Article

Higgs Field & Unruh Effect

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Abstract

The Unruh effect describes radiation detected by an accelerated detector. The vacuum seen in an inertial frame of Minkowski spacetime is a pure vacuum, while in a Rindler wedge it is a vacuum plus blackbody distribution of radiation. While the detector on the accelerated frame will witness this radiation, but the inertial observer witnesses no radiation. However, the inertial observer might be able to catch the accelerated object and find it will be thermalized to equilibrium with Unruh radiation. In this paper the Unruh radiation is examined primarily from the perspective of an accelerated body as observed in an inertial frame. This is then an exercise in quantum fields with a cubic interaction corresponding to the interaction of the vacuum with the accelerated body. The analysis is done in a solid state physics format to illustrate the essential ideas.

Keywords: Higgs field, Unruth effect, vacuum, Rindler wedge, Minkowski spacetime.

1 Introduction

Physics is holographic, which implies horizons or boundaries that conceal complete symmetry[1]. The number of degrees of freedom in the bulk volume is a vast redundancy [2], where only charges or hair on the boundary or horizon are real charges that carry real information. The singularity of a black hole or for a cosmology concealed by an event horizon then contains this complete symmetry with little information content. It is also the case that the Higgs field conceals symmetry, called secret or hidden symmetry[3], where the symmetry of the Lagrangian at a low energy is no longer the symmetry of the physical low energy vacuum. These two physics may then be fundamentally related to each other. This is seen by the examination of the Unruh effect from the perspective of the inertial frame.

The inertial observer witnesses a body moving with the invariant momentum interval

$$m^2 \;=\; E^2 \;-\; p^2.$$

This is used with the case of a body accelerating in the z direction with $p_z \;>>\; p_x$ and p_y. We then have

$$\begin{aligned} E \;&=\; \sqrt{p_x^2 \;+\; p_y^2 \;+\; p_z^2 \;+\; m^2} \;=\; p_z\sqrt{(p_x^2 \;+\; p_y^2 \;+\; p_z^2 \;+\; m^2)/p_z^2} \\ &\simeq\; p_z \;+\; \frac{1}{2}(p_x^2 \;+\; p_y^2 \;+\; m^2)p_z^{-1} \end{aligned} \tag{1.1}$$

and so we have

$$(E \;-\; p_z)p_z \;=\; \frac{1}{2}(p_x^2 \;+\; p_y^2 \;+\; m^2).$$

The right hand side is the Lorentz boosted energy and the left hand side is a classical-like Hamiltonian with a potential $\frac{m^2}{2}$.

Now consider an acceleration in the z direction so that from s to $s \;+\; \delta s$ proper interval

$$p_z(s \;+\; \delta s) \;=\; p_z(s) \;+\; ma_z\delta s.$$

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The right hand side has then

$$(E - p_z(s + \delta s))p_z(s + \delta s) = (E - p_z(s) - ma_z\delta s)(p_z(s) - ma_z\delta s)$$
$$\simeq (E - p_z(s))(p_z(s) - ma_z\delta s) - p_z ma_z\delta s.$$

Since the energy E is transformed by the acceleration then to $O(\delta s)$ we can treat $(E - p_z(s))(p_z(s) - ma_z\delta s)$ as H' and we have

$$H' = \frac{1}{2}(p_x^2 + p_y^2 + m^2) + p_z ma_z\delta s.$$

Now consider this within the context of a scalar field theory. The homogeneous term is then with $a_z = 0$

$$H = \frac{1}{2}|\nabla\phi|^2 + \frac{1}{2}m^2|\phi|^2.$$

With the left hand side as $H = H_0 + |\partial\phi/\partial t|^2$. The inhomogeneous term $p_z ma_z\delta s$ is constructed with the associations $p_z : \phi, m : \phi^2$ and $a_z : \phi$ and the time interval $\delta t \rightarrow \omega^{-1}$ the frequency of the scalar field and $\omega : \phi$ This means the acceleration is a cubic interaction term and we write

$$H_0 = \frac{1}{2}|\nabla\phi|^2 - \frac{1}{2}|\partial\phi/\partial t|^2 + \frac{1}{2}m^2|\phi|^2 + g|\phi|^2(\phi + \phi^*),$$

where g has units of inverse length. We may now write this in greater generality with the inclusion of a quartic term $|\phi|^4$. The mass is replaced with $m^2 \rightarrow -\mu^2$ and this is a perturbed quartic scalar field for the Higgs. This is the most general form of a scalar potential that is renormalizable.

