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Theoretical Study of Thermal Photon Emissions From Quark-Gluon Plasma Using Lattice QCD

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Abstract. In this paper, the resulting photon emission rate in the collision $ug \rightarrow sg\gamma$ is studied and calculated using Spectral Function simulation methods to understand the quark-gluon plasma. The Spectral Function and photon emission rate of the $ug \rightarrow sg\gamma$ reaction are analyzed at a critical temperature of 157 MeV with a flavor number of n_f=5. To calculate the spectral function with low statistical uncertainty, the quantum chromodynamics theory of quark-gluon collisions is used to investigate the accuracy of thermal photon emission in determining photon emission rates. The Spectral Function analysis utilized multi-lattice space and extrapolation correlation factors at nf=5 for the $ug \rightarrow sg\gamma$ collision to extract the behavior of the spectral function and its effects on the photon rate from the QCD lattice correlations. The photon emission rate from the $ug \rightarrow sg\gamma$ interaction at 157 MeV offers insights into collision dynamics through spatial transverse vector correlations and lattice QCD. The Spectral Function analysis was performed in a multi-lattice space based on the extrapolation correlation factors with the flavor number 5 of the $ug \rightarrow sg\gamma$ collision. The QCD correlations, combining non-perturbative and perturbative effects at finite coupling, show an agreement within 10%.

Keywords: Thermal Photon, Quark-Gluon Plasma, Lattice QCD, perturbative QCD, non-perturbative QCD

1. Introduction

Recently, a theoretical investigation of the emission of photons from the interaction of quark with gluon plasma became a rich field of the research for understanding the characteristics of matter at high energy densities[1]. Photons have been considered good informants of the interaction of quarks with gluons, as they are penetrating probes of quark-gluon plasma QGP, a state of matter in which quarks and gluons don't longer confined within hadrons[2]. Photon production is the main tool for exploring

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the strong interaction in the Large Hadron Collider (LHC) at CERN and the Relativistic Heavy Ion Collisions (RHIC) at Berge National Laboratory and is thought to be recreated in the heavy ion collisions at the LHC or the Relativistic Heavy Ion Collider (RHIC) [3]. The emission of photons is the best probe of QGP because they interact weakly, allowing them to escape without scattering, and thus serving as a direct signature of the thermodynamic state of the plasma [4]. Because they are colourless, photons can penetrate the QGP probes, and they are the only major multi-purpose tool to provide direct information about the quark-gluon plasma (QGP)[5]. The photon emissions are divided into 2nd categories: direct and decay photons. The first refers to the photons created in the collision before the final hadrons separate while the second refers to all the photons that come from the electromagnetic decay of the hadrons into the final state. However, decay photons provide valuable information for particle reconstruction and give a larger contribution to the signal than direct photons[6]. However, photon emission through nuclear interactions in the solid state is the focus of experimental and theoretical studies. Lattice Quantum Chromodynamics theory is a good tool for studying and understanding the distinguishable properties within quark-gluon interaction space[7]. Lattice QCD is a principled method. The Euclidean Functional integral was equivalent to the partition function of the corresponding statistical system. The Euclidean form revealed the close relationship between statistical mechanics and quantum field theory, which was obtained by rotating to imaginary time[8]. In topology, various generalizations are used to deal with the properties of the QCD network interaction system [9]. Despite great progress, photon spectra from annihilation quarks, Compton scattering in interacting quarks, gluon interactions, and inelastic hadron gas still face unsolved problems resulting from relativistic heavy ion collisions [10-11]. Perhaps the most important of them is that quarks are fermions that have three generations, which are six flavours, and these quarks are the ones that Gell-Mann presented [12].Additionally, the gluons are bosonic guides that direct the strong force from quark to quark, and there are eight gluons[13]. Below the phase transition, the thermal medium of quark-gluon interaction is characterized by hadrons described by the initial degrees of freedom, while above the transition, they are described by quarks and gluons, which are the initial degrees of freedom of Quantum Electrodynamics (QCD). The quark-gluon plasma in the high-temperature phase can be studied experimentally at higher energies [14]. Moreover, the Photon Rate emitted by the quark-gluon plasma interaction was classical and could be observed experimentally in heavy ions [15].

