BOHM'S 1952 PILOT WAVE THEORY REVISITED

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ABSTRACT: I investigate extending Bohm's original 1952 single-state pilot wave QM theory to the larger PQM regime of living matter in which conscious qualia emerges from direct back-reaction of classical level electrons and electromagnetic fields primarily on their macro-quantum coherent intrinsically mental pilot fields. I use insights from Roderick Sutherland's two-state fully relativistic Lagrangian extension of Bohm 1952 explaining many-particle nonlocal entanglements as locally retrocausal Costa de Beauregard "zig-zags" as further explained by Huw Price.[1]

KEYWORDS: Postquantum mechanics; Rod Sutherland; Retrocausality

"Classical limit" means all traces of quantum pilot waves vanish. No quantum uncertainty, no quantum statistics, no Born probability rule when h → 0. Introducing the "backactivity" 4-vector κ_{α} that restores the action-reaction principle between classical level particles and quantum level waves in the Bohm ontology: here is my corrected version of Roderick Sutherland's particle equation for the PQM regime.[2]

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[1] Based on e-mail discussions with Roderick Sutherland. All errors, if any, are mine.

[2] As of April 24, 2019, I am supposing minimal coupling. Note correction to quantum potential April 25, 2019.

$$\frac{1}{c}\frac{d}{d\tau}\left[(\frac{\kappa_0\sigma_0}{E}+\rho_0)u_\alpha\right]=\left(\frac{\partial}{\partial x^\alpha}+\frac{\kappa_\alpha}{\hbar}\right)\rho_0 u_0+u^\beta\left(\left(\frac{\partial}{\partial x^\beta}+\frac{\kappa_\beta}{\hbar}\right)j_\alpha-\left(\frac{\partial}{\partial x^\alpha}+\frac{\kappa_\alpha}{\hbar}\right)j_\beta\right)$$

$$\frac{\kappa_i}{p_i}=\left(1-\frac{\frac{\partial S}{\partial x^i}}{p_i}\right)$$

$$\frac{\kappa_0}{E}=\left(1-\frac{\frac{\partial S}{\partial t}}{E}\right)\backslash$$

$$i=1,2,3$$

I get Sutherland's particle QM equation and the correct classical geodesic equation. See below.[3]

Bohmians have an incomplete physical picture.[4] This is partly Bohm's fault in 1952. He did not distinguish *classical level* particle momentum p from pilot wave momentum ∇S. The classical limit means NO wave function, NO Born probability rule. In the 1952 formalism (simpler than Sutherland's, but same result in the end).

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[3] κ_μ is like a local gauge field potential, aka. connection for parallel transport in a fiber bundle over spacetime. The 4-velocities u_α are dimensionless.

[4] So do Bohrians.

Classical Mechanics (CM) limit means $\frac{\kappa_\alpha}{p_\alpha} \to 1$

along with

$$\begin{aligned}&\hbar \to 0\\&\Rightarrow\\&R = 0\\&S = 0\\&\psi = \mathrm{Re}^{i\frac{S}{\hbar}} \to 0\end{aligned}$$

The above PQM particle equation then reduces to the time-like geodesic equation in a Local Inertial Frame (LIF) obeying Einstein's Equivalence Principle (EEP) even in the PQM and QM cases.

$$\frac{du_\alpha}{d\tau} = 0$$

The same geodesic equation in a coincident Local Non-Inertial Frame (LNIF) is

$$\frac{Du^\alpha}{d\tau} = \frac{du^\alpha}{d\tau} - \Gamma^\alpha_{\beta\gamma} u^\beta u^\gamma = 0$$

$\Gamma^\alpha_{\beta\gamma}$ is the Levi-Civita connection
describing the local proper tensor acceleration
of the detector not the test particle whose
proper tensor acceleration is "weightless"
zero g-force.

