Investigation and Study of Photonic Current Rate in Bremsstrahlung process

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Abstract. In this paper, we investigate and study quantum theoretical of quark-gluon interaction modeling in QGP matter formatted. In theoretical modeling, we can use a flavor number, strength coupling, critical energy $T_c = 190$ MeV, system energy (400-650)MeV , fugacity of quark and gluon, and photon energy in range of 1-10 GeV parameter to calculation and investigation spectrum of photon rate. We calculation and study the photon rate produced through bremsstrahlung processes from the stable QGP matter. The photon rate production from $cg \rightarrow dgy$ and $cg \rightarrow bgy$ systems at bremsstrahlung processes are found to be increased with increased fugacity, decreased strength coupling, decreased the photons energy and temperature of system. The photons rate in $cg \rightarrow dgy$ is increases a little compared to the $cg \rightarrow bgy$ systems.

Keywords: Photonic Current Rate, Bremsstrahlung process.

1. Introduction

The elementary particle is considered as an one important field in physics because it uses a much more scientific method to study and investigate many facts to construction nature. Many theories introduced to study and understand the structure of nucleons and quark-gluon interaction formation the universal phase after the big bang stage [1]. Now, there are different experimental results on hadron observable in collisions at the Relativistic Heavy Ion-Collision (RHIC), its showing that hadron must be produced in high energy collisions through quark–gluon plasma (QGP) formatted fireball [2]. The most important idea of heavy collisions is to study and create a strong interaction material; it obtains from the transformation of containment matter into (hadronic state) to a quark-gluon free. The quark-gluon plasma was existed for a short time in volume $100 \text{ fm}^3$ and it can impossible detection the QGP state of matter directly. On the other hand, the different indirect signatures had been used to detect such as; strangeness enhancement, dilepton spectra, suppression and photon emission [5]. In fact, the theoretical approach to study and investigate
the elementary particles has been introduced by Standard Model; it’s evolved in 1970’s. The fundamentals of Standard Model are quantum chromodynamics and electroweak and theory [6]. The strength coupling is controlled on calculations of the photon production rate from a quark–gluon interaction in QCD medium and its possible limited only in certain situations. In weakly coupled quark with gluon indicate that the quark-gluon plasma (QGP) has a strength coupling smaller than one to complete estimation the photons rate [7]. Contrary to molecules and atoms, the quarks and gluons haven’t found in freely, but were confined in hadronic state. This state was quite similar to decomposition of the magnetic pole north and south and never isolated each other [8]. The rate of photon emission from QGP matter is has estimation using phase-space distributed. They are assume to be Bose-Einstein and Fermi-Dirac distributions, while the lattice QCD estimation indicated that QGP system has been strong interaction ,for both non-ideal corrections taken into account the photon rate[9].

2. Theory

The number of photonic emitting rate production per unit time per unit volume via the usual QCD theory is [10].

$$\Gamma_{qg}^{Br}(E, P) = - \frac{1}{2(2\pi)^3} F_B(E) \text{Im} \left[ \frac{\partial}{\partial \lambda} \right]$$

Where $F_B(E)$ is the distribution function of Bose-Einstein and $\text{Im} \left[ \frac{\partial}{\partial \lambda} \right]$ is the imaginary part of the retarded self-energy polarization tensor of the photons at Bremsstrahlung processes. The distribution function of Bose-Einstein $F_B(E)$ is given by [11].

$$F_B(E) = \frac{1}{e^{E/T} - 1}$$

Where $E$ is the energy of photon and $T$ is the heat energy of the system. Then the imaginary part $\text{Im} \left[ \frac{\partial}{\partial \lambda} \right]$ is given by [12].

$$\text{Im} \left[ \frac{\partial}{\partial \lambda} \right] = (-1) \frac{N C_F}{\pi^4} e^2 g_{Br}^2 \frac{T}{E^2} \left| f_{qf}(P) - f_{qf}(P + E) \right| (P^2 + (P + E)^2) dP$$