2. Theory

The thermal Photon Rate for quark-gluon plasma can write as[6].

$$\Delta\Gamma(E) = \frac{g^2}{(2\pi)^3}\frac{1}{2E}\frac{\rho(E)}{e^{\beta E}-1} \qquad (1)$$

Where g^2 is quantum chromodynamics coupling strength , E is photon energy , $\rho(E)$ is the Spectral Function and β is function of temperature T, $\beta = \frac{1}{T}$. The Quantum Chromodynamic Coupling Strength α_q is [16].

$$\alpha_q = \frac{g^2}{4\pi} \qquad (2)$$

The Spectral Function $\rho(E)$ is is defined as[17].

$$\rho(E) = 2ImG_r(E) \qquad (3)$$

where $G_r(E)$ is Euclidean current correlated and given by[18].

$$G_r(E) = \int_0^T e^{-i(pr-Et)}\,\langle J_\mu(r,t)J_\nu(0)^*\rangle dt \int d^3r \qquad (4)$$

Where p is momentum , r is position region of interaction ,E is energy, t is time of reaction , $J_\mu(r,t)$ and $J_\nu(0)$ are the vector electromagnetic current. Inserting Eq.(4) in Eq.(3) to obtained.

$$\rho(E) = 2Im \int_0^T e^{-i(pr-Et)} \langle J_\mu(r,t) J_\nu(0)^* \rangle dt \int d^3r \quad (5)$$

However ,the susceptibility χ_s of quark defined by .

$$\chi_s = \int_0^{\frac{1}{T}} dt \int \langle J_\mu(r,t) J_\nu(0)^* \rangle d^3r \quad (6)$$

According to the Lattice QCD theory, the Euclidean correlation function with energy can be write as[19].

$$G_r(E) = \frac{\sum_n^\infty e^{-iEt} G_r(t)}{T} \quad (7)$$

Where T is temperature and $G_r(t)$ is correlated function with time , Euclidean correlation function is a function of the new Spectral Function $\xi(E) = \int_0^T e^{-i(pr-Et)} \langle J_\mu(r,t) J_\nu(0)^* \rangle dt$ by [20-21].

$$G_r(t) = \frac{1}{\pi} \int_0^\infty \frac{\cosh\left[E\left(t-\frac{1}{3T}\right)\right]}{\sinh\left[\frac{E}{2T}\right]} dE \int_0^T e^{-i(pr-Et)} \langle J_\mu(r,t) J_\nu(0)^* \rangle dt \quad (8)$$

where the first term in integral of Eq.(8) is kernel correlated $\mathrm{K}(E)$,it is reduced to [22].

$$\mathrm{K}(E) = \frac{\cosh\left[E\left(t-\frac{1}{3T}\right)\right]}{\sinh\left[\frac{E}{2T}\right]} \quad (9)$$

Inserting Eq.(9) and Eq.(8)together Eq.(7) in Eq.(3) to product

$$\rho(E) = 2Im \frac{1}{T} \sum_n^\infty \int_0^\infty \frac{1}{\pi} e^{-i(kr-\omega t)} \langle J_\mu(r,t) J_\nu(0)^* \rangle d^3r \int_0^\infty e^{-iEt}\, \mathrm{K}(E,t) dt \quad (10)$$

The solution of integral Eq.(10) is [23] .

$$\rho(E) = 2\rho_T(E,k) + \lambda \rho_L(E,k) \quad (11)$$

Where $\rho_T(E,k)$ and $\rho_L(E,k)$ are transverse and longitudinal spectral functions, respectively and λ is parameter of perturbative.

Inserting Eq.(10) and Eq.(2) in Eq.(1) using the net charge of quarks$\sum e_q^2$ in system to results .

$$\Delta\Gamma(E) = \frac{\alpha_q}{2\pi^2} \frac{\sum e_q^2}{2E} \frac{[2\rho_T(E,k) + \lambda\rho_L(E,k)]}{e^{\beta E} - 1} \quad (12)$$

Furthermore, the two term of Spectral Functions in Eq.(11) are vanished if $k \to 0$ and the transverse spectral functions term is [24].

$$\rho_T(E,k) = 2\omega D \chi_s \quad (13)$$

Where k is momentume , ω is angular frequency and D is diffusion coefficient .The effective diffusion coefficient when$\omega \to E, \hbar \to 1$, is[25] .

$$D_{ef} = \frac{\rho(E)}{2E\chi_s} \quad (14)$$

Inserting Eq.(14) in Eq.(12) to obtained .

$$\Delta\Gamma(E) = \frac{\alpha_q}{2\pi^2} \sum e_q^2 \frac{\chi_s}{e^{\beta E} - 1} D_{ef} \quad (15)$$

The Strength Coupling Constant of quarks interaction is [26].

$$\alpha_q(T) = \frac{6\pi}{(33-2n_f) Ln \frac{8T}{T_c}} \quad (16)$$

where n_f is flavor number ,T is temperature of system and T_c is critical temperature . The critical temperature is[13].