We consider various interactions. The free particle has the potential m^2 so that $\Box D_f(x - y) = \delta^4(x - y)$ leads to the propagator of the form[4]

$$\langle 0|\phi(y)\phi(x)|0\rangle = \frac{1}{4\pi}\frac{1}{|x - y|^2},$$

and we let the separation $\delta = |x - y|$ between the fields be cut off at δ. This is renormalization theory in a nutshell. We are primarily interested in the vacuum bubble seen in figure 1.

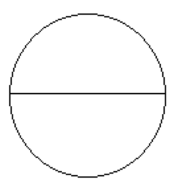

Figure 1

This will have the amplitude $g\int_\delta^\infty \Delta^{-6}d^4\Delta$ which is evaluated at the cutoff as $g\delta^{-2}$. The cut off in distance δ is adjusted to the acceleration; the larger the acceleration the more precise is the probe. This is then $\delta \sim 1/a_z$, and with the $g = p_z ma_z\omega^{-1}$ we have the above amplitude $g\int \Delta^{-6}d^4\Delta \sim a_z$.

Consider the interaction with the condensate of the Higgs field. A condensate of a scalar field ϕ is such that it has a nonzero vacuum expectation or that $\langle 0|\phi(x)|0\rangle = \epsilon$, where ϵ refers to the vacuum expectation value for the mass of the scalar field. We then have that the vacuum state of the field $\phi(x)$ is mapped from the vacuum expectation of the field $\phi(x)$ by

$$|0\rangle = U^\dagger|\Omega\rangle,$$

which means that $|0\rangle$ is a coherent state constructed from a condensate of vacua states and correspondingly that

$$\phi(x) = U\phi(x)U^\dagger.$$

Now write the operator $U = exp(c(a - a^\dagger))$, for the a and $a^\dagger$ operators acting on the vacua condensate $|\Omega\rangle$, and for the model above we have $c = g|\phi|^2$. In the case the operators are fermionic this is similar to the BCS state $(u_k - v_k a^\dagger_k a^\dagger{-}k|0\rangle$[5]. There is in this case a gap in energy between $|0\rangle$ and $|\Omega\rangle$ that is analogous to the BCS energy gap. The field $\phi(x)$ on the $|0\rangle$ vacuum is

$$\langle 0|\phi(x)|0\rangle = \langle\Omega|U\phi(x)U^\dagger|\Omega\rangle = \langle\Omega|(1 + c(a - a^\dagger) + \dots)\phi(x)(1 - c(a - a^\dagger) + \dots)|\Omega\rangle$$

$$= \langle\Omega|\phi(x)|\Omega\rangle + c\langle\Omega|[(a - a^\dagger),\ \phi(x)]|\Omega\rangle + \dots$$

Clearly the first term is zero which evaluates the condensate field on its vacuum, and the second term with the Fourier expansion of the field

$$\phi(x) = i\sum_k (a(k)e^{-ikx} + a^\dagger(k)e^{ikx})$$

means

$$\langle 0|\phi(x)|0\rangle = icsin(k_0x)c\langle\Omega|[(a - a^\dagger),\phi(x)]|\Omega\rangle +$$

which evaluates the expectation value ϵ for the Hamiltonian. The oscillating term is $e^{i\epsilon\delta s}$ with the association $\delta s \rightarrow \omega^{-1} \sim 1/a_z$. The condensate with the cubic field potential term then leads to the $\langle 0|exp(-2\pi H/a_z)|0\rangle$ evaluating

$$\langle 0|\phi(x)|0\rangle = \langle\Omega|\phi(x)|\Omega\rangle + \left\langle 0\middle|\frac{\partial}{\partial\sigma}exp(-2\pi H\sigma)\middle|0\right\rangle$$

for $\sigma = 1/a_z$. This means the partition function in a path integral contributed by the acceleration is $exp(-2\pi H/a_z)$, which corresponds to Unruh radiation.

