c) ***Bose-Einstein CONDENSATION***.

["**FUZZYICS**" (relative)-(... $\frac{\text{"1"}}{w^{1.000...}}$ -***HYPERBOLICITY***...) asymptotic-limit antipode].

(more correctly ["**FUZZYICS**" (relative)-(... $\lim_{\# \to \infty} \frac{\text{"\#"}}{w^{1.000...}} = d(w-0)$ -***HYPERBOLICITY***...) asymptotic-limit antipode])!

BB's SoC-tactics has *blinded* them to the reality that all three phases are ***equivalent***, and ***caused*** by ***only EVEN***-integer degrees-of-freedom/spacetime-dimensionality, via Siegel "**FUZZYICS**"!!!

BB claim three "distinct"-phases, which the "Parsimony-of-Dichotomy" (PoD)-**STRATEGY** of Siegel S.P.D. "**FUZZYICS**" ***automatically*** *integrates* (a) to (c), *versus* exact-opposite (b), *together* ***optimally*****!**:

- (a) ***Scale-free/Invariance*** (so called) "phase":

[Siegel S.P.D. "**FUZZYICS**" (relative)-(...GLOBALITY...) asymptotic-limit antipode on ***different*** S.P.D. "**FUZZYICS**" logic-levels!: here for (a) *both* the *equivalent*]:

when all-nodes/vertices/entities/energy-levels have same "fitness" , i. e. homogeneity, i. e. [Siegel S.P.D. "**FUZZYICS**" (relative)-(...GLOBALITY...) asymptotic-limit antipode on ***different*** S.P.D. "**FUZZYICS**" logic-levels!: here for (a) *both* the *equivalent*]: , i. e.

$r(h) = d(h-1) \quad i.e. \quad [g(e) = d(e)]$, their "fitness"-model "first-mover-wins" SoC-tactics reduce to their [Science, 286, 509 (1999); Physica 281A, 69 (2000)] ***Scale-free/Invariance*** model SoC-tactics, introduced to account for diverse-systems power-law connectivity-distribution!:

- www [Albert-Jeong-Barabasi, Nature (London) 401, 130 (1999), Albert-Barabasi, Phys. Rev. Lett. 85, 5234 (2000)],
- coauthorship-networks[Newman, con.-mat./0011144; Barabasi-Jeong-Neda-Ravasz-Schubert-Vicsek, cond.-mat./0104162],
- Internet[Faloutsos x 3,, Comput. Commun. Rev. 29, 251 (1999); Barabasi-Albert-Jeong, Nature (London) 406, 378 (2000)],
- citation-networks[Redner, Euro. Phys. B4, 131 (1998)].

Oldest-nodes/vertices/entities/lowest energy-levels acquire most-links/particles, (historical-precedence), "first-mover-wins" SoC-tactics, has $f(e) = e^{-b(e-m)}$ predicting $f(e) = \frac{1}{2}$, i. e. via $k_i(e_i, t, t_i) = m\left(\frac{t}{t_i}\right)^{f(e_i)}$, all nodes exhibit ***connectivity-increase***

[***topological-connectivity dimensionality lower-bound increase***:

$$\Delta d_T^C \equiv (2 \cdot \Delta genus + 1) \equiv (2 \cdot \Delta g + 1) \le D_{FRACTAL} \le d^{st} \equiv (d^s + d^t) = (d^s + 1)$$

of form:

$$\Delta d_T^C(t) \equiv (2 \cdot \Delta genus \sim t^{1/2} + 1) \equiv (2 \cdot \Delta g \sim t^{1/2} + 1) \le D_{FRACTAL} \le d^{st} \equiv (d^s + d^t) = (d^s + 1),$$

i. e.

$$\Delta d_T^C(t) \equiv (2 \cdot \Delta genus \sim t^{1/2} + 1) \equiv (2 \cdot \Delta g \sim t^{1/2} + 1) \sim t^{1/2} \text{],}$$

i. e. the oldest-nodes/vertices/entities/energy-levels with the smaller t_i have the larger k_i.

But the oldest and "richest" node/ vertex/ entity/energy-level is *not* the *absolute* winner, since its share of links/particles $\frac{k_{\max}(t)}{mt} \sim \frac{1}{t^{1/2}} \equiv t^{-1/2}$ decays to zero in the thermodynamic-$(t \to \infty)$-limit: $\lim_{t\to\infty} \frac{k_{\max}(t)}{mt} \sim \lim_{t\to\infty} \frac{1}{t^{1/2}} \equiv \lim_{t\to\infty} t^{-1/2} = 0$, creating a coexisting continuous-hierarchy of large-nodes/vertices/entities/energy-levels, such that the probability to have a [Barabasi -Albert-Jeong: Science 286, 509 (1999); Physica 281A, 69 (2000); Dorogovisev-Mendes-Samukhin, Phys. Rev. Lett. 85, 4633 (2000)] k-links/particles per node/vertex/entity/energy-level, the "degree-distribution" exhibits a power-law decay: $P(k) \sim \frac{1}{k^3} \equiv k^{-3}$,

wherein: rewiring, ageing, and other local-processes [Siegel S.P.D. "**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode] can modify scaling-exponents or introduce [Albert-Barabasi, Phys. Rev. Lett. 85, 5234 (2000); Dorogovisev-Mendes-Samukhin, Phys. Rev. Lett. 85, 4633 (2000); Amaral-Scala-Barthelemy-"Stanley", Proc. Nat. Acad. Sci. (U.S.A) 97, 11,149 (2000); Krapivsky-Redner-Leyvraz, Phys. Rev. Lett. 85, 4629 (2000); Krapivsky-Redner, cond.-mat/0011094] links/particles-number k-cutoffs, versus leaving their claimed (so called) "phase" unchanged.

versus

- (b) "Fit-Get-Rich" (FGR) (so called) "phase":

[Siegel S.P.D. "**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode on ***different*** S.P.D. "**FUZZYICS**" logic-levels!]:

supposedly distinct "versus" ***Scale-free/Invariance***(so called) "phase" (so called buzzword!) "emerges" when nodes/vertices/entities/energy-levels possess different-fitnesses, i. e. [Siegel S.P.D. "**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode on ***different*** S.P.D. "**FUZZYICS**" logic-levels] , i. e. heterogeneity, and an equation exists