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$$T_c = \left(\frac{90B}{\pi^2[(n_{sg} \times n_{cg}) + \frac{7}{4}(n_{cq} \times n_{sq} \times n_{fq})]}\right)^{\frac{1}{4}} \quad (17)$$

where B is Bag constant, n_{sg} and n_{cg} are the spin and coulour number of gluon , n_{cq} , n_{sq} and n_{fq} are couloir ,spin and flavor of quark.

3. Lattice setup

The thermal photon emission rate of the quark interaction with gluon interaction in the plasma phase can be computed used Lattice QCD calculation by using several lattice ensembles with a critical temperature of T_c = 157 MeV, generated with non-perturbative methods and simulation MATLAP soft word. The critical temperature for $ug \rightarrow s\,\gamma$ interaction system can be calculated using Eq.(14) with $n_{sg} = 2$ and $n_{cg} = 8$ for gluon and $n_{cq} = 3$, $n_{sq} = 2$ and $n_{fq} = 1 + 4 = 5$ for $ug \rightarrow s\,\gamma$ system, where $n_{fq} = 1$ for up (u) quark and $n_{fq} = 4$ for strange (S) quark with taken Bag constant $B^{\frac{1}{4}} = 260$ to result of critical temperature T_c = 157MeV .To start calculations, assuming lattice has finite spatial physical volume for ensembles $L = aN_s$, where a is the lattice spacing and N_s is the temporal lattice extents of the N_f = 1 + 4 for $ug \rightarrow s\,\gamma$quark-gluon interaction with lattice spacing a ≃0.066, 0.049, 0.039, and 0.033 fm . The discrete momentum is $k = \frac{2\pi}{L}(n_x + n_y + n_z)$ where n_x, n_y and $n_z \in$ Z in lattice QCD at temperature of $ug \rightarrow s\,\gamma$ system T=(125,157,225,275,325,375,425,475,525,575and 625) MeV, generated at the Wilson scale. The momentum takes to point along the lattice axes to minimize discretization effects. The physical volume for ensembles spatial lattice extents N_t is aN_τ = 1/T. The continuum Yang-Mills coupling g is related to lattice coupling β by $g^2 = \frac{2N}{\beta} = 4\pi\alpha_Q$ with number of plaquettes $\frac{LT}{a^2}$. Lattice-QCD simulations has been done at flavor number fermions $N_f = 5$ for dynamical $ug \rightarrow s\,\gamma$.

Table 1. Key parameters of QCD lattice groups used in simultaneous

T(MeV)	$\frac{T}{T_c}$	k	N_s	N_t	$\frac{\omega}{T}$	$\beta[\text{MeV}]^{-1}$	a (fm)	$\frac{\beta}{a}$
125	0.796	392	73	24	5	0.008	0.042	0.190
175	1.114	55o	52	17	10	0.0057	0.059	0.096
225	1.433	707	39	13	15	0.0044	0.079	0.055
275	1.751	864	33	11	20	0.0036	0.093	0.038
325	2.070	1021	27	9	25	0.0030	0.114	0.026
375	2.388	1178	24	8	30	0.0026	0.129	0.020
425	2.707	1335	21	7	35	0.0023	0.147	0.015
475	3.025	1492	18	6	40	0.0021	0.172	0.012
525	3.343	1649	18	6	45	0.0019	0.172	0.011
575	3.662	1906	15	5	50	0.0017	0.206	0.009
625	3.980	1963	15	5	55	0.0016	0.206	0.007

4.Results and Discussion

To understand and calculate thermal photon emission from quark-gluon plasma using Lattice QCD, a study of the time-varying energy density of quark-gluon plasma variations over time is presented. To obtain the Spectral Function and thermal photon rate in lattice QCD calculation, the strength coupling in lattice can calculate for flavor number $n_{fq} = 1 + 4 = 5$ for $ug \rightarrow s\,\gamma$ system using Eq.(13) taking account critical temperature T_c = 157MeV concerned the infinite- a Results were listed in Table (2).

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Table 2. The strength coupling calculated for $ug \rightarrow s\,\gamma$ system with $n_{fq} = 5$ using the critical temperature $T_c = 157\text{MeV}$.

