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Theoretical Investigation of Calculating The Spectrum of Photon Emissivity Using Quantum Chromo Dynamic QCD Theory

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Abstract :

In this paper, we calculate and study the photon emission from cg→sgγ plasma at chemical potentials of 284 MeV, 568 MeV and 852 MeV, using quantum chromodynamics (QCD) theory to model the quark-gluon interaction in QGP. In this model, flavor number (7), critical energy Tc=190 MeV, critical energy Tc=166.668 MeV, thermal energy (200 to 600) MeV, various force coupling and photon energy in the range (0.75-10.25) GeV were used to study the photon emission spectrum. The coupling of cg→sgγ collisions has been used to study the behavior of quarks. Based on theoretical values of the force coupling coefficient, it has been shown that the photon emission rate increases depending on the chemical potential, decreasing with increasing coupling strength. The spectral photon rate of cg→sgγ was found to increase with increasing thermal energy and chemical potential and to be inversely affected by photon energy. The resulting higher photon emission and cg→sgγ collision occur when the chemical potential Vq increases to a maximum of 852 MeV compared to the chemical potential of 281 MeV, indicating that the system is dominated by the chemical potential rather than temperature effects, and that photon emission is increasing. The probability of the cg → sgγ photon spectrum showed a slight increase at photon energy below 2 GeV compared to a deep decrease at 10.25 GeV due to hadronic effects and QCD.

Keywords: Spectrum, Photon Emissivity, Quantum Chromo Dynamic QCD, Charm Quark, Strange Quark.

دراسة نظرية لحساب طيف انبعاثية الفوتون باستخدام نظرية QCD الديناميكية الكروماتية الكمية

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مستخلص:

في هذه الورقة البحثية، قمنا بحساب ودراسة انبعاث الفوتونات من بلازما cg→sgγ عند جهود كيميائية تبلغ 284 مليون إلكترون فولت، و568 مليون إلكترون فولت، و852 مليون إلكترون فولت، باستخدام نظرية الكروموديناميكا الكمية (QCD) لنمذجة تفاعل الكوارك-الغلوون في QGP. في هذا النموذج، استُخدم رقم النكهة (7)، والطاقة الحرجة T_c=190 مليون إلكترون فولت، والطاقة الحرجة T_c=166.668 مليون إلكترون فولت، والطاقة الحرارية (200 إلى 600 مليون إلكترون فولت)، واقترانات قوى مختلفة، وطاقة الفوتون في النطاق (0.75-10.25 جيجا إلكترون فولت) لدراسة طيف انبعاث الفوتونات. كما استُخدم اقتران تصادمات cg→sgγ لدراسة سلوك الكواركات. واستنادًا إلى القيم النظرية لمعامل اقتران القوى، تبيّن أن معدل انبعاث الفوتونات يزداد تبعًا للجهد الكيميائي، وينخفض بازدياد قوة الاقتران. وُجد أن معدل الفوتونات الطيفي لـ cg→sgγ يزداد مع زيادة الطاقة الحرارية والجهد الكيميائي، ويتأثر عكسيًا بطاقة الفوتون. ويحدث انبعاث الفوتونات الأعلى الناتج عن ذلك، بالإضافة إلى تصادم cg→sgγ، عندما يزداد الجهد الكيميائي V_q إلى أقصى حد له وهو 852 مليون إلكترون فولت، مقارنةً بالجهد الكيميائي البالغ 281 مليون إلكترون فولت، مما يشير إلى أن النظام يهيمن عليه الجهد الكيميائي أكثر من تأثيرات درجة الحرارة، وأن انبعاث الفوتونات آخذ في الازدياد. وقد أظهر احتمال طيف الفوتونات cg→sgγ زيادة طفيفة عند طاقة فوتون أقل من 2 جيجا إلكترون فولت، مقارنةً بانخفاض حاد عند 10.25 جيجا إلكترون فولت، وذلك بسبب التأثيرات الهادرونية و QCD.

الكلمات المفتاحية: الطيف، انبعاثية الفوتون، QCD الديناميكي الكرومو-كمومي، كوارك ساحر، كوارك غريب.