$I(b,m) = \int de \;\; g(e)\frac{e^{-be}}{e^{b(e-m)}-1} = 1$ having a solution. $\frac{k_{\max}(t)}{mt} \sim \frac{1}{t^{1/2}} \equiv t^{-1/2}$ which indicates that each node/vertex/ entity/energy-level has a ***connectivity-increase*** in time:
[Siegel S.P.D. root-cause ultimate-origin at **0. Dimensionality/Degrees-of-Freedom Logic-Level O.**]

topological-connectivity dimensionality lower-bound increase:

$$\Delta d_T^C \equiv \left(2\cdot\Delta genus + 1\right) \equiv \left(2\cdot\Delta g + 1\right) \;\; \leq D_{FRACTAL} \leq d^{st} \equiv \left(d^s + d^t\right) = \left(d^s + 1\right)$$

of form:

$$\Delta d_T^C(t) \equiv \left(2\cdot\Delta genus \sim t^{1/2} + 1\right) \equiv \left(2\cdot\Delta g \sim t^{1/2} + 1\right) \;\; \leq D_{FRACTAL} \leq d^{st} \equiv \left(d^s + d^t\right) = \left(d^s + 1\right),$$

i. e.

$$\Delta d_T^C(t) \equiv \left(2\cdot\Delta genus \sim t^{1/2} + 1\right) \equiv \left(2\cdot\Delta g \sim t^{1/2} + 1\right) \;\; \sim t^{1/2},$$

i. e. the oldest-nodes/vertices/entities/energy-levels with the smaller t_i have the larger k_i]

but the [Bianconi-Barabasi, Europhys. Lett. (to be pub.)] dynamic-exponent is larger for highest-fitness nodes/vertices/entities/ energy-levels, allowing for [Adamic-Huberman, Science 287, 2115 (2000)] fitter-nodes/vertices/entities/energy-levels to join the network at some later time, and to surpass the older but less-fit nodes/vertices/entities/energy-levels by acquiring links/particles at higher-rates, this claimed (so called) "phase" describing their [BB] "get-rich-quick" phenomenon in which, with time, the fitter prevails. But, even though there exists a clear-winner similar to their ***Scale-free/Invariance***(so called) "phase", their fittest-node's/vertex's/entity's/energy-level's share of all links/particles decreases to zero in thermodynamic-$(t \to \infty)$-limit.

Since $f(e) = e^{-b(e-m)} < 1$, the fittest-node's/vertex's/entity's/energy-level's ***relative-connectivity*** decreases as $\frac{k(e_{\min},t)}{mt} \sim t^{f(e_{\min})-1}$, such competition again leading to a hierarchy of a few larger-"hubs" accompanied by many less-connected nodes/vertices/entities/energy-levels.
[Siegel S.P.D. "**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode on ***different*** S.P.D. "**FUZZYICS**" logic-levels!].

such that [Bianconi-Barabasi, Europhys. Lett. (to be pub.)] $P\left(k;g\left[r(h)\right]\right) \sim \frac{1}{k^{g[r(h)]}} \equiv k^{-g[r(h)]}$ holds.

"versus"

• (c) ***Bose-Einstein CONDENSATION*** (so called) "phase":
["**FUZZYICS**" (relative)-(... $\frac{\text{"1"}}{w^{1.000...}}$ -***HYPERBOLICITY***...) asymptotic-limit antipode].

(more correctly ["**FUZZYICS**" (relative)-(... $\lim_{\#\to\infty}\frac{\text{"\#"}}{w^{1.000...}} = d(w-0)$ -***HYPERBOLICITY***...) asymptotic-limit antipode])!

$I(b,m) = \int de \;\; g(e)\frac{e^{-be}}{e^{b(e-m)}-1} < 1$ ***in****equality* ***precludes*** any (BB) solutions:

$k_i\left(e_i,t,t_i\right) \neq m\left(\frac{t}{t_i}\right)^{f(e_i)}$, $\langle Z_t\rangle = \int deg(e)\int_1^t dt_0 e^{-be_i} k\left(e,t,t_0\right) \neq \frac{m}{z}t\left[1 + O\left(t^{-a}\right)\right]$, and $f(e) \neq e^{-b(e-m)}$,

equalities could only exist only when there exists a chemical-potential satisfying $I(b,m) = \int de \;\; g(e)\frac{e^{-be}}{e^{b(e-m)}-1} = 1$, *versus* here this exhibits a maximum at $m=0$, i. e. when $I\left(b,m\right)=\int de\ \ g\left(e\right)\frac{e^{-be}}{e^{b\left(e-m\right)}-1}<1$ (for given b and $g(e)$) there is no solution, a well-known signature of ***Bose-Einstein CONDENSATION***, indicating finite-fraction $n_0(b)$ of particles/links condense into lowest energy-level/node/vertex/entity.

Inter-node/vertex/entity/energy-level competition for links/particles favors largest-fitness - nodes/vertices/entities/energy-levels, those attracting a finite-fraction [$n_0(b)$] of links/particles-number. BB interpret this to mean that their ***Bose-Einstein CONDENSATION*** (so called) "phase" "predicts" a "real" "winner-take-all" phenomenon, wherein the fittest-node/vertex/entity/energy-level is not only the largest, but that which also acquires a finite-fraction of links/particles-number $\frac{n_0(b)}{mt}=1-[I(b,0)<1]>0$ despite continual-"emergence"/acquisition of new nodes/vertices/entities/energy-levels that compete for new links/particles acquisition.

BB claim to demonstrate a "FGR"- (so called) "phase" to ***Bose-Einstein CONDENSATION*** (so called) "phase" *phase-transition critical-phenomenon*.

But, with identification of BB "FGR"- (so called) "phase" as
["**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode].

versus

BB ***Bose-Einstein CONDENSATION*** (so called) "phase" as
["**FUZZYICS**" (relative)-(... $\frac{"1"}{w^{1.000...}}$ -***HYPERBOLICITY***...) asymptotic-limit antipode].