T(MeV)	$\frac{T}{T_c}$	$\frac{\omega}{T}$	$\beta[\text{MeV}]^{-1}$	a (fm)	$\alpha_c(T)$	$\omega \times 10^3$MeV
125	0.796	5	0.008	0.042	0.442	0.625
175	1.114	10	0.0057	0.059	0.374	1.750
225	1.433	15	0.0044	0.079	0.336	3.375
275	1.751	20	0.0036	0.093	0.310	5.500
325	2.070	25	0.0030	0.114	0.292	8.125
375	2.388	30	0.0026	0.129	0.278	11.250
425	2.707	35	0.0023	0.147	0.266	14.875
475	3.025	40	0.0021	0.172	0.257	19.000
525	3.343	45	0.0019	0.172	0.249	23.625
575	3.662	50	0.0017	0.206	0.243	28.750
625	3.980	55	0.0016	0.206	0.237	34.375

Table(2),shows strong coupling constant$\alpha_c(T)$ calculates as a function of thermal energy of system and flavour number at finte critical temperature of 157 MeV. The value of strong coupling constant for the $ug \rightarrow s\,\gamma$ system was increasing with decreasing thermal energy of system.It decreases from maximum 0.442at 125 Mev to minimum 0.237 at 625 Mev for $ug \rightarrow s\gamma$ system ,respectivelly.However ,the strong coupling constant for $ug \rightarrow s\,\gamma$ system with 5 flavour number is larger at minimum ratios $\frac{\omega}{T} = 5$ and $\frac{T}{T_c} = 0.796$. However, it is hoped that it will provide a reasonable estimate of photon production even for perturbative calculations of photon production by quark-gluon interaction using Lattice QCD theory.However,to discussion the simulation of Spectral Function strategy,the relation between $\frac{\omega}{T}$ in range(5,10,15,20,25,30,35,40,45,50 and 55) with thermal energy T in region from 125MeV to 625MeV and ploted in Figure1.

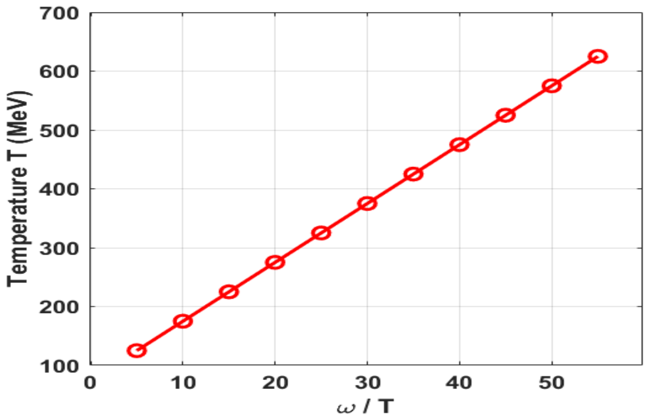

Figure 1. Plotted the behavior of Temperature of system $T(MeV)$ with ratio $\frac{\omega}{T}$.

Figure(1) show linear relationship between T(MeV) and W/T , the torque of $\frac{\omega}{T}$ was increased incresed T(MeV). To analysis the Spectral Function , the rescaled Spectral Function can calculate using the continuum lattice data in different ratio $\frac{\omega}{T}$ to include in the simulation,results calculation using the QCD Lattice are shown in Table 3 at two different values of local discretization k/T(3.14 and 4.97).

Table 3. The calculation of rescaled spectral function $G_r(t)$ as function of $\frac{\omega}{T}$ ratio using the continuum lattice.

$\frac{T}{T_c}$	$\omega \times 10^3$MeV	T(MeV)	$\frac{\omega}{T}$	$G_r(t)$	
				k/T	
				3.14	4.97
0.796	0.625	125	5	0.118	0.0750
1.114	1.750	175	10	0.139	0.1100
1.433	3.375	225	15	0.152	0.1390
1.751	5.500	275	20	0.164	0.1501
2.070	8.125	325	25	0.1680	0.160
2.388	11.250	375	30	0.17	0.161
2.707	14.875	425	35	0.172	0.164
3.025	19.000	475	40	0.174	0.168
3.343	23.625	525	45	0.176	0.170
3.662	28.750	575	50	0.178	0.172
3.980	34.375	625	55	0.180	0.174

Table(3) show transverse correlations $G_r(t)$ results from calculation in the continuous extrapolation of the ug→sγ system, the behaviour of $G_r(t)$ for different theoretical predictions in k/T (3.14 and 4.97) for $5 \leq \frac{\omega}{T} \leq 55$ by neglect the quark mass effects in QCD Lattice assuming m=T in simulations.Table(3) shows that the correlator is about from 0.118%–0.180% at moment k/T (3.4) and was 0.0750% to 0.71%f or momenta k/T was 4.97 at Euclidean time separations in range $5 \leq \frac{\omega}{T} \leq 55$,the behavoure illustrated in Figure.2 .