Introduction

Elementary particles are a major field of physics that deals with the fundamental components of nature and their interactions. Many scientific methods can be used to study and study the structural components. Recently, various theories have been proposed to understand the quark-gluon structure and the universal phase formation interaction after the Big Bang phase[1]. The collision of quarks and gluons has provided good tools for understanding the structure of nucleons and the astrophysical properties of condensed matter, described by the theory of quantum chromodynamics (QCD)[2]. Numerous hadron experiments have been conducted at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory and at the Large Hadron Collider (LHC) at CERN to study the extremely hot matter in quark-gluon plasma (QGP)[3]. The main idea of collisions is to study and create strongly interacting matter, which is obtained by converting confined matter from a hadronic state to a freely deconfined quark-gluon state. The quark-gluon plasma(QGP) is the superfluid state produced at Relativistic Heavy Ion Collisions (RHIC)[4]. Since Gell-Mann introduced the quark model, the world has divided quarks into three generations based on their quantum number flavors (up, down), (strange, charm), and (top, bottom) [5]. Quark families are fermions and are driven by massless bosons from the strong interaction, and have eight color and anticolor gluons at the same time[6]. However, the main theoretical model used to study and research the interaction of quarks and gluons was provided by the Standard Model, which was developed in the 1970s. The foundations of the Standard Model are quantum chromodynamics and electroweak theory [7]. The photons are the main tool to provide knowledge about the stages of quark-gluon collisions in plasmas[8]. There are emissions from two sources of hadron decay and direct photons, and the contribution of direct photons is smaller than that of photon decay; they provide direct information for particle reconstruction [9]. One of the key roles in the emission of photons from quark-gluon interactions in a QCD medium is the force coupling. Less strong coupling in quark-gluon plasma (QGP) refers to a quark that is weakly coupled to a gluon and increases photon emission[10]. During heavy ion collisions, photons are emitted due to quark-gluon interaction, providing much knowledge about quark-gluon plasma (QGP) [11].

Theory

Photon emission rate from quark-gluon collisions is giving by in momentum P and energy E and related by the fugacity of gluon and thermal energy T of the system by [12].

$$\Gamma_{qg}^{T}(E,P)=\frac{-\lambda_g}{4\pi^3}\frac{\mathrm{Im}\prod_{qg}^{T}(E,P)}{e^{\frac{E}{T}}-\lambda_g}\text{.............................}(1)$$

Where $\mathrm{Im}\prod_{qg}^{T}(E,P)$ is imaginary of the retarded of photons,it gives by[13].

$$\mathrm{Im}\prod_{qg}^{T}(E,P)=\frac{N_c C {g_e}^2 {g_c}^2 T|\mathrm{I_T}-\mathrm{I_L}|}{\pi^4 E^2}\int_0^\infty\Big(F_q(E-P)-F_q(P)\Big)\left((E-P)^2+P^2\right)dP\text{....}(2)$$

Where N_C is color number, C is Casimir operator $(\frac{4}{3})$[14], g_e is quantum electrodynamics couplings $({g_e}^2=4\pi\alpha_e)$ [15] and g_c is quantum chromodunamic coupling $(g^2(Q)=4\pi\alpha_s^{qg})$[16], I_T and T_L are transverse and longitudinal self-integraland $F_q(E-P)$ and $F_q(P)$ are Jutner distribution function of quark .Introduce charge $\sum q_q^2$ of quark and N_C=3 in Eq.(2) and simply to yield.

$$\mathrm{Im}\prod_{qg}^{T}(E,P)=\frac{64T|\mathrm{I_T}-\mathrm{I_L}|\sum q_q^2}{\pi^2 E^2}\int_0^\infty\Big(F_q(E-P)-F_q(P)\Big)\left((E-P)^2+P^2\right)dP\text{.......}(3)$$

The Juttner distribution function F_q *(p-E)* and F_q *(P)* are function of chemical potential V_q and quark fugacity λ_q and writes by [17].

$$F_q(p-E)=\lambda_q(e^{\frac{(E-p-V_q)}{T}}+\lambda_q)^{-1}\text{..............}(4)$$

And

$$F_q(P)=\lambda_q(e^{\frac{(p+V_q)}{T}}+\lambda_q)^{-1}\text{.....................}(5)$$

Insert Eq.(4) and Eq.(5) in Eq.(3) and used to obtaine .

