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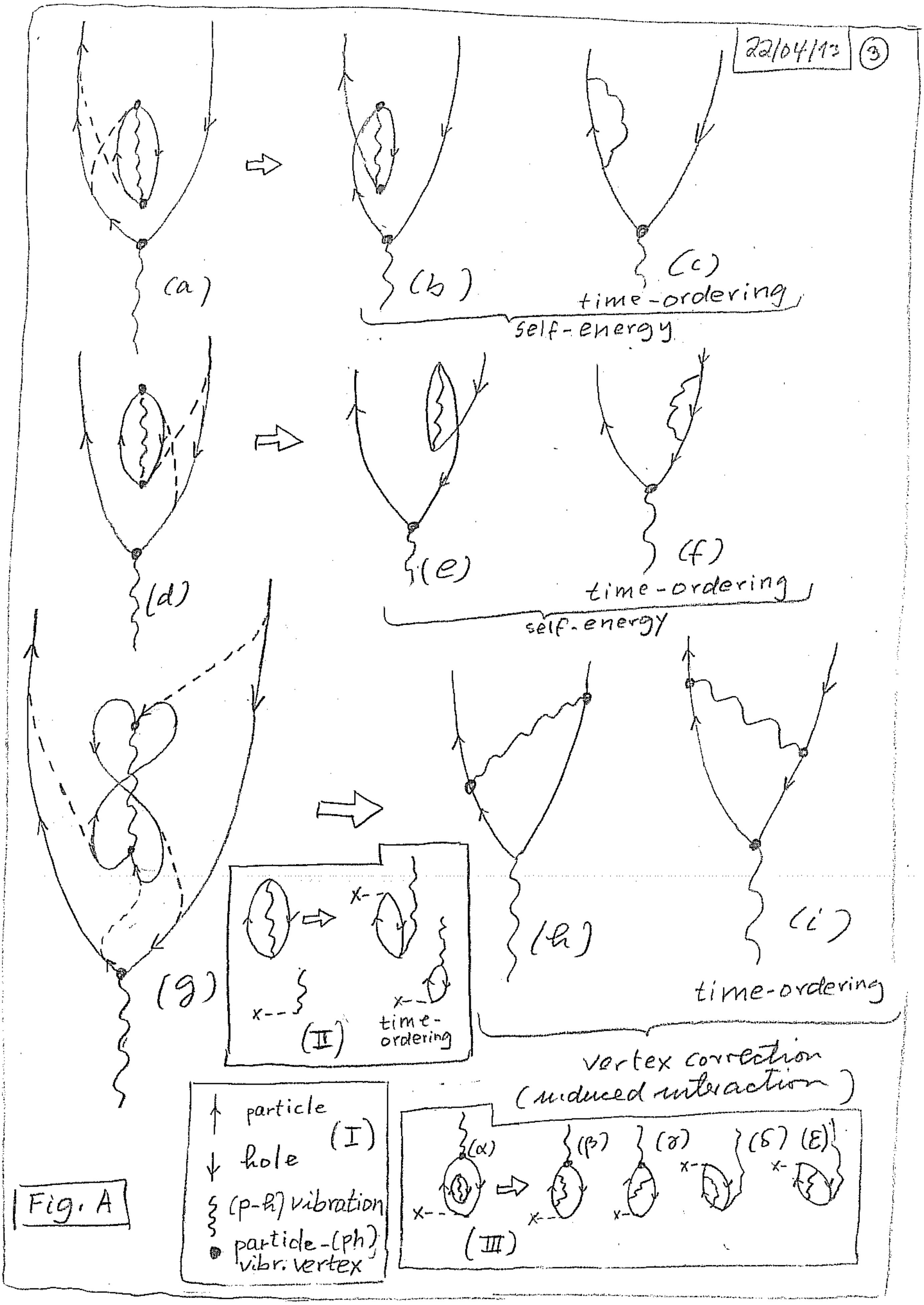
ZPF and Pauli principle at the basis of medium polarization effects: self-energy, vertex corrections and induced interaction ①

In keeping with [redacted] a central objective of [redacted] the formulation of quantum mechanics, namely that the ~~central~~ basic concepts on which it is based relate directly to experiment (Heisenberg), elementary modes of nuclear excitation (single-particle, collective vibrations and rotations), are solidly anchored on observation (inelastic and Coulomb excitation, one- and two-particle transfer reactions). [redacted] Of all quantal phenomena, zero point fluctuations (ZPF), closely connected with virtual states, ~~are likely~~ [redacted] to be [redacted] most representative [redacted] of the [redacted] essential differences existing between [redacted] quantum and classical mechanics. In fact, ZPF are intimately connected with the complementary principle ([redacted] Bohr), and thus with the indeterminacy [redacted] ([redacted] Heisenberg) and non-commutative (Born, Jordan) relations, and with the probabilistic interpretation (Born) of the (modulus squared) of [redacted] of the wavefunctions, solution of Schrödinger's or Dirac's [redacted] equations.