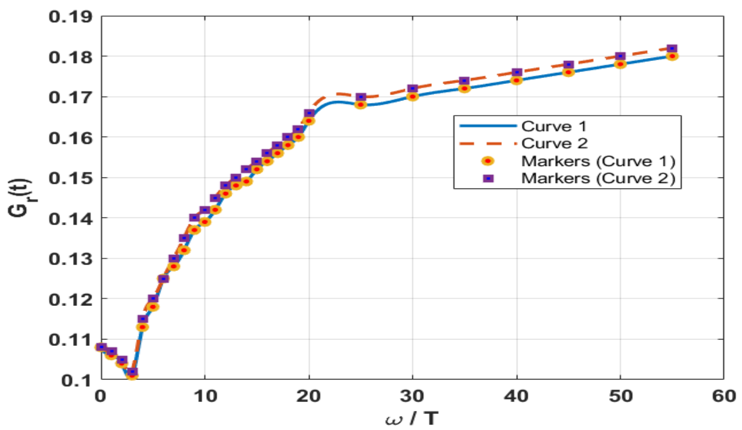

Figure 2. Plotted the behavior of rescaled spectral functions $G_r(t)$ with $\frac{\omega}{T}$.

The rescaled Spectral Function $G_r(t)$increases with increasing $\frac{\omega}{T}$ and decreases with increases $k/T$from 3.14 to 4.97 .However the correlation of Spectral Function increasing with increasing $\frac{T}{T_c}$ to reach maximum at 3.980 for both values of $k/T$from 3.14 to 4.97. The spectral function was increased in variance and reached a single point towards large time intervals between ω/T, the value of which depends on k/T, and the continuity limit can be reliably determined.Furthermore, the results can be

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enhanced by reducing the difference between the grid spacing to achieve a good fit with an acceptable spectral function.It minimizes the steady-state value on the continuum at smaller Euclidean time intervals.Figure 2 indicated that the strong coupling of the quark interaction in the system theory result in cg → bgγ also provides a relatively acceptable description, although this result concerns a non-Abelian gauge theory and is applicable in the large colour number limit.However, the perturbed corrections $G_r(t)$ of the Spectral Function show an improvement in their agreement with lattice correlator.The corrections $G_r(t)$ of spectral functions in Figure (2) constructed as a function to ω/T in two values of k/T with the non-interacting QCD, the lattice shows agree result at large ω/T.Table 4 shows the results of the Lattice QCD for the normalized spectral function $\rho(E,\lambda)$ by $\frac{2\chi_s\omega}{T}$at different ratios ω/T, which is largely observed at large ratio ω/T compared to smaller ratios at larger ω/T, the results agree with the results in Ref.[27].

Table 4. The results Lattace QCD of normalized Spectral Function $\rho(E,\lambda)$ by $\frac{2\chi_s\omega}{T}$ Vs. $\frac{\omega}{T}$ ratio.

$\frac{T}{T_c}$	$\omega \times 10^3$MeV	T(MeV)	$\frac{\omega}{T}$	$\frac{T\rho(E,\lambda)}{2\chi_s\omega}$	
				k/T	
				3.14	**4.97**
0.796	0.625	125	5	0.118	0.0750
1.114	1.750	175	10	0.140	0.152
1.433	3.375	225	15	0.138	0.141
1.751	5.500	275	20	0.133	0.137
2.070	8.125	325	25	0.132	0.136
2.388	11.250	375	30	0.131	0.135
2.707	14.875	425	35	0.130	0.134
3.025	19.000	475	40	0.129	0.133
3.343	23.625	525	45	0.1285	0.132
3.662	28.750	575	50	0.127	0.131
3.980	34.375	625	55	0.25	0.130

Table 4 shows that the lattice correlations were flat at small $\frac{\omega}{T}$ ratio compared to lower correlations for larger $\frac{\omega}{T}$, which corresponds to a small peak of $\frac{T\rho(E,\lambda)}{2\chi_s\omega}$ at $\frac{\omega}{T}$found in Figure 3.The normalized behaviour of the Spectral Function ρ(E,κ) appears to decrease dramatically and a continuous limit is obtained for the constant sensitivity 0.792 in the continuity limit.