Insert Eq.(4) and Eq.(5) in Eq.(3) and used $(P^2 + (E - P)^2) = E^2 - 2EP + 2P^2 = 2P^2 + E^2 - 2EP$ to obtaine .

$$\mathrm{Im}\prod_{qg}^{T}(E,P) = \frac{64T|\mathrm{I_T}-\mathrm{I_L}|\lambda_q \Sigma q_q^2}{\pi^2 E^2}\int_0^{\infty}\left((e^{\frac{(E-p-V_q)}{T}} + \lambda_q)^{-1} - (e^{\frac{(p+V_q)}{T}} + \lambda_q)^{-1}\right)(2P^2 + E^2 - 2EP)\,dP \ldots\ldots\ldots\ldots(6)$$

Assume $\alpha = \frac{(E-p-V_q)}{T}$ and $\beta = \frac{(p+V_q)}{T}$,the two exponential in Eq.(6) reduced to

$$(e^{\frac{(E-p-V_q)}{T}} + \lambda_q)^{-1} = e^{-\alpha} - \lambda_q e^{-2\alpha} + {\lambda_q}^2 e^{-3\alpha} - \ldots\ldots\ldots\ldots(7)$$

$$(e^{\frac{(p+V_q)}{T}} + \lambda_q)^{-1} = e^{-\beta} - \lambda_q e^{-2\beta} + {\lambda_q}^2 e^{-3\beta} - \ldots\ldots\ldots\ldots(8)$$

Inserting Eq.(7) and Eq.(8) in Eq.(6) to obtaine.

$$\mathrm{Im}\prod_{qg}^{T}(E,P) = \frac{64T|\mathrm{I_T}-\mathrm{I_L}|\lambda_q \Sigma q_q^2}{\pi^2 E^2}\int_0^{\infty}\left((e^{-\alpha} - e^{-\beta}) + \lambda_q(e^{-2\beta} - e^{-2\alpha}) + {\lambda_q}^2(e^{-3\alpha} - e^{-2\beta}) + {\lambda_q}^3(e^{-4\beta} - e^{-4\alpha}) - ..\right)(2P^2 + E^2 - 2EP)\,dP \ldots\ldots(9)$$

The results of integral in Eq.(9) is

$$\int_0^{\infty}\left((e^{-\alpha} - e^{-\beta}) + \lambda_q(e^{-2\beta} - e^{-2\alpha}) + {\lambda_q}^2(e^{-3\alpha} - e^{-2\beta}) + {\lambda_q}^3(e^{-4\beta} - e^{-4\alpha}) - ..\right)(2P^2 + E^2 - 2EP)\,dP = \left(e^{\frac{-(E-V_q)}{T}} - e^{\frac{-V_q}{T}}\right)\left(2\frac{{\lambda_q}^1}{1^3}\Gamma(3)T^3 + \frac{{\lambda_q}^1}{1}E^2T\Gamma(1) - 2\frac{{\lambda_q}^1}{1^2}\mathrm{E}T^2\Gamma(2)\right) - \left(e^{\frac{-2(E-V_q)}{T}} - e^{\frac{-2V_q}{T}}\right)\left(2\frac{{\lambda_q}^2}{2^3}\Gamma(3)T^3 + \frac{{\lambda_q}^2}{2}E^2T\Gamma(1) + 2\frac{{\lambda_q}^2}{2^2}\mathrm{E}T^2\Gamma(2)\right) + \left(e^{\frac{-3(E-V_q)}{T}} - e^{\frac{-3V_q}{T}}\right)\left(2\frac{{\lambda_q}^1}{3^3}\Gamma(3)T^3 + \frac{{\lambda_q}^1}{3}E^2T\Gamma(1) - 2\frac{{\lambda_q}^1}{3^2}\mathrm{E}T^2\Gamma(2)\right) - \cdots \ldots\ldots\ldots(10)$$