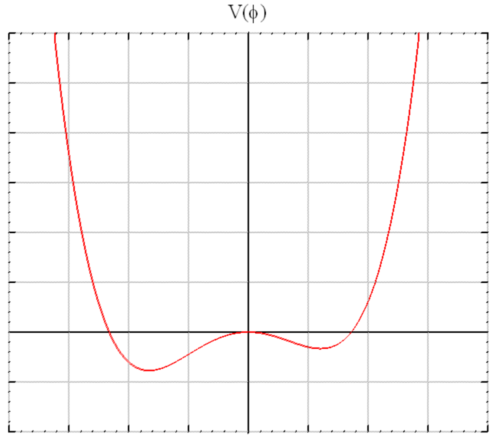

Figure 2

This is a perturbation on the quartic potential of the Higgs field so that it appears in figure 2. This then leads to an effective theory that connects Unruh radiation with the Higgs field and its interactions with quantum fields. This asymmetric potential is similar to that in the Coleman-de Luccia vacuum bubble model of inflationary cosmology[6].

2 General scalar field

Consider the case for the Higgs potential modified by accelerated mass as

$$V(\phi) = -\frac{1}{2}\mu^2|\phi|^2 + g(E)|\phi|^2(\phi + \phi^*) + \frac{1}{2}\lambda|\phi|^4 \tag{2.1}$$

which modifies the standard Higgs potential $V_h(\phi) = -\frac{1}{2}\mu^2|\phi|^2 + \frac{1}{2}|\phi|^4$ with a cubic term. The manner of derivation was to consider a highly boosted system which is effectively nonrelativistic. Now consider this as a Schrodinger type of problem. The field configuration for $g = 0$ has a minima as $\partial V_h(\phi)/\partial\phi^* = 0$, which occurs at $\phi^*\phi = \mu^2/2$, or $|\phi| = \mu/\sqrt{2\lambda}$. With the cubic term the field settles at the two values

$$\phi_0^\pm = -\frac{3}{2}\frac{g}{\lambda} \pm \frac{\mu}{\sqrt{2\lambda}}\sqrt{1 + \frac{9g^2}{\mu^2\lambda}}.$$

Now for $g << \mu$ this is approximately

$$\phi_0^\pm \simeq \pm\frac{\mu}{\sqrt{2\lambda}} - \frac{3}{2}\frac{g}{\lambda} + O(g^2)$$

Now consider small oscillations around the potential with ϕ_0 and the variable $|\phi| = \phi_0 + x$

$$V(|\phi|) = V(\phi_0) + \frac{\partial V_h(\phi)}{\partial|\phi|)}\Big|_{\phi_0} x + \frac{1}{2}\frac{\partial^2 V_h(\phi)}{\partial|\phi|^2}\Big|_{\phi_0} x^2 +$$

$$= V(\phi_0) + \frac{1}{2}V''(\phi_0)x^2.$$

The potential is then modeled as a circular trough in two dimensions with a minima at a radius $x_0^2 + y_0^2 = \mu^2/2\lambda$, for $\phi_0 \simeq \mu/\sqrt{2\lambda}$. The nonrelativistic potential in standard coordinates is then

$$V(x, y) = \frac{\omega}{2}[(x - x_0)^2 + (y - y_0)^2],$$

which is a potential for two coupled harmonic oscillators with $x_0 = y_0 = \mu/\sqrt{2\lambda}$.

The Hamiltonian $H = \frac{1}{2}p^2 + V(x, y)$ leads to the harmonic oscillator operators

$$A = \sqrt{\frac{\omega}{2}}\left(x - x_0 + \frac{i}{\omega}p_x\right), A^\dagger = \sqrt{\frac{\omega}{2}}\left(x - x_0 + \frac{i}{\omega}p_x\right)$$

$$B = \sqrt{\frac{\omega}{2}}\left(y - y_0 + \frac{i}{\omega}p_y\right), B^\dagger = \sqrt{\frac{\omega}{2}}\left(y - y_0 + \frac{i}{\omega}p_y\right)$$

where is is easy to show the total Hamiltonian is $H = \frac{1}{2}(A^\dagger A + B^\dagger B)$. We also have $A = a - \sqrt{\omega/2}x_0$ etc and this leads to the Hamiltonian

$$H = \omega(a^\dagger a + b^\dagger b) - \sqrt{\frac{\omega}{2}}X_0(a^\dagger + b^\dagger + a + b)$$

for $X = x_0 = y_0$, and constant term in X^2 removed. In addition the terms linear in the field operators are removed as being off diagonal. This means the interaction is quadratic for a standard set of harmonic oscillators plus a linear term.