Where $N$ is an overall degeneracy factor , $C_F$ is the Casimir operator of the system unitary group $\text{SU}(N_c)$ , $\alpha$ is the quantum electrodynamics coupling, $\Sigma e_q^2$ is the square charge of quark , $g_{Br}^2$ is the square quantum chromodynamic coupling , $T$ is the heat energy of system , $E$ is the energy of photons , $f_{qf}(P)$ is the fugacity of quark $f_{qf}(P)$ is the integral of the self-energy . The variance of constants self-energy is given by integral [13].

$$J_{T-L} = J_{T-L}$$

Then the dimensionless constants of the self-energy. Inserting Eq.(4) in Eq.(3), then imaginary part is reduced to.

$$\text{Im} \left[ \frac{\partial}{\partial \lambda} \right] = (-1) \frac{N C_F}{\pi^4} e^2 g_{Br}^2 \frac{T}{E^2} \left| f_{qf}(P) - f_{qf}(P + E) \right| (P^2 + (P + E)^2) dP$$

Introduce the electric charge of quarks $\Sigma e_q^2$ in Eq.(5) to given .

$$\text{Im} \left[ \frac{\partial}{\partial \lambda} \right] = (-1) \frac{N C_F}{\pi^4} e^2 g_{Br}^2 \frac{T}{E^2} \left| f_{qf}(P) - f_{qf}(P + E) \right| \sum e_q^2 f_{qf}(P) - f_{qf}(P + E) \right| (P^2 + (P + E)^2) dP$$

The Juttner distribution function for quark $f_{qf}(P)$ and $f_{qf}(P + E)$ are given by [14].

$$f_{qf}(P) = \frac{\lambda_q}{e^{(P+\lambda_q)T}+\lambda_q}$$

$$f_{qf}(P + E) = \frac{\lambda_q}{e^{(P+\lambda_q)T}+\lambda_q}$$

Where $\lambda_q$ is the fugacity parameter. Inserting Eqs.(7) and (8) in Eq.(6) and simply to reduced .

$$\text{Im} \left[ \frac{\partial}{\partial \lambda} \right] =$$
\[-1\frac{N_{C_F}}{\pi^2} e^2 g_{BR}^2 \frac{T}{E^2} \|I_T - I_L\| \sum e_q^2 \times \left[ \int_0^\infty \frac{\lambda_q(2P^2 + 2PE + E^2)}{e^{\frac{P^2}{T^2}} + \lambda_q} dP \right] \] 

\[ \int_0^\infty \frac{\lambda_q(2P^2 + 2PE + E^2)}{e^{\frac{P^2}{T^2}} + \lambda_q} dP \] ..........................(9)

The solve of the integral term give results 

\[ \int_0^\infty \frac{\lambda_q(2P^2 + 2PE + E^2)}{e^{\frac{P^2}{T^2}} + \lambda_q} dP = \Lambda(\lambda_q, E, T) = \left[ 2T^3 I(3) + 2ET^2 I(2) + E^2 T\Gamma(1) \right] \left[ \frac{\lambda_q^1}{1!} (1 + e^{-E}) - \frac{\lambda_q^2}{2!} (1 + e^{-2E}) + \frac{\lambda_q^3}{3!} (1 + e^{-3E}) - \frac{\lambda_q^4}{4!} (1 + e^{-4E}) + \frac{\lambda_q^5}{5!} (1 + e^{-5E}) - \ldots \frac{\lambda_q^n}{n!} (1 + e^{-nE}) \right] \] ..........................(10)

Inserting Eq.(10) in Eq.(9) to obtain .

\[ \text{Im}[\Pi_{qg}(E, P)] = (-1) \frac{N_{C_F}}{\pi^2} e^2 g_{BR}^2 \frac{T}{E^2} \|I_T - I_L\| \sum e_q^2 \Lambda(\lambda_q, E, T) \] ..........................(11)

The coupling parameter for QCD theory is given by [15].

\[ \alpha_{sc}^n = \frac{g_{BR}^2}{4\pi} \] ..........................(12)

Where \( g_{BR} \) is the constant of strong coupling interaction. The Casimir operator \( C_P \) is corresponded to representation of color charge is [16].

\[ C_P = \frac{(N_c^2 - 1)}{2N_c} \] ..........................(13)

where \( N_c \) is the color number constant.