(more correctly ["**FUZZYICS**" (relative)-(... $\lim_{\#\to\infty}\frac{"\#"}{w^{1.000...}}=d(w-0)$ -***HYPERBOLICITY***...) asymptotic-limit antipode])!,

But BB's claimed ostensibly-disparate (so called) phases:

• (a) ***Scale-free/Invariance*** ,
["**FUZZYICS**" (relative)-(...(***SCALE***-Invariance Symmetry-***RESTORING***...) asymptotic-limit antipode].

versus

• (b) "Fit-Get-Rich" (FGR) ,
["**FUZZYICS**" (relative)-[LOCALITY] asymptotic-limit antipode].

versus

• (c) ***Bose-Einstein CONDENSATION*** .
["**FUZZYICS**" (relative)-(... $\frac{"1"}{w^{1.000...}}$ -***HYPERBOLICITY***...) asymptotic-limit antipode],

(more correctly ["**FUZZYICS**" (relative)-(... $\lim_{\#\to\infty}\frac{"\#"}{w^{1.000...}}=d(w-0)$ -***HYPERBOLICITY***...) asymptotic-limit antipode])!

but/versus

• (a) ***Scale-free/Invariance*** ,

["**FUZZYICS**" (relative)-(...(***SCALE***-Invariance Symmetry-***RESTORING***...) asymptotic-limit antipode],

at the S.P.D. "**FUZZYICS**" logic-level***s***:

<u>I. Radius/Extent/*Scale*/... Logic-Level I.</u>
and
<u>IV.</u> **<u>Symmetries/Invariances/Noether's-Theorem Conservation-Laws Logic-Level IV.</u>** *star of possibilities*

(most especially in particular here the:

<u>*SCALE*-Invariance Symmetry-*Restoring /* Noether's-Theorem *SCALE-4-Current* Conservation-Law Logic-Level IV.</u>)

exact equivalence to

• (c) ***Bose-Einstein CONDENSATION***
["**<u>FUZZYICS</u>**" (<u>relative</u>)-(... $\frac{"1"}{w^{1.000...}}$ -***<u>HYPERBOLICITY</u>***...) asymptotic-limit antipode],

(more correctly ["**<u>FUZZYICS</u>**" (<u>relative</u>)-(... $\lim_{\#\to\infty} \frac{"\#"}{w^{1.000...}} = d(w-0)$ -***<u>HYPERBOLICITY</u>***...) asymptotic-limit antipode])!,
at the S.P.D. "**<u>FUZZYICS</u>**" logic-level***s***:

<u>II. Power-Spectrum Logic-Level II.</u>
and
<u>III. Critical-Exponents Logic-Level III.</u>

Thus BB's (so called) *phase-transition critical-phenomenon* is seen to be simply a restatement of the Siegel [<u>Symp. on Fractals,...</u>, M. R. S. Fall Mtg., Boston (1989)-5-papers!; <u>I. B. M. (a.k.a. Reich-III) Conf. On Computers and Mathematics</u>, Stanford (1986); <u>Schrodinger Centenary Symp.</u>, Imperial College, London (1987)] "automatic-mathematical-catastrophe" ("AUTMATHCAT") CROSSOVER between the two asymptotic-limit antipodes, most easily seen in S.P.D. "**<u>FUZZYICS</u>**" tabular/list-format analysis!: (below)

BB demonstrate this "FRG" (so called) phase to ***Bose-Einstein CONDENSATION*** (so called) "phase" by assuming an energy-(fitness)-distribution class $g(e) = Ce^q$ follows, with free-parameter q and energies/fitnesses chosen such that $e \in (0, e_{\max})$, with normalization giving $C = \frac{(q+1)}{e_{\max}^{q+1}}$, yielding a ***Bose-Einstein CONDENSATION*** *criterion/condition*:

$$\frac{(q+1)}{(be_{\max})^{q+1}} \int_{be_{\min}(t)}^{be_{\max}(t)} \frac{x^q}{e^x - 1} dx \quad < 1$$

where $e_{\min}(t)$ is the lowest-energy-level/fittest-node/vertex/entity/energy-level existing in the network at time t.
Extension of integration-limits respectively to 0 and ∞ BB claim to find critical-temperature's lower-bound:

$$T_{BE} = \frac{1}{b_{BE}} \quad > \quad \frac{e_{\max}}{\left[z(q+1)\Gamma(q+2)\right]^{1/(q+1)}} \equiv e_{\max}\left[z(q+1)\Gamma(q+2)\right]^{-1/(q+1)}$$

BB's numerical-simulation SoC-tactics reveals a chemical-potential m indicating a sharp-transition from positive $m > 0$ to negative $m < 0$ corresponding to "their" predicted *phase-transition critical-phenomenon* between "FGR" (so called) "phase" to ***Bose-Einstein CONDENSATION*** (so called) "phase", i. e. between *most-connected* node's/vertex's/entity's/energy-level's relative occupation-number as a function of temperature. BB claim to find time-*in*dependence of ratio $\left[\frac{k_{\max}(t)}{mt}\right]_{\in \ BOSE-EINSTEIN \ CONDENSATION} = \frac{k_{\max}}{mt}$ indicating that largest-node/vertex/entity/ energy-level maintains a finite-fraction of total-links/particles-number even as network continues to evolve/expand temporally, a signature of ***Bose-Einstein CONDENSATION***!

Versus for $T < T_{BE} = \dfrac{1}{b_{BE}} > \dfrac{e_{\max}}{\left[z(q+1)\Gamma(q+2)\right]^{1/(q+1)}} \equiv e_{\max}\left[z(q+1)\Gamma(q+2)\right]^{-1/(q+1)}$ the most-connected node/vertex/entity/energy-level gradually loses its share of links, $\left[\dfrac{k_{\max}(t)}{mt}\right] \sim t^{?}$.

Since real-networks exhibit temperature T-independent fitness-distribution $r(h)$, thus real-networks' occupancy of either BB's "FGR (so called) "phase" or/versus BB's ***Bose-Einstein CONDENSATION*** (so called) "phase" is similarly temperature T-independent.

BB give as example, choosing $r\ (h) = (l+1)(1-h)^{l}$ and $l > l_{BOSE-EINSTEIN\ CONDENSATION} = 1$, BB find network ***Bose-Einstein CONDENSATION*** with temperature T *vanishing* from *all topologically*-relevant quantities.