Pauli principle brings about essential modifications of the virtual fluctuations of the many-body system, modifications which are instrumental in the dressing and interweaving of the elementary modes of excitation (see Figs. A and B; within the present context, see also J.R. Schrieffer, Theory of superconductivity, Benjamin, N.Y (1964) p.134).



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3
(a)
(b)
(c)
time-ordering
self-energy
(d)
(e)
(f)
time-ordering
self-energy
(g)
(h)
(i)
time-ordering
vertex correction
(induced interaction)
(II)
time-ordering
particle
hole
(p-h) vibration
particle-(ph) vibr. vertex
(I)
(α)
(β)
(γ)
(δ)
(ε)
(III)

Fig. A

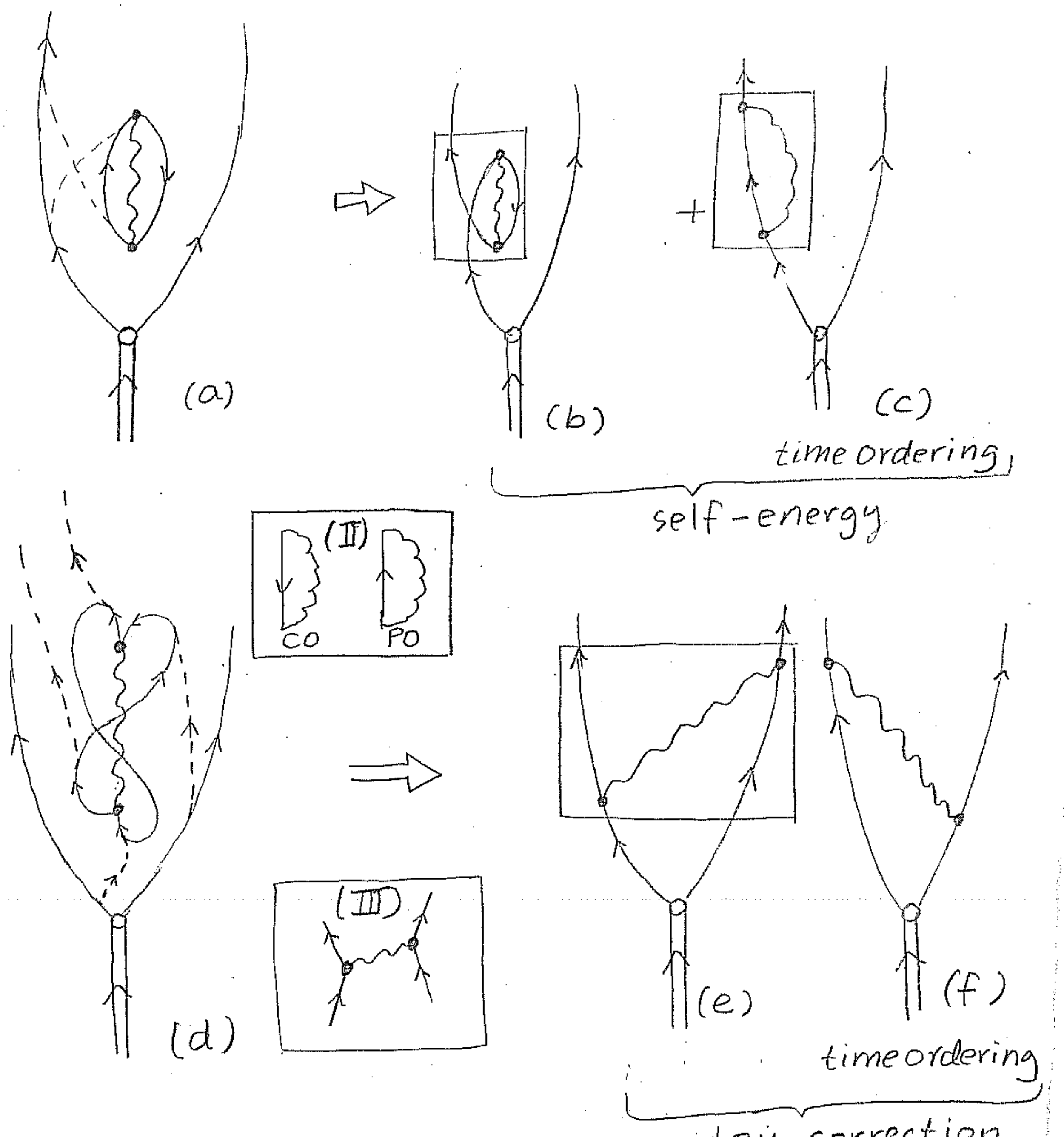
~~coherent state~~

Caption Fig. A

Nuclear field theory (NFT) diagrams correspon-
ding to the lowest order medium polarization
effects renormalizing the properties of a
(wavy line)
particle-hole collective mode, linear combination
((up-going)-(down-going) arrowed lines)
of particle-hole excitations calculated within
the random phase approximation (RPA) in
of a bare interaction, and leading to the
particle vibration coupling vertex (solid
dot, see inset (I), bottom). The action of
an external field on the zero point
fluctuations (ZPF) of the vacuum (inset (II)),
forces a virtual process to become real, lea-
ding to a collective vibration by annihilating
a (virtual, spontaneous) particle-hole exci-
tation (backwardsgoin RPA amplitude) or,
in the time ordered process, by creating
a particle-hole excitation which eventually,
through the particle-vibration coupling vertex,
correlate into the collective (coherent state;
forwardsgoing amplitudes). Now, oyster-like
diagrams associated with the vacuum ZPF
can occur at any time (see inset III). Because the
texture of the vacuum is permeated by
symmetry rules (while one can violate
energy conservation in a virtual state one cannot
violate e.g. angular momentum conservation or the