Inserting Eq.(12) and Eq.(13) in Eq.(11) to obtain .

\[ \text{Im}[\Pi_{qg}(E, P)] = (-1) \frac{N_{C_F}}{\pi^2} e^2 \alpha_{sc}^n \sum e_q^2 \|I_T - I_L\| \frac{T}{E^2} \Lambda(\lambda_q, E, T) \] ..........................(14)

The quantum electrodynamics QED coupling constant [17].

\[ \alpha = \frac{e^2}{4\pi} \] ..........................(15)

substituting Eq.(15) in Eq.(14) to obtain .

\[ \text{Im}[\Pi_{qg}(E, P)] = (-1) \frac{N_{C_F}}{\pi^2} \frac{16}{3} \alpha \alpha_{sc}^n \sum e^2 \|I_T - I_L\| \frac{T}{E^2} \Lambda(\lambda_q, E, T) \] ..........................(16)

Inserting Eq.(16) in Eq.(11) to obtain .

\[ \Gamma_{qg}^{BR}(E, P) = \frac{N_{C_F}}{\pi^2} \frac{8}{3} \alpha \alpha_{sc}^n \sum e_q^2 \|I_T - I_L\| \frac{T}{E^2} F_B(E) \Lambda(\lambda_q, E, T) \] ..........................(17)

The overall degeneracy factor \( N \) in QCD theory is equal to quantum number of color \( N_c = 3 \), then Eq.(17) becomes.

\[ \Gamma_{qg}^{BR}(E, P) = \frac{8}{3} \alpha \alpha_{sc}^n \sum e_q^2 \|I_T - I_L\| \frac{T}{E^2} F_B(E) \Lambda(\lambda_q, E, T) \] ..........................(18)

The Bosonic function distribution for gluon \( F_B(P) \) [18] and simply to .

\[ F_B(E) = \frac{\lambda_q}{e^T - \lambda_q} = \frac{1}{\frac{e^T}{\lambda_q} - 1} \approx \lambda_q e^{-E} \] ..........................(19)

The Eq.(18) becomes with Eq.( 19) is.

\[ \Gamma_{qg}^{BR}(E, P) = \frac{8}{3} \alpha \alpha_{sc}^n \sum e_q^2 \|I_T - I_L\| \frac{T}{E^2} \lambda_q e^{-E} \Lambda(\lambda_q, E, T) \] ..........................(20)

The strength coupling constant is given by [19].

\[ \alpha_{sc}^n = \frac{6\pi}{(3\pi - 2\alpha^2) \ln \left( \frac{E}{\mu_0} \right)} \] ..........................(21)

where \( \mu_1 \) is the momentum or heat energy and \( \mu_1 \approx 8T \) and \( \mu_0 \) is refers to heat energy or momentum in hadrons phase \( \mu_0 \approx T_{cr} \), where \( T_{cr} \) is the critical temperature .

3. Results
To obtain the spectrum of photons rate at bremsstrahlung process depend on the quantum chromodynamic QCD theory one can calculate the strength coupling through estimation the flavor number. The estimation of flavor number included in estimating the summed on total flavor number \( N_f = \sum_{n=1}^{6} n_f \) using Table 1 for system species, the system \( cg \rightarrow dgy \) in being the number flavor \( n_f = 6 \) of charm quark \( (n_f = 4) \) and down quark \( (n_f = 2) \) and the system \( cg \rightarrow bgy \) in being the number flavor \( n_f = 9 \) of charm quark \( (n_f = 4) \) and bottom \( (n_f = 5) \) in the system.