[in Siegel S.P.D. "**FUZZYICS**", this would mean that:

[***topological-connectivity dimensionality lower-bound increase***:

$$\Delta d_T^C \neq \Delta d_T^C(T) \equiv \left(2\cdot\Delta genus + 1\right) \neq \left(2\cdot\Delta genus(T) + 1\right) \equiv \left(2\cdot\Delta g + 1\right) \neq \left(2\cdot\Delta g(T) + 1\right)$$
$$\leq D_{FRACTAL} \leq d^{st} \equiv \left(d^s + d^t\right) = \left(d^s + 1\right)$$

of form:

$$\Delta d_T^C(t) \neq \Delta d_T^C(t;T) \equiv \left(2\cdot\Delta genus \sim t^{1/2} + 1\right) \neq \left(2\cdot\Delta genus(T) \sim t^{1/2} + 1\right) \equiv \left(2\cdot\Delta g \sim t^{1/2} + 1\right) \neq \left(2\cdot\Delta g(T) \sim t^{1/2} + 1\right)$$
$$\leq D_{FRACTAL} \leq d^{st} \equiv \left(d^s + d^t\right) = \left(d^s + 1\right),$$

i. e.

$$\Delta d_T^C(t) \neq \Delta d_T^C(t;T) \equiv \left(2\cdot\Delta genus \sim t^{1/2} + 1\right) \neq \left(2\cdot\Delta genus(T) \sim t^{1/2} + 1\right) \equiv \left(2\cdot\Delta g \sim t^{1/2} + 1\right) \neq \left(2\cdot\Delta g(T) \sim t^{1/2} + 1\right) \sim t^{1/2}$$

].

Thus BB argue that temperature T is only a simple control-parameter in their SoC-tactics model, (rooted in their technically-simpler choice of defining $g(e) \neq g(e,T)$, but in their Fig. 2b inset, changing q iso-T still does this, so T is *not* necessary), but whose "tuning" performs their *phase-transition critical-phenomenon*
[Siegel S.P.D. "AUTMATHCAT" CROSSOVER, but root-cause ultimate-origin (a la [Menger's, Dimensiontheorie, Teubner (1929)] dimension-theory) **0. Dimensionality/ Degrees-of-Freedom Logic-Level 0.** is *decidedly* ***not*** "just a simple control-parameter", but ***the root-cause ultimate-origin*!!!**].

BB close cryptically by referring to [Krapivsky-Redner-Leyvraz Phys. Rev. Lett. 85, 4629 (2000); P. Krapivsky and S. Redner, cond.-mat/0011094] prediction of a gelation-phenomenon for "nonlinear preferrential attachment" $\Pi(k) \sim k^{n>1}$. In comparing this "gelation" vs. ***Bose-Einstein CONDENSATION*** in single-node/vertex/entity/energy-level success of links/particles-capture, BB conclude cryptically that ***Bose-Einstein CONDENSATION*** can exist only if fitness exists!(?)

"EUREKA" and "SHAZAM" For Artificial Neural-Networks'
via A-NN *BRILLOUIN-IZATION / FOURIER-IZATION (BoANN) / (FoANN)*:
BOSE-EINSTEIN CONDENSATION of "*BOSE-EINSTEIN MACHINE*" to
Optimize Optimization-Problems Optimally (OOPO) "*NIT-PICKING*" *CONTROL* For the *Right*-Reasons via "FUZZYICS" S.P.D. "INEVITABILITY -WEB" *AUTOMATICALLY* with *OPTIMALITY Efficiency* VIA *QUANTUM-STATISTICS DICHOTOMY* PARSIMONY-of-*DICHOTOMY* (PoD)-STRATEGY versus *Hobbling* Sigmoidal Switching-Function *Crutch* "Boltzmann-Machine" "Simulated-Annealing" *IN*efficiency Useless Slow/Costly/Memory-Hogging Brute-Force Flailing-Away "Specificity-of-Complexity" (SoC)-Tactics: Brillouin-ization (BoANN/ Fourier-ization(FoANN) /Bose-Einstein-ization (Condensation) (B-E-CoANN) of Artificial-Neural-Networks

Artificial neural-networks' (A-NN's) Achilles'-heel, the ***wrong*** sigmoidal switching-function, via "EUREKA" + "SHAZAM" softwares, without any radial-basis-functions, can be made to undergo "noise-induced/driven phase-transitions (NITs) which permit *control* via "NIT-**picking**" to effect forced quantum-tunneling to global-minimum (if such exists) via " Bose-Einstein ***CONDENSATION***" to ***automatically*** optimize optimization-problems optimally (OOPO) with ***optimality*** via "FUZZYICS"' Synergetics Paradigm & Dichotomy (S.P.D.) "INEVITABILITY_-WEB" list-format analysis!

Fuzzy-logic/physics "FUZZYICS"' "fuzzycity" Optimizing Optimization-Problems Optimally (OOPO) of neural-networks (A-N-Ns) Via *quantum-statistics* crossover equivalence to switching-function sigmoidal→***Anti***-sigmoidal crossover equivalence to (so called) "noise" power-spectrum crossover "Noise-'Induced'/ 'Driven'-Phase-Transitions" (NIT's) ***vast-acceleration*** *control* via "NIT-Picking": "Eureka" and "Shazam" A-N-N *Bose-Einstein* ***Condensation*** ***AUTOMATIC OPTIMALITY*****!**

Siegel[Symp. on Fractals, Scaling,..., MRS Fall Mtg., Boston (1989)-5-papers!; I. B. M.(a.k.a. "Reich-III") Conf. On Computers and Mathematics, Stanford (19*86*); J. Noncryst. Sol. 40, 453 (19*80*); Aristotle Birthday Symposium on Mechanics and Physics, Thessoloniki (1990); Bull. A. P. S. March Mtgs.: Anaheim (1990); Indianapolis (1992);...] S.P.D. "**FUZZYICS**" ***automatically*** with ***optimality*** is, in list-format:

SYNERGETICS PARADIGM & DICHOTOMY(SPD) "*COMMON-FUNCTIONING-PRINCIPLE*"
***PARSIMONY*-of-DICHOTOMY (POD)-*STRATEGY DIMENSIONALITY-DOMINATION* (DD)-**
INEVITABILITY

ROOT-CAUSE
ULTIMATE-ORIGIN
(0.)
DIMENSIONALITY/
DEGREES-of-FREEDOM
LEVEL-0. LOGIC:

AUTMATHCAT
d-o-f = d^{st} = **ODD**-INTEGER <------DIM-CAT-------> **EVEN**-INTEGER = d^{st} =d-o-f
CROSSOVER
via
INTERMEDIATE
CONTINUOUS
INTERPOLATING
FRACTIONAL
FRACTAL-DIMENSIONALITY
***UN**CERTAINTY*
FLUCTUATIONS
d^{st} = **ODD**-Z < D^{st} < **EVEN**-Z = d^{st}

cau ß ses **cau ß ses** **cau ß ses**

(I.)
EXTENT/*SCALE*/RADIUS
LEVEL-I. LOGIC:

(relative) (relative)

AUTMATHCAT
[BOUNDARYFUL]=[LOCALITY] <------DIM-CAT-------> (...GLOBALITY...)=(...BOUNDARYLESS...)
CROSSOVER

{Kallen-Lehmann
&/|| &/||
representation-equivalence}

(II.)
POWER-SPECTRUM

LEVEL-II. LOGIC:

[“1”/$\omega^{\mathbf{0}}$-WHITE/ FLAT/FUNCTION*LESS*]

AUTMATHCAT
<- - - - - - -DIM-CAT- - - - - - - >
CROSSOVER

(...”1”/$\omega^{\underline{1.000...}}$ **HYPERBOLICITY**...) whose frequency-***integral*** defines at least ***necessary***-condition for so-called “complexity” as Noether’s-theorem ***SCALE***-4-current 4-***CON***vergence /***CONSERVATION*:**
$(d/d\omega)\ [[\partial_\mu J^\mu_{\underline{\mathbf{SCALE}}} = \mathbf{0}]\ (\omega)] = 1/\omega$ =(for arbitrary base)= “1”/ω

&/||

&/||

(III.)
CRITICAL-EXPONENT
LEVEL-III. LOGIC:

n = **0**

AUTMATHCAT
<- - - - - -DIM-CAT- - - - - - ->
CROSSOVER

n = **1.000...**

⇑
⇓

⇑
⇓

⇑
⇓

DIMENSIONALITY
DEGREES-of-FREEDOM -
INDEPENDENT
ALSO
ROOT-CAUSE
ULTIMATE-ORIGIN
(IV.)
NOETHER'S - THEOREM :
CONTINUOUS -LIE-GROUP
S C A L E-INVARIANCE
SYMMETRY
LEVEL-IV. LOGIC:

SCALE - INVARIANCE
SYMMETRY - **RESTORING**

<-------CROSSOVER---------->

SCALE - INVARIANCE
SYMMETRY - **BREAKING**

⇑
causes
⇓

⇑
causes
⇓

⇑
causes
⇓

$\partial_\mu J^\mu_{\underline{SCALE}}$ **= 0**
SCALE-4-CURRENT
4-[*CON*VERGENCE]
4-[*CONSERVATION*]
whose frequency-***derivative*** defines at least ***necessary***-condition for so-called “complexity” as Noether’s-theorem ***SCALE***-4-current 4-***CON***vergence/ ***CONSERVATION*:**
$(d/d\omega)\ [[\partial_\mu J^\mu_{\underline{\mathbf{SCALE}}} = \mathbf{0}]\ (\omega)] = 1/\omega$ =(for arbitrary base)= “1”/ω

<-------CROSSOVER---------->

0 ¹ $\partial_\mu J^\mu_{\underline{SCALE}}$
SCALE-4-CURRENT
4-(... *DI*VERGENCE...)
4-(...*NON*-CONSERVATION...)

& & &

DIMENSIONALITY
DEGREES-of-FREEDOM -
INDEPENDENT
ALSO
ROOT-CAUSE
ULTIMATE-ORIGIN
(V.)
STAR-{SET}
OF
OTHER-POSSIBLE

NOETHER'S - THEOREM:
CONTINUOUS-LIE-GROUP
SYMMETRI*ES-SET*
LEVEL-IV. LOGIC*(S)* :

... - INVARIANCE***S*** SYMMETRY - **RESTORINGS** -***SET***	<-------CROSSOVER***S***--------->	... - INVARIANCE***S*** SYMMETRY - **BREAKINGS** -***SET***
⇑ causes ⇓	⇑ causes ⇓	⇑ causes ⇓
{$\partial_\mu J^\mu_{...}$ **= 0}-*SET*** **{ . . .**-4-CURRENT***S*}-*SET*** **{**4-[CONVERGENCE***S***]**}-*SET*** **{**4-[CONSERVATION***S***]**}-*SET***	<-------CROSSOVER***S***--------->	**{**$0 \neq \partial_\mu J^\mu_{...}$**}-*SET*** **{ . . .**-4-CURRENT***S*}-*SET*** **{**4-(... DIVERGENCE***S***...)**}-*SET*** **{**4-(...NON-CONSERVATION***S***...)**}-*SET***

[fluctuation-dissipation theorem-equivalent] noise ≅ generalized-susceptibility [$\chi(\omega)$ = d(OUTPUT)/d(INPUT) = d(EFFECT or RESULT)/d(CAUSE)] power-spectrum qualitative-type functional-form and quantitative critical-exponent "automatic-mathematical-catastrophe" (AUTMATHCAT) "dimensionality-catastrophe" (DIM-CAT) crossover second-order phase-transition critical-phenomenon.

[the Kallen-Lehmann representation-equivalence, reviewed succinctly by Bjorken & Drell, are that extant measures of asymptotic-limit antipodes of the PARSIMONY-of-Dichotomy (relative) [LOCALITY] = [BOUNDARYFUL] versus (relative) (...BOUNDARYLESS...) = (...GLOBALITY...): propagators ≅ Green's-functions ≅ diffusivity ≅ ... are equivalent to extant measures of asymptotic-limit antipodes of the PARSIMONY-of-Dichotomy (relative) ["l"/ω^0-WHITE/FLAT/FUNCTIONLESS] versus (relative) (..."1"/$\omega^{1.000...}$...-FLICKER **HYPERBOLICITY**...): {fluctuation-dissipation theorem-equivalent} noise ≅ generalized-susceptibility power-spectrum as complex-functions of complex-variable ω=ω'+i ω" in first even-integer critical-dimensionality complex-plane C in their pure-mathematics analyticity].

QUANTUM-STATISTICS DICHOTOMY

Siegel[Schrodinger Centenary Symposium, Imperial College, London (1987); The Copenhagen Interpretation Fifty Years After The Como Lecture, Joensuu (1987); Bull. A. P. S. March Mtgs.: Anaheim (1990); Indianapolis (1992);...] manifestly-demonstrated, for quantum-statistics/NWB-law Dichotomy, generic: Takagi[Prog. Theo. Phys. Suppl. 88, 1 (1986)]-Oguri[Phys. Rev. (1985)]-Brout[Colloquium, U. C. Berkeley (1986)]-Susskind[Colloquium, U. C. Berkeley (1986)]- ...
$1/[\, e^{\hbar w/k_B T} - (-1)^{(d^{st} + 2\cdot spin)} \,] = 1/[\, e^{\hbar w/k^B T} - (-1)^{D(\notin Z)} \,]$ dimensionality-dependent/dominated (DD)-**INEVITABILITY**, in **SPD** "**CFP**" PoD-**STRATEGY** (DD)-**INEVITABILITY** list-format:

QUANTUM-STATISTICS DICHOTOMY

[D. Lichtenstein and M. Rubenstein, J. Math. Phys. (~1966)]

Takagi-Oguri-Brout-Susskind-...