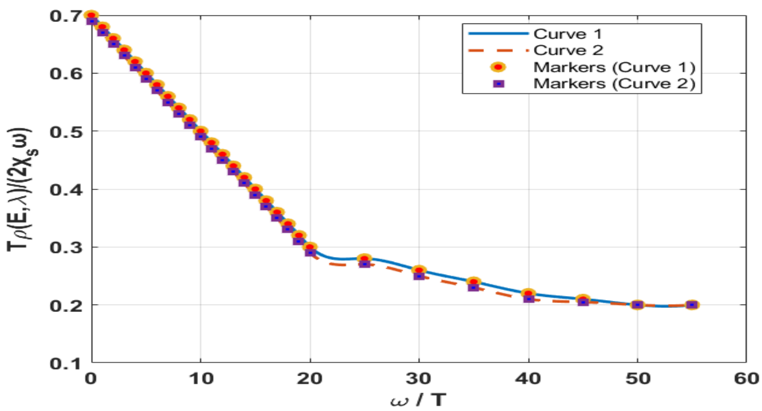

Figure 3. The normalized Spectral Function $\rho(E,\lambda)$ with $\frac{2\chi_s\omega}{T}$ at varouse $\frac{\omega}{T}$ ratio.

The strong coupling Spectral Function was used to describe the propagation in Eq. (14) and the $ug \rightarrow s\,\gamma$ interaction with perturbation theory, results of Lattice QCD calculation for effective diffusion $D_{ef}T$ Vs . $\frac{\omega}{T}$ ratio are listed in Table 5.

Table 5. Effective diffusion coefficient $D_{ef}T$ calculation data with different $\frac{\omega}{T}$ ratio.

$\frac{T}{T_c}$	$\omega \times 10^3$MeV	T(MeV)	$\frac{\omega}{T}$	$D_{ef}T$	
				k/T	
				3.14	4.97
0.796	0.625	125	5	0.61	0.39
1.114	1.750	175	10	0.35	0.15
1.433	3.375	225	15	0.23	0.095
1.751	5.500	275	20	0.15	0.088
2.070	8.125	325	25	0.14	0.082
2.388	11.250	375	30	0.135	0.077
2.707	14.875	425	35	0.13	0.072
3.025	19.000	475	40	0.129	0.068
3.343	23.625	525	45	0.127	0.067
3.662	28.750	575	50	0.126	0.066
3.980	34.375	625	55	0.125	0.065

The Spectral Function in Eq. (14) fits best the Spectral Function obtained using the QCD lattice approach in the $ug \rightarrow s\,\gamma$ system.Table(5) shows results of D_{ef} for the $ug \rightarrow s\,\gamma$ system using leading-order perturbation theory at strong coupling of up quark qith gluon . Figure 4 shows the behaviour of the effective diffusion coefficient in D_{ef} in Eq. (14) obtained using the perturbative QCD with $\frac{\omega}{T}$ shown in the graph, D_{ef} is proportional to the increase in $\frac{\omega}{T}$and also shows the corresponding perturbation and the convergence of the estimates can be checked by changing the scale $\frac{\omega}{T}$.However, the $D_{ef}T$ varied less than $\frac{T}{T_c}$which increases with decreasing $\frac{T}{T_c}$ and energy T(MeV).

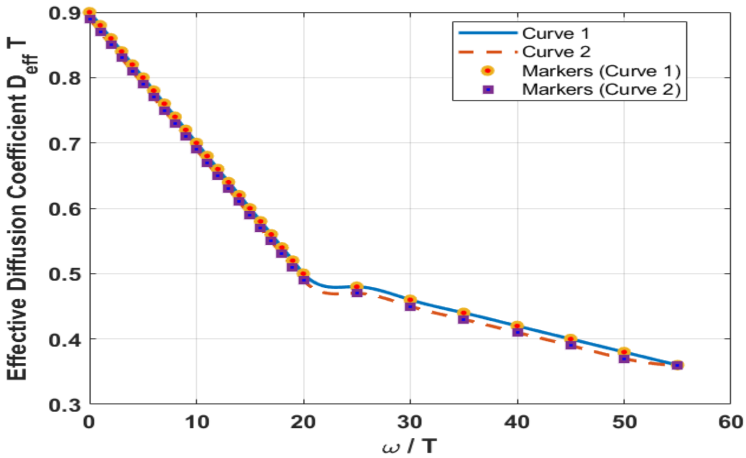

Figure 4. Results calculation ofeffective diffusion coefficient $D_{ef}T$ versus different $\frac{\omega}{T}$ ratio.

