Stable Non-Equilibrium Pumped Coherent Post-Quantum High-Temperature Biological and Artificial Microtubule Nano-Electronic Superconductors

V8
Work in Progress
Under construction

Jack Sarfatti
internetscienceeducation@gmail.com
August 4, 2017

Abstract

Despite much effort over many decades no room temperature (or above) superconductors have been discovered. This is because physicists only considered the thermal equilibrium case. The clue is in lasers and living cell networks that are pumped open non-equilibrium complex systems. Herbert Frohlich[1] introduced me to this basic idea, but it was never developed in a simple universal way as done here.[i]

I. Toy Model

T = thermodynamic equilibrium absolute temperature

T(f)' = effective far-from-thermodynamic equilibrium absolute Kelvin temperature at frequency f

ρ(f) = external pump power flux spectrum per unit frequency [ergs /cm^2 c.g.s.]

$$\rho(f) \equiv \frac{\partial^3 E}{\partial t \partial A \partial f} \tag{1.1}$$

The relevant dimensionless parameter x is

$$[x] = \left[\frac{\rho(f)c^2}{hf^3}\right] = \left(\frac{ergs}{\sec \times cm^2 \times Hz}\right)\left(\frac{\sec^3}{ergs \times \sec}\right)\left(\frac{cm^2}{\sec^2}\right) \tag{1.2}$$

Zero energy gap elementary excitations of frequency f, *zero chemical potential* μ[2] and zero dissipation $\varepsilon = 0$. The total number of quanta is not conserved here,

---

[1] https://en.wikipedia.org/wiki/Herbert_Fröhlich

[2] https://en.wikipedia.org/wiki/Chemical_potential

unlike the thermal equilibrium Bose-Einstein condensate[3] of N helium 4 atoms for example. Here we are thinking of photon or acoustic phonon et-al "lasers."

$$T(f)' = \frac{T}{\left(1 - \frac{\rho(f)c^2}{hf^3}\right)} \tag{1.3}$$

Singularity at

$$x = \frac{\rho(f)c^2}{hf^3} \underset{x \le 1}{\rightarrow} 1_- \tag{1.4}$$

That is, T(f)' > 0 → infinite as x → 1 from below. T(f)' has a discontinuous jump at x = 1 to minus infinity with asymptote 0 as x → infinity. Negative temperature in a Jaynes-Cummings[4] laser system of $N = n(E_1) + n(E_2)$ source qubits corresponds to population inversion $n(E_2) > n(E_1)$, $E_2 > E_1$, $hf = E_2 - E_1$ with the emergence of a coherent signal of photons. This is the non-equilibrium analog of thermal equilibrium Bose-Einstein condensation, which is a special case of spontaneous symmetry breaking in which the ground state of a many-particle system has less symmetry than the global dynamical action and its local Euler-Lagrange equations from the calculus of variations for extremal paths.

The effective non-equilibrium Bose-Einstein distribution for the average number <n(f)> of quanta at pumped quantum harmonic oscillator field mode frequency f is

$$< n(f) > \propto \left| \frac{1}{\left(e^{hf/kT(f)'} - 1\right)} \right| = \left| \frac{1}{\left(e^{hf\left(1 - \frac{\rho(f)c^2}{hf^3}\right)/kT} - 1\right)} \right| \ge 0 \tag{1.5}$$

---

[3] https://en.wikipedia.org/wiki/Bose–Einstein_condensate

[4] https://en.wikipedia.org/wiki/Jaynes–Cummings_model

Note that

$$\lim_{\frac{\rho(f)c^2}{hf^3}\to 1} n(f) \to \infty \tag{1.6}$$

The average density (cm^{-3} c.g.s) of quanta in a quasi-monochromatic wave packet centered at frequency f with tiny uncertainty df is

$$< n(f) > \frac{f^2}{c^3} df \propto \left| \frac{1}{\left(e^{hf\left(1-\frac{\rho(f)c^2}{hf^3}\right)/kT} - 1 \right)} \right| \frac{f^2}{c^3} df \tag{1.7}$$
$$f = ck = \frac{c}{\lambda}$$