Pauli principle), the process shown in the
inset III (a) leads, through Pauli principle

correcting processes (exchange of fermionic arrowed lines) to self-energy (inset III (β), (δ)) and vertex corrections (induced p-h interaction; inset III (γ), (ε)) processes. The first ones are detailed in graphs (a)-(f), while the second ones in graphs (g)-(i). In keeping with the ~~fact that~~ the vibrational states can be viewed as a coherent states exhausting a large fraction of the EWSR (e.g. a Giant Resonance) for which the

associated uncertainty relations in momentum and coordinate fulfills the absolute minimum consistent with quantum mechanics ($\Delta\alpha_{\lambda\mu}\Delta\Pi_{\lambda\mu} = \hbar/2$, $\alpha_{\lambda\mu} = (\hbar\omega_\lambda/2C_\lambda)^{1/2}(\Gamma^\dagger_{\lambda\mu}+\Gamma_{\lambda\mu})$ bein the (harmonic) collective coordinate, $\Pi_{\lambda\mu}$ being the conjugate momentum; cf. e.g. R. Glauber, in Proceedings of the International School of Physics E. Fermi, on Quantum Optics, Course XLII, ed. R. Glauber, Ac. Press, N.Y. (1969) p. 15), there is a strong cancellation between the contribution of self-energy and vertex correction diagrams (P.F. Bortignon and R.A. Broglia, Nucl. Phys.), implying small anharmonicities and long lifetimes ($\Gamma/E \ll 1$, where Γ is the width and E the centroid of the mode $|\lambda\mu\rangle = \Gamma^\dagger_{\lambda\mu}|0\rangle$, $(\hbar\omega_\lambda/2C_\lambda)^{1/2}$ being the ZPF amplitude (cf. e.g. Brink and Broglia, Nuclear Superfluidity, pp 185, 298)



I

particle

hole

pair (addition) vibration

o particle-pair vibr. vertex

• particle-(ph) vibr. vertex

FIG. B

Caption Fig. 13

Pauli effects associated (p-h) ZPF dressing pairing vibrational modes (see inset, bottom left) in terms of self-energy (graphs (a)-(c); correlation (CO) and polarization (PO) diagrams, inset II) and vertex correction (graph (d)-(f); induced particle-particle interaction, inset (III)) processes.