Table 1. The main properties of quarks [20].

| Fermions | Name | Mass | Electric Charge | \( N_f \) |
|----------|------|------|-----------------|----------|
| Quarks   | Up (u) | \( 2.3^{+0.7}_{-0.5} \) MeV/c² | \( +\frac{2}{3} e \) | 1 |
|          | Down (d) | \( 4.8^{+0.5}_{-0.3} \) MeV/c² | \( -\frac{1}{3} e \) | 2 |
|          | Strange (s) | \( 95 \pm 5 \) MeV/c² | \( -\frac{1}{3} e \) | 3 |
|          | Charm (c) | \( 1.275 \) | \( +\frac{2}{3} e \) | 4 |
|          | Bottom (b) | \( \pm 0.025 \) GeV/c² | \( -\frac{1}{3} e \) | 5 |
|          | Top (t) | \( 173.2 \pm 0.9 \) GeV/c² | \( +\frac{2}{3} e \) | 6 |

In order to calculate the photons rate, we can evaluated the strength coupling, total charge and total flavor number. For the strength coupling calculation for quarks-gluon interaction at bremsstrahlung, the photons are yielding at temperature around (400, 450, 500, 550, 600 and 650 MeV) are necessary. The strength coupling can be calculated using Eq.(21) and so one can use summation of the flavor number \( n_f = (4 + 2) = 6 \) for \( cg \rightarrow dgy \) and \( n_f = (4 + 5) = 9 \) for \( cg \rightarrow bgy \) system with the critical temperature \( T_c = 190 \) and the temperatures of system in the range (400 to 650 MeV), results are shown in table (2) for \( cg \rightarrow dgy \) and \( cg \rightarrow bgy \) systems respectively.

Table 2. Results of strength coupling for \( cg \rightarrow dgy \) and \( cg \rightarrow bgy \) systems using the critical temperature \( T_c = 190 \).

| \( T \) Mev | Running strength coupling \( \alpha_{\chi}^{Tc} \) |
|------------|-----------------|
| \( n_f = 6 \) | \( n_f = 8 \) |
| 400 | 0.3178 | 0.3926 |
| 450 | 0.3051 | 0.3769 |
| 500 | 0.2945 | 0.3638 |
| 550 | 0.2856 | 0.3528 |
| 600 | 0.2779 | 0.3433 |
| 650 | 0.2712 | 0.3350 |

A numerical theoretical calculation of the spectra of photons emission from quark-gluon interaction at bremsstrahlung process using the Eq.(20) and MATLAB program with taken \( \alpha = \frac{1}{137} \), \( J_L \approx -4.26 \), \( \lambda_q = 0.068 \) and \( \lambda_g = 1 \), results are shown in Table 3 and Figure 1 for \( cg \rightarrow dgy \) system and Table 4 and Figure 2 for system.

Table 3. Rate of photon production (or yield) \( \Gamma_{dg}^B (E, p) \) at \( T_c = 190 \) MeV with \( \lambda_g = 1 \) and \( \lambda_q = 0.068 \) in system \( cg \rightarrow dgy \) has flavor number \( n_f = 6 \) in Bremsstrahlung process.

\[
\Gamma_{dg}^{Br} (E, p) = \frac{1}{GeV^2 fm^4}
\]
Table 4. Rate of photon production $\Gamma_{qg}^{BR}(E, p)$ at $T_c = 190$ MeV with $\lambda_g = 1, \lambda_q = 0.068$ in system $cg \rightarrow dgy$ has flavor number $n_f = 9$ in Bremishtahlang process.