Here is the picture I propose. There is a missing PQM back-activity parameter in the entire Bohm interpretation from 1952 that carries over into Sutherland's extension of it. This may be why Einstein instinctively thought that Bohm's solution was "too cheap." Roger Penrose has honestly stated that Copenhagen collapse interpretations do not have a bona-fide classical limit. So, I claim the following. First in the non-relativistic limit, with only strong measurements – one retarded wave function like in Stapp's picture – for simplicity only easy to generalize to weak measurements and Aharonov's two waves like Sutherland does, with only the real part. We need the imaginary part too, save that for later.

The PQM Hamilton-Jacobi equation is then

$$\frac{\partial S}{\partial t}+\kappa_0=\frac{1}{2m}\left(\vec{\nabla}S+\vec{\kappa}\right)^2-V+\frac{\hbar^2}{2m}\frac{\left(\vec{\nabla}+\frac{\vec{\kappa}}{\hbar}\right)\cdot\left(\vec{\nabla}+\frac{\vec{\kappa}}{\hbar}\right)R}{R}$$

The classical limit as defined above PQM → CM sends the PQM H-J equation to the classical energy equation

$$E=\frac{p^2}{2m}+V$$

The continuity equation classical limit is 0 = 0, i.e. all vestiges of quantum waves on classical particles vanishes. The PQM continuity equation is

$$\left(\hbar\frac{\partial}{\partial t}+\kappa_0\right)R^2+\hbar\left(\vec{\nabla}+\frac{\vec{\kappa}}{\hbar}\right)\cdot\left(R^2\frac{\vec{\nabla}S+\vec{\kappa}}{m}\right)=0$$

$$\frac{\partial}{\partial t}R^2+\vec{\nabla}\cdot\left(R^2\frac{\vec{\nabla}S}{m}\right)=-\frac{\kappa_0R^2}{\hbar}-\frac{\vec{\kappa}}{\hbar}\cdot\left(R^2\frac{\vec{\nabla}S+\vec{\kappa}}{m}\right)-\vec{\nabla}\cdot\left(R^2\frac{\vec{\kappa}}{m}\right)$$

The PQM theory is non-unitary seen on the RHS of the above equation because the quantum pilot waves have sources and sinks that depend on the classical particle observables.

The quantum limit PQM → QM of zero backactivity is the de Broglie guidance zero wave function source case

$$\kappa_0 \to 0$$
$$\vec{\kappa} \to 0$$
$$\Rightarrow \text{ Bohm 1952}$$
$$\frac{\partial S}{\partial t} = -\frac{1}{2m}(\nabla S)^2 + V - \frac{h^2}{2m}\frac{\nabla^2 R}{R}$$
$$\frac{\partial R^2}{\partial t} + \vec{\nabla} \cdot \left(\frac{R^2 \vec{\nabla} S}{m} \right) = 0$$

Now the issue is when is PQM needed? That's where Frohlich effect comes into play – another story.

PQM Macro-Quantum Coherence Pumped Non-Equilibrium Frohlich Bose-Einstein Condensates

The non-relativistic nonlinear Landau-Ginzburg equation in the 1952 Bohm ontology for off-diagonal order in the reduced density matrix[5] of bosonic quasiparticles in a many-particle system prevented from reaching thermodynamic equilibrium is[6]

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[5] I use lower-case ψ for single-particle wave functions and upper-case Ψ for Landau-Ginzburg Oliver Penrose-Lars Onsager "ODLRO" local order parameters factorization of the density matrices from spontaneously broken continuous symmetries in the many-particle ground state 3D bulk (P.W. Anderson's "More is Different" Higgs-Goldstone "spontaneous broken symmetry" SBS as distinct from Kitaev's global topological order the 2D boundaries of the bulk with Hawking-type "area laws" of Susskind's "hologram conjecture." The present model is only for von Neumann strong measurements, extending to Yakir Aharonov's weak measurements with the destiny wave added to Stapp's history wave suggest renaming the corresponding reduced correlations as the "destiny matrix."