$1/[\, e^{\hbar w/k_B T} - (-1)^{(d^{st} + 2\cdot \mathrm{spin})} \,] =$

$1 / \left[e^{\hbar w / k_B T} - (-1)^{D(\notin Z)} \right]$

GENERIC DIMENSIONALITY-DEPENDENT/DOMINATED

QUANTUM-STATISTICS

DD-**INEVITABILITY**

vs.

AUTMATHCAT

<-------DIM-CAT------->

CROSSOVER

via

FERMI-DIRAC (FERMIONS):		**BOSE-EINSTEIN (BOSONS):**
$1/\left[e^{\hbar w/k_B T} - (-1)^{D=ODD-Z}\right] \cong$	$1/\left[e^{\hbar w/k_B T} - (-1)^{D(\notin Z)}\right] \cong$	$1/\left[e^{\hbar w/k_B T} - (-1)^{D=EVEN-Z}\right] \cong$
↓	↓	↓
$1 / \left[e^{\hbar w / k_B T} + 1 \right]$		$1 / \left[e^{\hbar w / k_B T} - 1 \right]$
↓	↓	↓
via $e^{\hbar w/k_B T}$ Taylor/power-series expansion in infra-red-($\hbar w \ll k_B T$)-limit	via Euler-formula $e^{ip} = -1$	via $e^{\hbar w/k_B T}$ Taylor/power-series expansion in infra-red-($\hbar w \ll k_B T$)-limit
↓	↓	↓
$1/\left[+1+\left[1+\left(\hbar w / k_B T\right)+\ldots\right]\right] \cong$	$1/\left[e^{\hbar w/k_B T} - e^{ipD}\right] \cong$	$1/\left[-1+\left[1+\left(\hbar w / k_B T\right)+\ldots\right]\right] \cong$
↓	↓	↓
$1/\left[+1+\left[1+\left(\hbar w / k_B T\right)+\ldots\right]\right] \cong$	via deMoivre-formula: $e^{iq} = \cos q + i \sin q$	$1/\left(\hbar w / k_B T\right) = (k_B T/\hbar)\cdot 1/w \cong$
↓	↓	↓ ↓
$1/\left[2+\left(\hbar w / k_B T\right)+\ldots\right] \cong 1/2 \cong$	$1/\left[e^{\hbar w/k_B T} - \left(\cos(pD) + i\sin(pD)\right)\right] \cong$	
↓	↓	↓
$\left["1"/w^0 - WHITE / FLAT\right]$ POWER-SPECTRUM	via $e^{\hbar w/k_B T}$ Taylor/power-series expansion in infra-red-($\hbar w \ll k_B T$)-limit	$\left(\ldots "1"/w^{1.000-} - HYPERBOLICITY\ldots\right)$ POWER-SPECTRUM
	↓	
with n = **0** CRITICAL-EXPONENT	$1/\left[1+\left(\hbar w / k_B T\right)+\ldots \left(\cos(pD) + i\sin(pD)\right)\right] \cong$	with n = **1.000...** CRITICAL-EXPONENT
GEOMETRICALLY RECTANGLE ***HOMOTOPY*** to ***ELLIPSE***	$1/\left[\left[1+\left(\hbar w / k_B T\right)+\ldots+\cos(pD)\right] + i\sin(pD)\right] \cong$ ***COMPLEX*** QUANTUM-STATISTICS	**GEOMETRICALLY** ***HYPERBOLA*** obeying equation:

obeying equation:

$$\left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2 = 1$$

same (+) ***sign***

$$\left[e^{\hbar w / k_B T} + 1\right]^{-1}$$

"No-ons" = "Nothing-ons" = "ENC-ons" in *Intermediate Interpolating Continuous Fractional Fractal-Dimensionality* ***UN****certainty* ***FLUCTUATIONS*** ***except*** at ***HALF***-Integer "ANY-ons" = "Semi-ons"

$$\left(\frac{x}{a}\right)^2 - \left(\frac{y}{b}\right)^2 = 1$$

same (-) ***sign***

$$\left[e^{\hbar w / k_B T} - 1\right]^{-1}$$

C O N I C S E C T I O N S of C O N E

ELLIPSE**:**

$$\left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2 = 1$$

FERMIONS = ELLIPSE

PARABOLA:

<--- $x^2 + 2xy = 1$ --->

AUTMATHCAT
<-------DIM-CAT------->
CROSSOVER
"ANYONS"= PARABOLA

HYPERBOLA**:**

$$\left(\frac{x}{a}\right)^2 - \left(\frac{y}{b}\right)^2 = 1$$

HYPERBOLA = BOSONS

GEOMETRICALLY
"ANALOGOUS"
to
SPECIAL-RELATIVITY
LIGHT-CONE
SECTIONS:

SPACELIKE	NULL	TIMELIKE
ELLIPSE	<---CROSSED-LINES --->	HYPERBOLA
v ">" c	v = c	v < c

AUTMATHCAT
<-------DIM-CAT------->
CROSSOVER

manifestly-demonstrating that quantum-statistics Dichotomy *follows exactly* **SPD** "**CFP**" (PoD)-**STRATEGY** (DD)**-INEVITABILITY!**

ARTIFICIAL-NEURAL-NETWORKS (A-NN's): OPTIMIZING OPTIMIZATION-PROBLEMS OPTIMALLY (OOPO)

"Engineering" by-rote brute-force on-node *hobbling* sigmoidal switching-function *crutch* implementation leads to "Boltzmann-machine" "simulated-annealing" inefficiency useless unimplementable-hardware slow/costly/memory-hogging flailing-away software "specificity-of-(so-called) 'complexity'" (SoC)-tactics with little/no ***all-important understanding*** *of* ***meaning***!!!

All-important understanding *of* ***meaning*** starts with:

• (1) realization that an A-NN is a *statistics*:
Lippmann[Lincoln Labs. Repts. (~1978- ~1982)] ab initio first review of artificial neural-networks (A-NN's) defined a neural-network as a "statistics" (hence amenable to Newcombe(1***8***81)-Weyl(19*16*)-Benford(19*38*)-Kac(19*55*) inter-digit *statistical* (*on-average*) correlations $P(d) = \log_{10}\left(1+\frac{1}{d}\right)$ analysis, but this is not our subject here *yet*).