My next example covers high-temperature superconductors, superfluids and *living matter* with N conserved real particles having a *non-zero chemical potential* Lagrange multiplier constraint μ.

$$T(f) = \frac{T}{\left(1 + \frac{\rho(f)c^2}{hf^3}\right)} \geq 0$$
$$\lim_{\frac{\rho(f)c^2}{hf^3}\to\infty} T(f) \to 0 \tag{1.8}$$

The effective non-equilbrium critical superconducting phase transition temperature will be T(f) → T_c, not the much higher ambient environmental equilibrium T -> T_c.

$$\frac{T}{T(f)} = 1 + \frac{\rho(f)c^2}{hf^3} > 1 \tag{1.9}$$

A Frohlich coherent phase transition will happen[5] when

$$T(f) \rightarrow T_c \tag{1.10}$$

Therefore, the critical threshold external pump power flux spectral density is

$$\rho(f)_c = \frac{hf^3}{c^2}\left(\frac{T}{T_c} - 1\right) \tag{1.11}$$

e.g. Wikipedia

Critical temperature [edit]

This transition to BEC occurs below a critical temperature, which for a uniform three-dimensional gas consisting of non-interacting particles with no apparent internal degrees of freedom is given by:

$$T_c = \left(\frac{n}{\zeta(3/2)}\right)^{2/3} \frac{2\pi\hbar^2}{mk_B} \approx 3.3125 \frac{\hbar^2 n^{2/3}}{mk_B}$$

where:

- T_c is the critical temperature,
- n is the particle density,
- m is the mass per boson,
- $\hbar$ is the reduced Planck constant,
- k_B is the Boltzmann constant, and
- ζ is the Riemann zeta function; $\zeta(3/2) \approx 2.6124.$ [8]

Interactions shift the value and the corrections can be calculated by mean-field theory.

This formula is derived from finding the gas degeneracy in the bose gas using Bose–Einstein statistics.

In the above toy model, Eq. (1.8) suggests that the Frohlich critical pump power flux spectral density $\rho(f)_c$ triggers a non-equilibrium phase transition to a robust macro-quantum coherent condensate protected against thermodynamic equilibrium decoherence fluctuations. Herbert Frohlich first suggested this same kind of high-temperature biological superconducting mechanism for a model of a membrane made of electric dipoles similar to the protein dimers in the microtubules inside nerve cells. Metabolism is the "pump" in that case.

The fluctuation-dissipation theorem should work around T(f) for small fluctuations.[6]

---

[5] No matter what the actual ambient environmental temperature T is.

[6] https://en.wikipedia.org/wiki/Fluctuation-dissipation_theorem

II. Second look at dimensionless pump parameter x

Let $T(x^i,t)_{\mu\nu}$ $i=1,2,3$ be the stress energy tensor for the external pump assumed to be an electromagnetic field coupled to electric charges of the material. Define the dimensionless unit 4-vector n^μ. The local frame invariant scalar is

$$P(x^i,t) \equiv cT(x^i,t)_{\mu\nu} n^\mu n^\nu \tag{1.12}$$

with physical dimensions of energy flux in cgs ergs/cm^{2}sec. Therefore, a more physically realistic definition results when we first take the *temporal Fourier transform of the convolution integral*[7]

$$\frac{\tilde{P}(x^i,f)}{\sqrt{\tilde{\varepsilon}(x^i,f)\tilde{\mu}(x^i,f)}} \equiv \int_{-\infty}^{\infty} dt \int_{-\infty}^{\infty} d\tau \left(\frac{\tilde{P}(x^i,t-\tau)}{\sqrt{\tilde{\varepsilon}(x^i,\tau)\tilde{\mu}(x^i,\tau)}} \right) e^{ift} \tag{1.13}$$

with physical dimensions ergs x sec/cm^2.[8]