[6] ℓ is the photon-electron scattering length in the material. $T_{\delta\gamma}(\text{Frohlich EM pump})$ is the energy stress tensor of the photons of the external Frohlich pump. T_{eq} is the environmental temperature when the Frohlich pump is switched off. T is the effective off-equilibrium temperature, and T_c is the critical temperature for Bose-Einstein condensation in the thermodynamic equilibrium case with the Frohlich pump switched off. Θ is the step function = 0 when $T > T_c$ and = 1 when $T \leq T_c$.

$$i\hbar\left(\frac{\partial}{\partial t}+\varsigma\frac{|\Psi|^2\kappa_0}{\hbar}\right)\Psi=-\frac{\hbar^2}{2m}\left(\vec{\nabla}+\varsigma\frac{|\Psi|^2\vec{\kappa}}{\hbar}\right)\cdot\left(\vec{\nabla}+\varsigma\frac{|\Psi|^2\vec{\kappa}}{\hbar}\right)\Psi+V\Psi+\xi|\Psi|^2\Psi$$

$$\Psi=|\Psi|e^{i\frac{S}{\hbar}}$$

$$-\left(\frac{\partial S}{\partial t}\right)|\Psi|e^{i\frac{S}{\hbar}}+i\hbar\frac{\partial|\Psi|}{\partial t}e^{i\frac{S}{\hbar}}+i\varsigma|\Psi|^3\kappa_0 e^{i\frac{S}{\hbar}}=$$

$$-\frac{\hbar^2}{2m}\left(\vec{\nabla}+\varsigma\frac{|\Psi|^2\vec{\kappa}}{\hbar}\right)\cdot\left(\vec{\nabla}+\varsigma\frac{|\Psi|^2\vec{\kappa}}{\hbar}\right)|\Psi|e^{i\frac{S}{\hbar}}+\left(V|\Psi|+\xi|\Psi|^3\right)e^{i\frac{S}{\hbar}}$$

$$\left(\vec{\nabla}+\varsigma\frac{|\Psi|^2\vec{\kappa}}{\hbar}\right)\cdot\left(\vec{\nabla}+\varsigma\frac{|\Psi|^2\vec{\kappa}}{\hbar}\right)|\Psi|e^{i\frac{S}{\hbar}}=$$

$$\left(\vec{\nabla}\cdot\vec{\nabla}\left(|\Psi|e^{i\frac{S}{\hbar}}\right)+\vec{\nabla}\cdot\left(\varsigma\frac{|\Psi|^3\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar}\right)+\varsigma\frac{|\Psi|^2\vec{\kappa}\cdot\vec{\nabla}\left(|\Psi|e^{i\frac{S}{\hbar}}\right)}{\hbar}+\varsigma^2\frac{|\Psi|^4}{\hbar^2}\vec{\kappa}\cdot\vec{\kappa}\right)$$

The relation of Frohlich coherence to PQM backactivity is still under investigation. One possible model is in the equations below.

$$\kappa_\mu\overset{?}{=}\frac{\alpha\Theta\left(T-T_c\right)T_{\mu\nu}\left(\text{Frohlich EM pump}\right)\kappa^\nu}{\sqrt{T_{\delta\gamma}T^{\delta\gamma}}}$$

$$T\overset{?}{=}\frac{T_{eq}}{1+\dfrac{\ell T_{\delta\gamma}\kappa^\delta\kappa^\gamma}{k_B T_{eq}\hbar^2}}$$