• (2) realization that an A-NN with "engineering" by-rote brute-force on-node *hobbling* sigmoidal switching-function *crutch* is a ***quantum****-statistics.*

Many Rogers[IEEE J. Neural Networks (~1990s)-Hsu[A.-I. N.-N. Assn. Mtgs.(~1980s); SPIE Mtgs.(~1980s)] have called for "1"/f-'noise'" acceleration of A-NN's functioning to converge to the global-minimum optimum-solution, iff one exists.

Demuth-Beale[Matlab "Neural-Network Tool Box", The Math Works (~1990s)] have come closest, via artificial "radial-basis functions", but with lack of any understanding, for the wrong reasons!

They use an on-(A-NN)-node radial-basis -functions to concoct a *Gaussian* switching-function $f(E,T) = 2^{-x^2} \approx \left(b^{-x^2} \approx e^{-x^2} \approx 10^{-x^2}\right)$ (to other possible bases b or e or 10 or...) to replace standard by-rote sigmoidal switching-function (to other possible bases b or 2 or 10 or ...): $f(E,T) = \frac{1}{1+e^{\frac{-E}{T}}} \approx \left(\frac{1}{1+b^{\frac{-E}{T}}} \approx \frac{1}{1+2^{\frac{-E}{T}}} \approx \frac{1}{1+10^{\frac{-E}{T}}}\right)$ in terms of "energy" E and "temperature" T and claim some five thousand (three orders-of-magnitude) less-memory/faster-convergence to some global-minimum optimization.

But *with**out*** any real ***understanding*** of the ***meaning*** of what they have done!

So-called "simulated-annealing' is often touted as a *mindless* was to seek a global-minimum optimal-solution, if one exists, from A-NN trapping in local-minima non-optimal non-solutions.

But again *with**out*** any real ***understanding*** of the ***meaning*** of what is being done, and ***why***, except for its internal "specificity-of-complexity" (SoC)-tactics: computer-simulation number-crunchings!

Just *what* standard by-rote sigmoidal switching-function (to other possible bases b or 2 or 10 or ...):

$$f(E,T) = \frac{1}{1+e^{\frac{-E}{T}}} \approx \left(\frac{1}{1+b^{\frac{-E}{T}}} \approx \frac{1}{1+2^{\frac{-E}{T}}} \approx \frac{1}{1+10^{\frac{-E}{T}}}\right)$$

is, and ultimately *detrimentally* ***means***

requires ***understanding*** via *identification* of it as *equivalent to* quantum-theory Fermi-Dirac quantum-statistics:

$$f^{N.N./sigmoidal}_{on-node\ switching-function}(E,T) = \frac{1}{1+e^{\frac{-E}{T}}} \approx \left(\frac{1}{1+b^{\frac{-E}{T}}} \approx \frac{1}{1+2^{\frac{-E}{T}}} \approx \frac{1}{1+10^{\frac{-E}{T}}}\right)$$

understanding of the fact that :

$$f^{NN/sigmoidal}_{on-node\ switching-function}(E,T) = \frac{1}{1+e^{\frac{-E}{T}}} \approx \left(\frac{1}{1+b^{\frac{-E}{T}}} \approx \frac{1}{1+2^{\frac{-E}{T}}} \approx \frac{1}{1+10^{\frac{-E}{T}}}\right) =$$

$$f^{NN/sigmoidal}_{on-node\ switching-function}(E,T) = \frac{1}{+1+e^{\frac{-E}{T}}} \approx \left(\frac{1}{+1+b^{\frac{-E}{T}}} \approx \frac{1}{+1+2^{\frac{-E}{T}}} \approx \frac{1}{+1+10^{\frac{-E}{T}}}\right) =$$

$$f^{Fermi-Dirac}_{Quantum-Statistics}(E,T) \equiv f^{F.-D.}(E,T) = \frac{1}{e^{\frac{E}{k_BT}}+1} \approx \left(\frac{1}{b^{\frac{E}{k_BT}}+1} \approx \frac{1}{2^{\frac{E}{k_BT}}+1} \approx \frac{1}{10^{\frac{E}{k_BT}}+1}\right) \equiv$$

$$f^{Fermi-Dirac}_{Quantum-Statistics}(w,T) \equiv f^{F.-D.}(w,T) = \frac{1}{e^{\frac{\hbar w}{k_BT}}+1} \approx \left(\frac{1}{b^{\frac{\hbar w}{k_BT}}+1} \approx \frac{1}{2^{\frac{\hbar w}{k_BT}}+1} \approx \frac{1}{10^{\frac{\hbar w}{k_BT}}+1}\right)$$

Understanding of the ***meaning*** of this is from " the chemical-elements", in which "fermions" Fermi-Dirac quantum-statistics

$$f^{Fermi-Dirac}_{Quantum-Statistics}(w,T) \equiv f^{F.-D.}(w,T) = \frac{1}{e^{\frac{\hbar w}{k_BT}}+1} \approx \left(\frac{1}{b^{\frac{\hbar w}{k_BT}}+1} \approx \frac{1}{2^{\frac{\hbar w}{k_BT}}+1} \approx \frac{1}{10^{\frac{\hbar w}{k_BT}}+1}\right)$$

electrons *automatically traps the system in any/every local-minima*, called "the chemical-elements"!

Exact-opposite/diametrically-opposed “bosons” Bose-Einstein quantum-statistics

$$f^{Bose-Einstein}_{Quantum-Statistics}(w,T) \equiv f^{B.-E.}(w,T) = \frac{1}{e^{\frac{\hbar w}{k_B T}}-1} \approx \left(\frac{1}{b^{\frac{\hbar w}{k_B T}}-1} \approx \frac{1}{2^{\frac{\hbar w}{k_B T}}-1} \approx \frac{1}{10^{\frac{\hbar w}{k_B T}}-1} \right)$$

suffer from ***no*** such *automatically trapping the system in any local-minima.*