| $E_{\gamma}$ GeV | $\alpha_{1}^{sc}$ | $\alpha_{2}^{sc}$ | $\alpha_{1}^{sc}$ | $\alpha_{2}^{sc}$ | $\alpha_{1}^{sc}$ | $\alpha_{2}^{sc}$ |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| $T=400$ MeV     | 4.7120e-07      | 8.5998e-07      | 1.4514e-06      | 2.3077e-06      | 3.4980e-06      | 5.1009e-06      |
| $T=450$ MeV     | 2.2995e-08      | 5.1841e-08      | 1.0270e-07      | 1.8498e-07      | 3.0967e-07      | 4.8952e-07      |
| $T=500$ MeV     | 1.2233e-10      | 4.6452e-10      | 1.3857e-09      | 3.4638e-09      | 7.5927e-09      | 1.4918e-08      |
| $T=550$ MeV     | 7.6514e-13      | 5.0135e-12      | 2.3089e-11      | 8.2176e-11      | 2.4068e-10      | 6.0621e-10      |
| $T=600$ MeV     | 4.9713e-15      | 5.6499e-14      | 4.0383e-13      | 2.0574e-12      | 8.1183e-12      | 2.6292e-11      |
| $T=650$ MeV     | 3.2784e-17      | 6.4755e-16      | 7.1979e-15      | 5.2601e-14      | 2.8020e-13      | 1.1693e-12      |

Figure 1. Rate of photon production $\Gamma_{qg}^{BR}(E, p)$ as a function of $E_{\gamma}$ for $cg \rightarrow dgy$ system at $T_c = 190$ MeV.
Figure 2. Rate of photon production $\Gamma_{qg}^{Br}(E, p)$ as a function of $E_\gamma$ for $cg \rightarrow bg\gamma$ system at $T_c = 190$ MeV.

To compute the net electric charge for $cg \rightarrow dg\gamma$ and $cg \rightarrow bg\gamma$ systems at the bremsstrahlung processes can be estimated using the summation of all charges for quarks in the system and be deduced using the $\sum^n e_q = \frac{(2)}{3} + \frac{(1)}{3} = \frac{5}{3}$ for both systems. However, the photons rate calculated with the same parameters except fugacity that taken $\lambda_q = 0.02$ [13] and $\lambda_g = 0.08$[13], results are shown in Table 5 and Figure 3 for $cg \rightarrow dg\gamma$ system and Table 6 and Figure 4 for system.

Table 5. Rate of photon production $\Gamma_{qg}^{Br}(E, p)$ at $T_c = 190$ MeV with $\lambda_q = 0.02, \lambda_g = 0.08$ in system $cg \rightarrow dg\gamma$ has flavor number $n_f = 6$ in Bremishtahlang process.

| $E_\gamma$ GeV | $\alpha_1^{Sc}$ | $\alpha_1^{c}$ | $\alpha_2^{Sc}$ | $\alpha_2^{c}$ | $\alpha_3^{Sc}$ | $\alpha_3^{c}$ | $\alpha_4^{Sc}$ | $\alpha_4^{c}$ |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| T=400MeV       | 0.3178         | 0.3051         | 2945           | 0.2856         | 0.2779         | 0.2712         |                 |                |
| T=450MeV       | 1.6468e-08     | 2.7792e-08     | 4.4185e-08     | 6.6969e-08     | 9.7656e-08     |                 |                |                |
| T=500MeV       | 9.9318e-10     | 1.9675e-09     | 3.5436e-09     | 5.9319e-09     | 9.3772e-09     |                 |                |                |
| T=550MeV       | 2.6549e-11     | 6.6366e-11     | 1.4508e-10     | 2.8584e-10     |                 |                |                |                |
| T=600MeV       | 1.3791e-16     | 1.0078e-15     | 2.2404e-14     |                 |                |                |                |                |
| T=650MeV       | 1.2407e-17     | 2.3437e-12     | 3.9240e-14     |                 |                |                |                |                |
Figure 3. Rate of photon production $\Gamma_{qg}^{BR} (E, p)$ as a function of $E_\gamma$ for $c g \rightarrow d g \gamma$ system at $T_c = 190 \text{ MeV}$.