Table 5. and Figure 4 show the best details for estimating the diffusion coefficient $D_{ef}T$ in Eq. (14) using the extracted polynomials, which leads to a large spread in the results because D_{ef} ' comes from

results falling into two well-separated intervals and the results tend to decrease with increases in $\frac{\omega}{T}$. The behavior of the spectral function is affected by the distribution of diffusion around light-like motions and has minimums and maximums in the frequency range. The D_{ef} results in Table 5 and Figure 4 obtained from simulations are significantly constrained by the spectral function ρ(E,κ) depending on the Lattice QCD approach as the solutions used to analyze the Spectral Function . Results show good agreement with experimental results [27].Representative Spectral Function defined by in Eq.(8) and (10) obtaine using Lattice QCD calculation for different ω/T , results show in Table 6 and Figure 5 .

Table 6. Spectral function calculation using lattice QCD with $\frac{\omega}{T}$ ratio.

$\frac{T}{T_c}$	$\omega \times 10^3$MeV	T(MeV)	$\frac{\omega}{T}$	$\xi(E)\frac{\cosh[E(t-\frac{1}{3T})]}{\sinh[\frac{E}{2T}]\chi_s}$	
				k/T	
				3.14	4.97
0.796	0.625	125	5	9.098	9.01
1.114	1.750	175	10	3.756	7.767
1.433	3.375	225	15	1.875	5.565
1.751	5.500	275	20	0.129	0.112
2.070	8.125	325	25	0.125	0.098
2.388	11.250	375	30	0.123	0.082
2.707	14.875	425	35	0.121	0.076
3.025	19.000	475	40	0.119	0.063
3.343	23.625	525	45	0.118	0.051
3.662	28.750	575	50	0.101	0.042
3.980	34.375	625	55	0.098	0.039

Table 6. indicates the cg → dgγ interaction system, weak couplings of 0.098 and 0.039 were predicted for both k/T (3.14 and 4.97) with the highest values $\boldsymbol{\omega}$ of 34.375× 10^3MeV . The data in Table 6 show that the lattice data reach a minimum and lose their sensitivity to the photon rate at large momentum w/T and K/T which are useful in adopting frequency Spectral Function to describe QCD correlations.

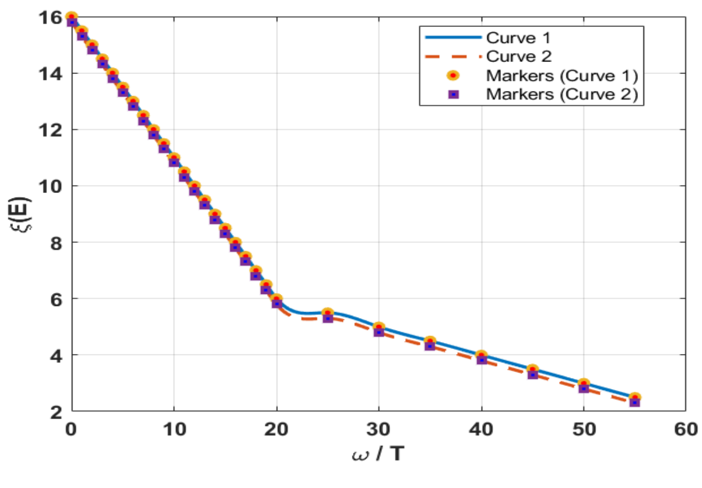

Figure 5 . Representative ploted of Spectral Function $\xi(E)\frac{\cosh[E(t-\frac{1}{3T})]}{\sinh[\frac{E}{2T}]\chi_s}$ with $\frac{\omega}{T}$ ratio.

Figure(5). Representative ploted of Spectral Function calculation using lattice QCD data for four different $\frac{\omega}{T}$ratio.Figure(5) represents to the spectral functions for two k/T (3.14 and 4.97), it was shown that the ρ(E,κ) corresponding to upper and lower extremes of D_{ef} (k) shown in Fig. (4). Moreover, the Spectral Function for small w/T units shows better agreement with each other as k/T (3.14 and 4.97) and less agreement over large w/T, while the relative change in the reconstructions remains approximately close.The spectrum of photon emission produces by interaction up quark with gluon in higher energy collisions can be calculated from the Spectral Function using Lattice QCD simulation of the current correlator in Eq.(12).Results show in table(7) and plotted in figure(6)

Table 7. The photon emission rate at $T_c = 157\ MeV$ in $ug \rightarrow sg\gamma$ system.