This Hamiltonian has the cubic perturbation term $V_3 = g(E)|\phi|^2(\phi + \phi^*)$ in addition. For $g(E) = g\omega$ this perturbing potential is replaced with

$$V_3 = g\omega\left[(a^\dagger a + b^\dagger b)X_0 + a^\dagger a a^\dagger + a a^\dagger a + b^\dagger b b^\dagger + b b^\dagger b\right], \tag{2.2}$$

where terms ${a^\dagger}^2,\ {b^\dagger}^2\ a^2,\ b^2$ and linear in these operators are dropped. The total Hamiltonian

$$H \ = \ \omega(1 \ + \ 6gX_0)(a^\dagger a \ + \ b^\dagger b) \ + \ g\omega(a^\dagger a a^\dagger \ + \ a a^\dagger a \ + \ b^\dagger b b^\dagger \ + \ b b^\dagger b).$$

may be analyzed with perturbation of the cubic interaction terms on the diagonalized Hamiltonian with the addition of a ϕ^4 term without V_3. The sign of the mass term, with $-\mu\phi^2$ terms in the Hamiltonian, is absorbed into the ω. Without the quartic potential the solution would contain hyperbolic functions which imply an unstable system.

The total Hamiltonian may be simplified by removing the redundancy of the a, $a^\dagger$ and b, $b^\dagger$ operators. These are also generalized for summations over states with

$$H \ = \ (1 \ + \ 6gX_0)\sum_k \omega(k) a^\dagger_k a_k \ + \ \sum_{k,q}\xi(q)(a^\dagger_{k+q}a^\dagger_{-k-q}a_{-k}a_{-q})$$

$$+ \ g\sum_{k,q}\omega(k)[a^\dagger_{k-q}a_k a^\dagger_q \ + \ a_{k-q}a^\dagger_k a_q].$$

The Hamiltonian for $g \ = \ 0$ may be diagonalized with the operators a_k and $a^\dagger_k$ transformed at

$$a_k \ = \ A_k\alpha_k \ + \ B_k\alpha^\dagger_{-k}$$

$$a^\dagger_k \ = \ A_k\alpha^\dagger_k \ + \ B_k\alpha^\dagger_{-k}$$

$$a_{-k} \ = \ A_k\alpha_{-k} \ - \ B_k\alpha^\dagger_k$$

$$a^\dagger_{-k} \ = \ A_k\alpha\dagger_k \ - \ B_k\alpha_{-k}.$$

The elements $A_k$and B_k are the Bogoliubov coefficients with $cosh(\theta_k) \ = \ A_k$ and $B_k \ = \ sinh(\theta_k)$. The Hamiltonian is then in quadratic form as

$$H \ = \ (1 \ + \ 6gX_0)\sum_k\omega(k)\alpha^\dagger_k\alpha_k \ + \ \sum_{k,q}\xi(q)A_kB_kA_{k-q}B_{k-q} \tag{2.3}$$

$$+ \ \sum_k[\omega(k)(A^1_k \ - \ B^2_k) \ - \ 2A_kB_k\sum_q A_{k+q}B_{k+q}](\alpha^\dagger_k\alpha_k \ + \ \alpha^\dagger_{-k}\alpha_{-k})$$

$$+ \ \sum_k[2\omega(k)A_kB_k \ + \ (A^2_k \ - \ B^2_k)\sum_q A_{k+q}B_{k+q}](\alpha^\dagger_k\alpha^\dagger_{-k} \ + \ \alpha_k\alpha_{-k})$$

$$+ \ O(\alpha^\dagger_{k+q}\alpha^\dagger_{-k-q}\alpha_k\alpha_{-k}).$$

The third term must vanish so we have

$$\sum_k[2\omega(k)A_kB_k \ + \ (A^2_k \ - \ B^2_k)\sum_q A_{k+q}B_{k+q}] \ = \ 0.$$