• (3) “EUREKA” (“Bosonization”) involves this above quantum-statistics Dichotomy ***understanding*** of the ***meaning***: that the “fermions” Fermi-Dirac quantum-statistics

$$f^{Fermi-Dirac}_{Quantum-Statistics}(w,T) \equiv f^{F.-D.}(w,T) = \frac{1}{e^{\frac{\hbar w}{k_B T}}+1} \approx \left(\frac{1}{b^{\frac{\hbar w}{k_B T}}+1} \approx \frac{1}{2^{\frac{\hbar w}{k_B T}}+1} \approx \frac{1}{10^{\frac{\hbar w}{k_B T}}+1} \right)$$

automatically traps the system in any/every local-minima,

versus

exact-opposite/diametrically-opposed “bosons” Bose-Einstein quantum-statistics

$$f^{Bose-Einstein}_{Quantum-Statistics}(w,T) \equiv f^{B.-E.}(w,T) = \frac{1}{e^{\frac{\hbar w}{k_B T}}-1} \approx \left(\frac{1}{b^{\frac{\hbar w}{k_B T}}-1} \approx \frac{1}{2^{\frac{\hbar w}{k_B T}}-1} \approx \frac{1}{10^{\frac{\hbar w}{k_B T}}-1} \right)$$

suffer from ***no*** such *automatically trapping the system in any local-minima.*

Hence “**EUREKA**” (“bosonization”) ***quantum**-statistics* qualitative-*type* ***CROSSOVER***, from Fermi-Dirac (“fermions”) to Bose-Einstein (“boson”), is ***absolutely mandatory*!!!**

ARTIFICIAL NEURAL-NETWORKS OPTIMALITY ANALYSIS :

via
(Siegel)
“FUZZYICS” S.P.D. I.-W.

***(A. N.-N.)*:**

$$f^{Fermi-Dirac}_{Quantum-Statistics}(w,T;\text{"1"}=\#) \equiv$$
$$\equiv f^{F.-D.}(w,T;\text{"1"}=\#) =$$
$$= \frac{\text{"1"}=\#}{e^{\frac{\hbar w}{k_B T}}+1} \approx$$
$$\left(\begin{array}{l} \approx \frac{\text{"1"}=\#}{b^{\frac{\hbar w}{k_B T}}+1} \approx \\ \approx \frac{\text{"1"}=\#}{2^{\frac{\hbar w}{k_B T}}+1} \approx \\ \approx \frac{\text{"1"}=\#}{10^{\frac{\hbar w}{k_B T}}+1} \end{array} \right)$$

***(A. N.-N.)*:**

“EUREKA”:

vs.
AUTMATHCAT
<-------DIM-CAT------>
CROSSOVER

via

“BOZONIZATION”
<------------------->>>
CROSSOVER

***(A. N.-N.)*:**

$$f^{Bose-Einstein}_{Quantum-Statistics}(w,T;\text{"1"}=\#) \equiv$$
$$\equiv f^{B.-E.}(w,T;\text{"1"}=\#) =$$
$$= \frac{\text{"1"}=\#}{e^{\frac{\hbar w}{k_B T}}-1} \approx$$
$$\left(\begin{array}{l} \approx \frac{\text{"1"}=\#}{b^{\frac{\hbar w}{k_B T}}-1} \approx \\ \approx \frac{\text{"1"}=\#}{2^{\frac{\hbar w}{k_B T}}-1} \approx \\ \approx \frac{\text{"1"}=\#}{10^{\frac{\hbar w}{k_B T}}-1} \end{array} \right)$$

&

+

(A. N.-N.)

“SHAZAM”:

$$\lim_{\#\to\infty}\left\{\begin{array}{l} f^{Bose-Einstein}_{Quantum-Statistics}(w,T;\text{"1"}=\#)\equiv \\ \equiv f^{B.-E.}(w,T;\text{"1"}=\#)= \\ =\dfrac{\text{"1"}=\#}{e^{\frac{\hbar w}{k_B T}}-1}\approx \\ \approx\left(\begin{array}{l}\approx\dfrac{\text{"1"}=\#}{b^{\frac{\hbar w}{k_B T}}-1}\approx \\ \approx\dfrac{\text{"1"}=\#}{2^{\frac{\hbar w}{k_B T}}-1}\approx \\ \approx\dfrac{\text{"1"}=\#}{10^{\frac{\hbar w}{k_B T}}-1}\end{array}\right)\end{array}\right\}=$$

$$=\lim_{\#\to\infty}\left[\frac{\text{"1"}=\#}{e^{\frac{\hbar w}{k_B T}}-1}\right]=\left[\frac{d\,(w-0)}{e^{\frac{\hbar w}{k_B T}}-1}\right]\approx$$

$$\approx\lim_{\#\to\infty}\left[\frac{\text{"1"}=\#}{b^{\frac{\hbar w}{k_B T}}-1}\right]=\left[\frac{d\,(w-0)}{b^{\frac{\hbar w}{k_B T}}-1}\right]\approx$$

$$\approx\lim_{\#\to\infty}\left[\frac{\text{"1"}=\#}{2^{\frac{\hbar w}{k_B T}}-1}\right]=\left[\frac{d\,(w-0)}{2^{\frac{\hbar w}{k_B T}}-1}\right]\approx$$

$$\approx\lim\left[\frac{\text{"1"}=\#}{10^{\frac{\hbar w}{k_B T}}-1}\right]_{\#\to\infty}=\left[\frac{d\,(w-0)}{10^{\frac{\hbar w}{k_B T}}-1}\right]=$$

$$=d\,(w-0)$$

CONCLUSION

Artificial (by rote) sequential: (so called) “simulated-annnealing” + (so called) “Boltzmann-machine” is replaced and superseded by the herein manifestly-demonstrated “***Bose-Einstein Condensation*** ‘machine’”**!**

Artificial neural-networks’ (A-NN’s) Achilles’-heel, the ***wrong*** sigmoidal switching-function, via “EUREKA” + “SHAZAM” softwares, without any radial-basis-functions, can be made to undergo “noise-induced/driven phase-transitions (NITs) which permit *control* via “NIT-**picking**” to effect forced quantum-tunneling to global-minimum (if such exists) via “ Bose-Einstein

CONDENSATION" to ***automatically*** optimize optimization-problems optimally (OOPO) with ***optimality*** via "FUZZYICS"' Synergetics Paradigm & Dichotomy (S.P.D.) "INEVITABILITY_-WEB" list-format analysis!

Fuzzy-logic/physics "FUZZYICS"' "fuzzycity" Optimizing Optimization-Problems Optimally (OOPO) of neural-networks (A-N-Ns) Via *quantum-statistics* crossover equivalence to switching-function sigmoidal→***Anti***-sigmoidal crossover equivalence to (so called) "noise" power-spectrum crossover "Noise-'Induced'/ 'Driven'-Phase-Transitions" (NIT's) ***vast-acceleration*** *control* via "NIT-Picking": "Eureka" and "Shazam" A-N-N *Bose-Einstein* ***Condensation*** ***AUTOMATIC OPTIMALITY*!**