Table 6. Rate of photon production $\Gamma_{qg}^{BR} (E, p)$ at $T_c = 190 \text{ MeV}$ with $\lambda_q = 0.02$, $\lambda_g = 0.08$ in system $c g \rightarrow b g \gamma$ has flavor number $n_f = 8$ in Bremishtahlng process.

| $E_\gamma \text{ GeV}$ | $\Gamma_{qg}^{BR}(E, p) \frac{1}{\text{GeV}^2 \text{fm}^4}$ |
|----------------------|---------------------------------|
|                      | $T=400\text{MeV}$ | $T=450\text{MeV}$ | $T=500\text{MeV}$ | $T=550\text{MeV}$ | $T=600\text{MeV}$ | $T=650\text{MeV}$ |
| $\alpha_1^{sc}$      | 0.3926             | 0.3769             | 0.3638             | 0.3528             | 0.3433             | 0.3350             |
| $\alpha_1^{sc}$      | 0.4581e-03         | 0.4332e-03         | 0.4055e-03         | 0.3781e-03         | 0.3508e-03         | 0.3335e-03         |
| $\alpha_1^{sc}$      | 5.4581e-03         | 5.4332e-03         | 5.4055e-03         | 5.3781e-03         | 5.3508e-03         | 5.3335e-03         |
| $\alpha_1^{sc}$      | 8.2730e-03         | 8.2433e-03         | 8.2055e-03         | 8.1781e-03         | 8.1508e-03         | 8.1335e-03         |
| $\alpha_1^{sc}$      | 1.2063e-02         | 1.1866e-02         | 1.1666e-02         | 1.1466e-02         | 1.1266e-02         | 1.1066e-02         |
| $\alpha_1^{sc}$      | 1.1766e-02         | 1.1566e-02         | 1.1366e-02         | 1.1166e-02         | 1.0966e-02         | 1.0766e-02         |
| $\alpha_1^{sc}$      | 5.4923e-03         | 5.4723e-03         | 5.4523e-03         | 5.4323e-03         | 5.4123e-03         | 5.3923e-03         |
| $\alpha_1^{sc}$      | 8.3278e-03         | 8.3078e-03         | 8.2878e-03         | 8.2678e-03         | 8.2478e-03         | 8.2278e-03         |
| $\alpha_1^{sc}$      | 5.3781e-03         | 5.3581e-03         | 5.3381e-03         | 5.3181e-03         | 5.2981e-03         | 5.2781e-03         |
| $\alpha_1^{sc}$      | 3.4923e-03         | 3.4723e-03         | 3.4523e-03         | 3.4323e-03         | 3.4123e-03         | 3.3923e-03         |
| $\alpha_1^{sc}$      | 1.1766e-02         | 1.1566e-02         | 1.1366e-02         | 1.1166e-02         | 1.0966e-02         | 1.0766e-02         |
| $\alpha_1^{sc}$      | 1.1266e-02         | 1.1066e-02         | 1.0866e-02         | 1.0666e-02         | 1.0466e-02         | 1.0266e-02         |
4. Discussion