Details of the algebra

$$\vec{\nabla}\cdot\vec{\nabla}\left(|\Psi|e^{i\frac{S}{\hbar}}\right)$$

$$\vec{\nabla}\left(|\Psi|e^{i\frac{S}{\hbar}}\right)=\frac{i\vec{\nabla}S}{\hbar}|\Psi|e^{i\frac{S}{\hbar}}+\vec{\nabla}|\Psi|e^{i\frac{S}{\hbar}}$$

$$\vec{\nabla}\cdot\vec{\nabla}\left(|\Psi|e^{i\frac{S}{\hbar}}\right)=\vec{\nabla}\cdot\left(\frac{i\vec{\nabla}S}{\hbar}|\Psi|e^{i\frac{S}{\hbar}}+\vec{\nabla}|\Psi|e^{i\frac{S}{\hbar}}\right)$$

$$\vec{\nabla}\cdot\left(\frac{i\vec{\nabla}S}{\hbar}|\Psi|e^{i\frac{S}{\hbar}}\right)=\frac{i\vec{\nabla}^2S}{\hbar}|\Psi|e^{i\frac{S}{\hbar}}+\frac{i\vec{\nabla}S\cdot\vec{\nabla}|\Psi|}{\hbar}e^{i\frac{S}{\hbar}}-\left(\frac{\vec{\nabla}S}{\hbar}\right)^2|\Psi|e^{i\frac{S}{\hbar}}$$

$$\vec{\nabla}\cdot\left(\vec{\nabla}|\Psi|e^{i\frac{S}{\hbar}}\right)=\frac{\left(\vec{\nabla}S\right)^2}{\hbar^2}|\Psi|e^{i\frac{S}{\hbar}}+\left(\vec{\nabla}^2|\Psi|\right)e^{i\frac{S}{\hbar}}+\frac{i}{\hbar}\vec{\nabla}|\Psi|\cdot\vec{\nabla}Se^{i\frac{S}{\hbar}}$$

The above terms occur in Bohm's 1952 QM pilot wave theory. The new PQM pilot wave source terms are:

$$\vec{\nabla}\cdot\left(\varsigma\frac{|\Psi|^3\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar}\right)=\varsigma\frac{3|\Psi|^2\vec{\nabla}|\Psi|\cdot\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar}+\varsigma\frac{|\Psi|^3\vec{\nabla}\cdot\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar}+i\varsigma\frac{|\Psi|^3\vec{\nabla}S\cdot\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar^2}$$

$$\varsigma\frac{|\Psi|^2\vec{\kappa}\cdot\vec{\nabla}\left(|\Psi|e^{i\frac{S}{\hbar}}\right)}{\hbar}=\varsigma\frac{\left(\frac{i\vec{\kappa}\cdot\vec{\nabla}S}{\hbar}|\Psi|^3+|\Psi|^2\vec{\kappa}\cdot\vec{\nabla}|\Psi|\right)e^{i\frac{S}{\hbar}}}{\hbar}$$

Collecting terms and cancelling the common phase factor

$$-\left(\frac{\partial S}{\partial t}\right)|\Psi|e^{i\frac{S}{\hbar}}+i\hbar\frac{\partial|\Psi|}{\partial t}e^{i\frac{S}{\hbar}}+i\varsigma|\Psi|^{3}\kappa_{0}e^{i\frac{S}{\hbar}}$$

$$=-\frac{\hbar^{2}}{2m}\left(\begin{array}{l}\frac{(\vec{\nabla}S)^{2}}{\hbar^{2}}|\Psi|e^{i\frac{S}{\hbar}}+(\vec{\nabla}^{2}|\Psi|)e^{i\frac{S}{\hbar}}+\frac{i}{\hbar}\vec{\nabla}|\Psi|\cdot\vec{\nabla}Se^{i\frac{S}{\hbar}}+\frac{i\vec{\nabla}^{2}S}{\hbar}|\Psi|e^{i\frac{S}{\hbar}}+\varsigma\frac{3|\Psi|^{2}\vec{\nabla}|\Psi|\cdot\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar}+\varsigma\frac{|\Psi|^{3}\vec{\nabla}\cdot\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar}\\+i\varsigma\frac{|\Psi|^{3}\vec{\nabla}S\cdot\vec{\kappa}e^{i\frac{S}{\hbar}}}{\hbar^{2}}+\varsigma\frac{\left(\frac{i\vec{\kappa}\cdot\vec{\nabla}S}{\hbar}|\Psi|^{3}+|\Psi|^{2}\vec{\kappa}\cdot\vec{\nabla}|\Psi|\right)e^{i\frac{S}{\hbar}}}{\hbar}+\varsigma^{2}\frac{|\Psi|^{4}}{\hbar^{2}}\vec{\kappa}\cdot\vec{\kappa}e^{i\frac{S}{\hbar}}\end{array}\right)$$