Photon energy E(GeV)	**The strength coupling $\alpha_q(T)$**			
	0.442	**0.374**	**0.336**	**0.31**
1	8.730×10^{-11}	5.415×10^{-10}	1.553×10^{-9}	3.068×10^{-9}
1.5	2.186×10^{-12}	4.46×10^{-11}	2.546×10^{-10}	7.994×10^{-10}
2	4.767×10^{-14}	3.111×10^{-12}	3.422×10^{-11}	1.644×10^{-10}
2.5	9.816×10^{-16}	2.032×10^{-13}	4.267×10^{-12}	3.106×10^{-11}
3	1.96×10^{-17}	1.282×10^{-14}	4.118×10^{-13}	5.622×10^{-12}
3.5	3.841×10^{-19}	7.92×10^{-16}	5.998×10^{-14}	9.92×10^{-13}
4	7.434×10^{-21}	4.826×10^{-17}	6.925×10^{-15}	1.722×10^{-13}
4.5	1.426×10^{-22}	2.912×10^{-18}	7.911×10^{-16}	2.955×10^{-14}
5	2.717×10^{-24}	1.745×10^{-19}	8.966×10^{-17}	5.03×10^{-15}

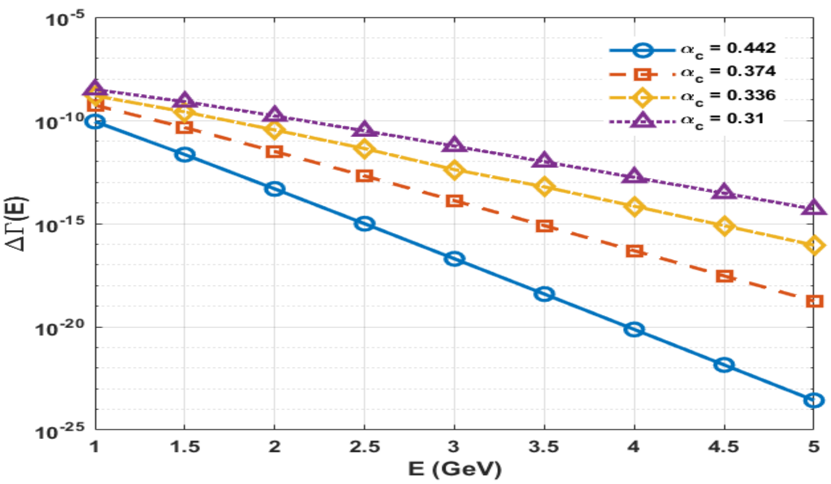

Figure 6. Representative ploted of spectral rate $\Delta\Gamma(E)$with photon energy E (GeV) .

In Figure 6, the spectral photon emission $\Delta\Gamma(E)$ performed a function of photon energy E(GeV) and the strength coupling (0.442,0.374,0.336 and 0.31),the $\Delta\Gamma(E)$ increases with increases thermal energy of the system and increases with decreasing strength coupling .Generally , the photon emission was decreased with increased photon energy and vice versa.This is consistent with the experimental of the relevant transition temperature at low photon energy and quenched quantum transition temperature, which is about 65% higher than full QCD.

4. Conclusion

Euclidean lattice correlates were used in Lattice QCD calculation to estimate the photon emission produced from $ug \rightarrow sg\gamma$ interaction at critical temperature 157 Mev. The rate of photon emission calculated by extrapolated methods with the simulation of Spectral Function ρ(E,λ) and correlate $G_r(E)$ satisfies the rule to analyses the asymptotic behavior of photon emission. The Spectral Function is extrapolated to a single lattice spacing in the continuum using Lattice QCD calculations as well as non-perturbative effects on the Spectral Function correlation. The non-perturbative is showing at lower w/T ratios compared to higher w/T ratios and the lattice correlation was a significant continuum in contrast to the perturbative correlator parameter. The lattice QCD calculation of the Spectral Function shows a similar curvature of the perturbative correlation for larger w/k and non-perturbative effects appear even at high w/T, the perturbative and non-perturbative correlation indicating a large non-perturbative modulation. The photon emission rate from $ug \rightarrow sg\gamma$ was calculated using the Spectral Function data, and the resulting rate of the reaction had a stable behavior concerning the change of the coupling strength for all thermal energy of the $ug \rightarrow sg\gamma$ system. The Photon Rate at the lowest photon energy is found to be large despite the decreasing coupling strength showing some dependence on thermal energy, while the Photon Rate at the highest photon energy drops to a small rate. The correlations show an agree about 10%.

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