Due to quantum chromo dynamic theory, we present the theoretical results for the calculation the photon rate of photon production from bremsstrahlung at the different photon energy (1-10) GeV at critical temperature 90MeV with the different fugacity for quark and gluon. The calculation has been done for two different $cg \rightarrow dgy$ and $cg \rightarrow bgf$ quarks systems have total flavor number 6 and 9. From Table 2, it can be shown that running strength coupling $a_{gs}^{sc}$ decreases with increase the temperature of quark gluon system for both $cg \rightarrow dgy$ and $cg \rightarrow bgf$ systems ,this because the confinement and asymptomatic behavior of quarks with concerning the fact or slow photons rate, the results show the photons rate increased with decreased the strength coupling and vice versa. Furthermore, the behaviour of the strength coupling of $cg \rightarrow bgf$ system is larger than the strength coupling of $cg \rightarrow dgy$ system because to effect of flavor number for the same critical energy and temperature of the system . To each system , the strength coupling $a_{gs}^{sc}$ and the photon rate spectrum of the emitted bremsstrahlung is calculated in photons energies $E_{\gamma}$ GeV ranging (1-10GeV) .The total photons rate of the bremsstrahlung emission has been obtained due to integrating the Eq.(9) on the photon momentum determined previously. For each photon energy and temperature of the system, the number of photons emission from bremsstrahlung is obtained by using Eq.(20). Briefly, the photon rate from bremsstrahlung are slowing down with increased energy of photons and the photons will be attenuated in the QGP mater .As for the $cg \rightarrow dgy$ system , the photon spectrum emitted in bremsstrahlung at energy $E_{\gamma} = 1GeV$ is faster compare with $E_{\gamma} = 10GeV$ .this indicate for energy $E_{\gamma} = 10 GeV$ the system emission photons by small rate . On the other hand, the emitted photons by bremsstrahlung with fugacity $\lambda_q = 0.02$, $\lambda_g = 0.08$ are lower than $\lambda_q = 1$ and $\lambda_g = 0.068$ , that’s means when increased fugacity lead to emission more photons for both systems. Consequently, the fugacity hasn't yet ε much by effected on increasing, but the strength and flavor number can induce more photons to emit the higher energy bremsstrahlung. In conclusion ,the fugacity intense to the
photons spectrum obtained in bremsstrahlung process, this calculation will be supply more knowledge about reaction of quark and gluon to conceive the nature of shielding of the source. In the this work, the bremsstrahlung emissions of \( cg \rightarrow dqy \) and \( cg \rightarrow hgy \) systems are increased with decreasing strength coupling for photons energies in the interval 1-10 GeV. In Figures 1 to 4, the spectra of photons rate \( r_{\text{qg}}(E,P) \) of the bremsstrahlung emerging by photon energy are represented in Tables (4-7). As expected, the photon emission rate of the bremsstrahlung at high-energy yield in small region of system around the QGP matter. Generally, the photons emission rate values of the bremsstrahlung increased with increased fugacity and increased flavor and decreased strength coupling of then system. However, larger photons rate appear in the high-energy region, where \( E_p < 10 \text{ GeV} \) and reach a maximum at the energy of the photons \( E_\gamma = 1 \text{ GeV} \). These differences indicate that the cross-section of reaction in \( E_\gamma = 1 \text{ GeV} \) can be probable compare cross section in \( E_p = 10 \text{ GeV} \) in the high energy region (1-10)GeV. In all Figures (1-4), the plotted for photons rate are given same behavior with range high energy(1-10)GeV but the photons yield rate in Figure 3 and (4) with fugacity \( \lambda_q = 0.02, \lambda_g = 0.08 \) are lowered than at Figures 1 and 2 with fugacity \( \lambda_g = 1 \) and \( \lambda_q = 0.068 \) by a factor \( \sim 10^2 \).

5. Conclusion

In concluding that the calculation of the photon rate through the bremsstrahlung process enhanced by flavor number, strength coupling fugacity, photon energy and temperature of the QGP mater system and give stability feature in quark–gluon system formation. The overall evaluation of photon emission rate production through the bremsstrahlung process and the spectra as a function of strength coupling and photon energy incorporate to give the result of photon yield rate. The photon rate for the bremsstrahlung has been increased with increased fugacity and increased flavor and decreased strength coupling of the system. Thus, the consideration of the quntum chromodynamic theory in the quark –gluon is the important role in the calculation of photon rate at the high energy. So, this theoretical model can be supply results to improve the other theoretical and experimental results.

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