$$+V\Psi+\xi|\Psi|^{2}\Psi$$

$$-\left(\frac{\partial S}{\partial t}\right)|\Psi|+i\hbar\frac{\partial|\Psi|}{\partial t}+i\varsigma|\Psi|^{3}\kappa_{0}$$

$$=\left(\begin{array}{l}\frac{(\vec{\nabla}S)^{2}}{2m}|\Psi|-\frac{\hbar^{2}}{2m}\vec{\nabla}^{2}|\Psi|-i\frac{\hbar}{2m}\vec{\nabla}|\Psi|\cdot\vec{\nabla}S-\frac{i\vec{\nabla}^{2}S}{\hbar}|\Psi|e^{i\frac{S}{\hbar}}-\frac{3\hbar}{2m}\varsigma|\Psi|^{2}\vec{\nabla}|\Psi|\cdot\vec{\kappa}-\frac{\hbar}{2m}\varsigma|\Psi|^{3}\vec{\nabla}\cdot\vec{\kappa}\\-\frac{i}{2m}\varsigma|\Psi|^{3}\vec{\nabla}S\cdot\vec{\kappa}-\varsigma\frac{\hbar}{2m}\left(\frac{i\vec{\kappa}\cdot\vec{\nabla}S}{\hbar}|\Psi|^{3}+|\Psi|^{2}\vec{\kappa}\cdot\vec{\nabla}|\Psi|\right)-\frac{\varsigma^{2}}{2m}|\Psi|^{4}\vec{\kappa}\cdot\vec{\kappa}\end{array}\right)$$

$$+V|\Psi|+\xi|\Psi|^{3}$$

Separating out real and imaginary parts. The Frohlich coherent macro-quantum PQM Hamilton-Jacobi equation from the real part is

$$-\left(\frac{\partial S}{\partial t}\right)=-\frac{1}{2m}(\nabla S)^2-\frac{\hbar^2}{2m}\frac{\vec{\nabla}^2|\Psi|}{|\Psi|}+V+\xi|\Psi|^2$$
$$-\varsigma\frac{3\hbar}{2m}|\Psi|\vec{\nabla}|\Psi|\cdot\vec{\kappa}-\frac{\hbar}{2m}\varsigma|\Psi|^2\vec{\nabla}\cdot\vec{\kappa}-\varsigma\frac{\hbar}{2m}|\Psi|\vec{\kappa}\cdot\vec{\nabla}|\Psi|-\frac{\varsigma^2}{2m}|\Psi|^3\vec{\kappa}\cdot\vec{\kappa}$$

The spontaneous broken symmetry Higgs-Goldstone term QM coupling parameter is ξ. The PQM backactivity non-linear non-unitary coupling parameter is ς.

The imaginary part is now the non-conserved pilot wave current density PQM equation.

$$\frac{\partial|\Psi|}{\partial t}+\frac{\hbar}{2m}\vec{\nabla}|\Psi|\cdot\vec{\nabla}S+\frac{\hbar\vec{\nabla}^2S}{2m}|\Psi|=2\varsigma\frac{\vec{\kappa}\cdot\vec{\nabla}S}{2m}|\Psi|^3+\varsigma|\Psi|^3\kappa_0$$
$$\Rightarrow$$
$$\frac{\partial|\Psi|^2}{\partial t}+\vec{\nabla}\cdot\left(|\Psi|^2\frac{\vec{\nabla}S}{m}\right)=2\varsigma|\Psi|^4\left(\frac{\vec{\kappa}\cdot\vec{\nabla}S}{m}+\kappa_0\right)$$

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