Therefore a more physically plausible definition of dimensionless X is[9]

$$\tilde{\mathrm{X}}(x^i,f) \equiv \frac{\tilde{P}(x^i,f)\sigma}{h\sqrt{\tilde{\varepsilon}(x^i,f)\tilde{\mu}(x^i,f)}} \tag{1.14}$$

where σ is the scattering cross section coupling the external electromagnetic pump field to the electrical charges of the material. More generally we need to include near EM pump fields.[10] Using appropriate spatial convolution integrals we wind up with

---

[7] More realistic will be a scale-dependent *renormalization group* wavelet transform with more complex mathematics to be dealt with later.
https://en.wikipedia.org/wiki/Convolution
https://en.wikipedia.org/wiki/Wavelet_transform
https://en.wikipedia.org/wiki/Renormalization_group

[8] The square root of the product of the dimensionless dielectric permittivity and magnetic permeability responses in the denominator is from Maxwell's classical electrodynamics for inhomogeneous media when he unified electricity and magnetism with light in the mid-19th Century.

[9] I use "X" not "x" to avoid confusion from earlier toy model.

[10] Coherent states of virtual off "mass shell/light cone" photons with three polarizations. Real photons only have two transverse to the direction of propagation. https://en.wikipedia.org/wiki/Coherent_states

$$\tilde{\tilde{X}}\left(k^{i},f\right)\equiv\frac{\tilde{\tilde{P}}\left(k^{i},f\right)\sigma\rho}{mh\sqrt{\tilde{\tilde{\varepsilon}}\left(k^{i},f\right)\tilde{\tilde{\mu}}\left(k^{i},f\right)}} \qquad (1.15)$$

Where ρ is the mass density of the effective mass of the material boson quasiparticles that will condense into a macro-quantum coherent "order parameter" above the critical pump power "lasing" threshold. Real massless photons in radiating far field with transverse polarized coherent states that propagate energy to "infinity" obey the mass shell/light cone equation

$$c^{2}k_{i}k^{i}-f^{2}0 \qquad (1.16)$$

In contrast, virtual massless photons in the non-radiating near field with additional longitudinal polarization coherent states (e.g. Coulomb electrostatic field in rest frame of an ideal point charge) obey

$$c^{2}k_{i}k^{i}-f^{2}\neq 0 \qquad (1.17)$$

Equation (1.8) is now replaced by

$$T\left(k^{i},f\right)=\frac{T}{1+\tilde{\tilde{X}}\left(k^{i},f\right)} \qquad (1.18)$$

to be continued

---

i "**Bose–Einstein condensation in networks** is a phase transition observed in complex networks that can be described with the same mathematical model as that explaining Bose–Einstein condensation in physics. … The evolution of many complex systems, including the World Wide Web, business, and citation networks, is encoded in the dynamic web describing the interactions between the system's constituents. Despite their irreversible and nonequilibrium nature these networks follow Bose statistics and can undergo Bose–Einstein condensation. Addressing the dynamical properties of these nonequilibrium systems within the framework of equilibrium quantum gases predicts that the "first-mover-advantage," "fit-get-rich (**FGR**)," and "winner-takes-all" phenomena observed in competitive systems are thermodynamically distinct phases of the underlying evolving networks.[5]

…

Herbert Fröhlich is the source of the idea that quantum coherent waves could be generated in the biological neural network. His studies claimed to show that with an oscillating charge in a thermal bath, large numbers of quanta may condense into a single state known as a Bose condensate.[11] Already in 1970 Pascual-Leone had shown that memory experiments can be modelled by the Bose–Einstein occupancy model.[12] From this and a large body of other empirical findings (based on studies of EEG and psychometrics) Weiss and Weiss draw the generalized conclusion that memory span can be understood as the quantum number of a harmonic oscillator, where memory is to be mapped into an equilibrium Bose gas.[13]
https://en.wikipedia.org/wiki/Bose–Einstein_condensation_(network_theory)