The redefined cubic interaction produces the terms

$$V^{(3)} \ = \ g\omega\Big(A_{k-q}A_qA_k(\alpha^\dagger_{k-q}\alpha_k\alpha^\dagger_q \ + \ \alpha_{k-q}\alpha^\dagger_k\alpha_q) \tag{2.4}$$

$$+ \ A_{k-q}B_qB_k(\alpha^\dagger_{k-q}\alpha_{-q}\alpha^\dagger_{-k} \ + \ \alpha_{k-q}\alpha^\dagger_{-q}\alpha_{-k})\Big)$$

The last part of this interaction is a Hamiltonian, while the first 6 terms are self-interaction terms of the scalar field.

The model is now modified so the cubic term is $g(E)\Gamma^\dagger(\phi + \phi^*)\Gamma$, which are Yukawa-like coupling Lagrangians between the Higgs particle to the vector boson. In the case the Higgs particle is absorbed the gauge boson W, Z absorbs the degree of Goldstone boson, or where the scalar is produced this is Higgs particle production or Higgs-stralung processes. This could just as well be treated as Yukawa-like interaction terms for fermion fields $g(E)\bar{\psi}(\phi + \phi^*)\psi$. For gauge field $\Gamma = (A,\ W,\ Z)$ the $\alpha^\dagger$, α are replaced by operators b, $b^\dagger$ are employed to describe photons and b, $b^\dagger$ describe the weak currents. The cubic interaction term is then

$$V^{(3)} = g\sum_{k,q}\omega(q)\Big(A_{k-q}A_qA_k(b^\dagger_{k-q}\alpha_{-q}b_k + b_{k-q}\alpha_q b^\dagger_k) + gA_{k-q}\alpha^\dagger_{k-q}B_qB_k(b^\dagger_{k-q}\alpha^\dagger_k b_{-q} + b_{k-q}\alpha_{-q}b^\dagger_{-k})\Big)$$
$$+ g\sum_{k,q}\omega(q)\Big(A_{k-q}A_qA_k(b^\dagger_{k-q}\alpha_k b^\dagger_q + b_{k-q}\alpha^\dagger_k b_q) + gA_{k-q}B_qB_k(b^\dagger_{k-q}\alpha_{-q}b^\dagger_{-k} + b_{k-q}\alpha^\dagger_{-q}b_{-k})\Big) \tag{2.5}$$

The first four of these terms describe the production or absorption of Goldstone bosons, a form of Higgsstralung, by the gauge field. The next four describe the production or absorption of the Higgs particle or Goldstone boson by the absorption or generation of the gauge fields. These terms correspond to the processes in the figure 3 below. The cubic potential then results in vacuum bubbles for gauge particles, plus open triad diagrams that couple the Higgs field to the $W^\pm$ and Z^0 gauge fields. The cubic vacuum bubble in the spacetime diagram for the accelerated observer is set at the origin and extends to a radius ρ corresponding to a hyperbolic accelerated path. The diagram for the accelerated observer with a vacuum bubble is seen in figure 4.

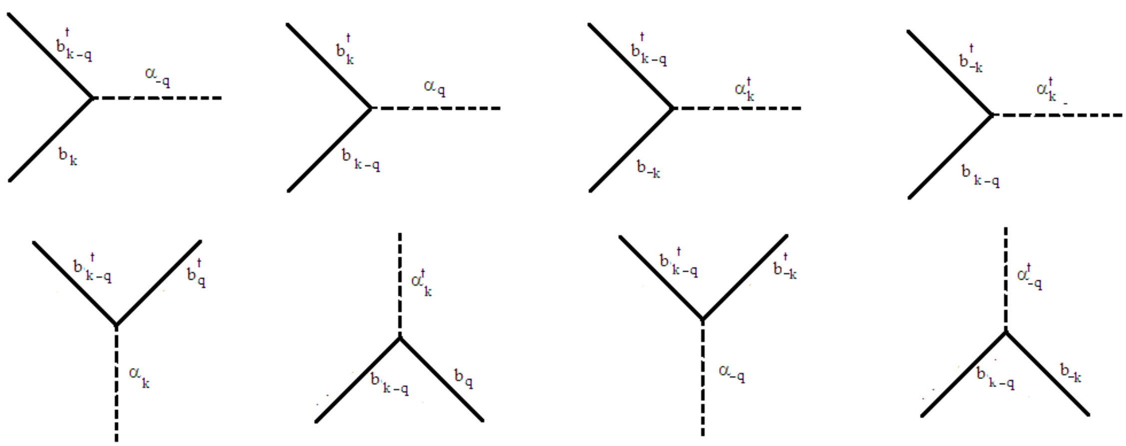

Figure 3

An observer on an accelerated frame, with acceleration g, has the observer behind them at a distance $\rho = c^2/g$. The larger the acceleration the the closer to the horizon the observer is. It is also interesting that for two particles to remain a constant distance from each other they must have different accelerations.

The Rindler wedge spacetime metric [7] distances are parameterized as

$$t = \rho sinh\omega,\ x = \rho cosh\omega$$

the angle ω is a parametrized time. the metric in the Minkowksi form is then

$$ds^2 = -d\rho^2 - \rho^2 d\omega^2 - dy^2 + dz^2.$$

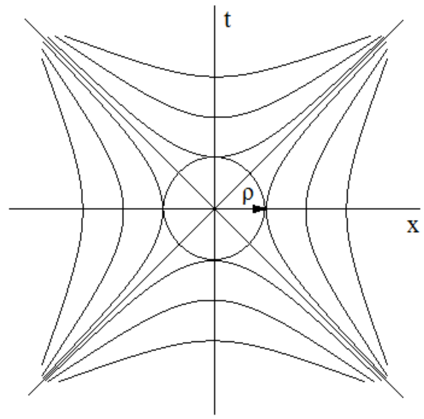

Figure 4

If we euclideanize this so that the metric is not Lorentzian we can then think of the unitary time development operator $U(t) = exp(-iHt)$ across region I to region II. We do this to consider the evolution of a quantum fluctuation that encloses the origin of the diagram above. We then replace $i \rightarrow 1$ and the time is evaluated for the entire loop, think of this as the perimeter of the loop, as $t \rightarrow \rho\omega|_0^{2\pi} = 2\pi\rho$. We then have the operator $U(\omega) = exp(-2\pi\rho H)$. The proper distance ρ between the hyperbolic surface and event horizon is $\rho = c^2/a$, for a the acceleration. The unitary operation $e^{-iHt/\hbar}$ is replaced with $t/\hbar - \rightarrow 2\pi ic^2/a$. If the cubic coupling term $g \rightarrow ig$ the $6igX_0\sum_k \omega(k)\alpha_k^\dagger\alpha_k$ recovers the Unruh radiation result for $6gX_0t/\hbar = 2\pi/k_Ba$ so the quadratic term is $2\pi\sum_k \omega(k)\alpha_k^\dagger\alpha_k/k_Ba$. This recovers for choice of the coupling constant g the Unruh effect and is a way of building Unruh radiation from the Higgs field. The cubic corresponding to the Higgs field and its interaction with the Z and $W^\pm$ fields enter into the picture at electroweak unification and perturb the standard result. This would occur as well with black holes.

3 Phase transitions and the cubic interaction

The physics below the symmetry breaking scale will suppress the terms seen in equation 5. The initial cubic terms in the transformation diagonal in the quartic field results in an imaginary quadratic term corresponding to Unruh radiation. At the EW energy and boundary for the recovery of symmetry the Higgs mechanism enters into the picture. This is a form of phase transition in the Unruh effect.

The high temperature expansion of a one loop effective potential is

$$V(\phi,\ T) = -\frac{\pi^2}{9}T^4 + \frac{\lambda}{24}(3\phi_c^2 - \sigma^2)T^2 - \frac{\lambda^{3/2}}{12\pi}(3\phi_c^2 - \sigma^2)^{3/2}T$$

which contains imaginary parts for $\phi < \sigma/3$. Here ϕ_c is the expectation of the scalar field $\phi_c = \langle\phi_c\rangle$. The scalar field obeys a Hamiltonian that is related to the Helmholtz free energy by a Legendre transformation with the probe current j and $j\int d^3x\phi$ such that

$$A(j,\ T) = \frac{H + j\int d^3x\phi}{vol}$$

so the classical field is then

$$\phi_c = \frac{\partial A}{\partial j}.$$

The volume $vol \simeq L^3$ defines a form of box quantization.

The partition function $Z(\beta) = Tr\ e^{-H\beta}$ so that

$$ln\ Z(\beta) = = \int \frac{vol\ d^3k}{(2\pi)^3}\left(\frac{\omega_k\beta}{2} + ln(1 - e^{-omega_k\beta})\right)$$

and the potential $V(\phi,\ T) = A(j,\ T) = j\phi_c$ is

$$V(\phi,\ T) = \frac{m}{2}\phi_c^2 + \int \frac{vol\ d^3k}{(2\pi)^3}\left(\frac{\omega_k}{2} + \beta^{-1}ln(1 - e^{-\omega_k\beta})\right).$$

The quadratic expansion of the potential $V(\phi)\ simeq\ V(\phi_c)\ \ \frac{1}{2}\partial_{\phi\phi}V(\phi_c)(\phi - \phi_c)^2$ gives

$$V(\phi_c,T) = V(\phi_c) + \int \frac{vol\ d^3k}{(2\pi)^3}\left(\frac{\omega_k}{2} + \beta^{-1}ln(1 - e^{-\omega_k\beta})\right),$$

with $\omega_k = \sqrt{k^2 + \partial_{\phi\phi}V}$. The renormalized effective potential is then

$$V(\phi,\ T) = \frac{\lambda}{4}(\phi_c^2 - \sigma^2) + \frac{T^4}{2\pi^2}\int_0^\infty x^2 ln(1 - e^{f(x)})dx + \frac{\lambda^2(3\phi_c^2 - \sigma^2)^2}{64\pi^2}\left[ln\left(\frac{\lambda(3\sigma_c - \sigma^2)}{\mu^2}\right) + \frac{1}{2}\right],$$

for $f(x) = \sqrt{x^2 + \lambda(3\sigma_c - \sigma^2)/T^2}$. In this manner the cubic term in the potential, or effective potential at the one-loop level, is manifested in a broken symmetry theory at the length ϕ_c.

4 Discussion

The inertial observer does not witness Unruh radiation. However, the inertial observer will measure an accelerated mass to have a temperature. This temperature is associated with the Unruh effect, and is equal to the Unruh temperature for a massive body at equilibrium with Unruh radiation in its inertial frame. An inertial observer may then interpret the heating of the body according to physics different from the Unruh radiation of the accelerated frame.

The quadratic term to emerge from the cubic interaction is $6gX_0\sum_k \omega(k)\alpha_k^\dagger\alpha_k$. The term $X_0 = \mu/\sqrt{2\lambda}$. For lower energy processes, for temperature $T < 10^{15}K$, corresponding to $10^{15}cm/s^2$ acceleration or a black hole mass $M < 10^8 kg$, photons dominate this process and the interaction term is $g\sqrt{2\omega(k)}B_k^2 a_k^\dagger a_k$ with the vacuum expectation above $\langle 0|exp(-2\pi H/a_z)|0\rangle$. A black hole with a mass greater than this will be in the symmetry breaking domain of the effective potential. The one loop physics of the Higgs field then recovers the one-loop physics of accelerated frame physics in spacetime.

The argument with effective potential illustrates how the cubic interaction associated with the coupling of accelerated massive particles with the vacuum is connected to the Higgs potential. The Higgs field reduces the symmetry of the vacuum and associated particle states from the symmetries of the Lagrangian. This means the Higgs field effectively hides symmetry. Event horizons of black holes similarly hide symmetries and the degree of freedom of particles and fields that enter the black hole. The exterior observer then observes matter and field that enter a black hole arbitrarily red shifted and as such hidden. This paper examines the phenomenology of general scalar fields and the effective potential for the Higgs field to illustrate how measurable aspect of the Unruh effect can be derived. The Higgs field corresponds to the particle horizon of a Rindler wedge.

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