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

$$\mathrm{Im}\prod{}_{qg}^{T}(E,P)=\frac{64T|\mathrm{I_T}-\mathrm{I_L}|\lambda_q\sum q_q^2}{\pi^2E^2}\Big[\left(e^{\frac{-(E-V_q)}{T}}-e^{\frac{-V_q}{T}}\right)\left(2\frac{\lambda_q{}^1}{1^3}\Gamma(3)T^3+\frac{\lambda_q{}^1}{1}E^2T\Gamma(1)-2\frac{\lambda_q{}^1}{1^2}\mathrm{E}T^2\Gamma(2)\right)-\left(e^{\frac{-2(E-V_q)}{T}}-e^{\frac{-2V_q}{T}}\right)\left(2\frac{\lambda_q{}^2}{2^3}\Gamma(3)T^3+\frac{\lambda_q{}^2}{2}E^2T\Gamma(1)+2\frac{\lambda_q{}^2}{2^2}\mathrm{E}T^2\Gamma(2)\right)+\left(e^{\frac{-3(E-V_q)}{T}}-e^{\frac{-3V_q}{T}}\right)\left(2\frac{\lambda_q{}^1}{3^3}\Gamma(3)T^3+\frac{\lambda_q{}^1}{3}E^2T\Gamma(1)-2\frac{\lambda_q{}^1}{3^2}\mathrm{E}T^2\Gamma(2)\right)-\cdots.\Big]\ldots\ldots\ldots\ldots\ldots\ldots(11)$$

The Eq.(1) together Eq.(11) to results .

$$\Gamma_{qg}^{T}(E,P)=\frac{16T|\mathrm{I_T}-\mathrm{I_L}|\lambda_q\lambda_g\sum q_q^2}{\pi^5E^2(e^{\frac{E}{T}}-\lambda_g)}\Big[\left(e^{\frac{-2(E-V_q)}{T}}-e^{\frac{-2V_q}{T}}\right)\left(2\frac{\lambda_q{}^2}{2^3}\Gamma(3)T^3+\frac{\lambda_q{}^2}{2}E^2T\Gamma(1)+2\frac{\lambda_q{}^2}{2^2}\mathrm{E}T^2\Gamma(2)\right)-\left(e^{\frac{-(E-V_q)}{T}}-e^{\frac{-V_q}{T}}\right)\left(2\frac{\lambda_q{}^1}{1^3}\Gamma(3)T^3+\frac{\lambda_q{}^1}{1}E^2T\Gamma(1)-2\frac{\lambda_q{}^1}{1^2}\mathrm{E}T^2\Gamma(2)\right)-\left(e^{\frac{-3(E-V_q)}{T}}-e^{\frac{-3V_q}{T}}\right)\left(2\frac{\lambda_q{}^1}{3^3}\Gamma(3)T^3+\frac{\lambda_q{}^1}{3}E^2T\Gamma(1)-2\frac{\lambda_q{}^1}{3^2}\mathrm{E}T^2\Gamma(2)\right)-\cdots.\Big]\ldots\ldots\ldots\ldots\ldots\ldots(12)$$

The coupling constantbetween quqrk qnd gluon is [18].

$$\alpha_s^{qg}(\mu^2)=\frac{12\pi}{(33-2n_F)ln(\frac{8T}{T_c})^2}\ldots..(13)$$

Where T is thermal energy and T_c is the critical temperature .

Results

Quantum chromodynamic effects can be used to calculate the spectral distribution of quark-gluon plasma collisions. In the context of QCD theory, the photon emission rate is of great interest in understanding the spatial extent of the photon source in a cg→sgγ plasma.To calculate the spectrum of photons rate depending on QCD theory,fistly can be estimate, the coupling constant can be estimated by the quantum flavor number. The flavor number is the summation flavor number of quarks in cg→sgγ plasma system, $n_F = \sum_{n=1}^{6} n_{F_n}$ using Table (1) for quarks species, to results $n_F=7$ for cg→sgγ collision in being the flavor $n_f=4$ of chram quark and strange quark ($n_f=3$).

Table(1): Physical properties of quarks [19].

Quarks	Mass	Charge	N_f
Up (u)	$2.3^{+0.7}_{-0.5}\,MeV/c^2$	$+{}^{2}/_{3}\,e$	1
Down (d)	$4.8^{+0.5}_{-0.3}\,MeV/c^2$	$-{}^{1}/_{3}\,e$	2
Strange (s)	$95 \pm 5\,MeV/c^2$	$-{}^{1}/_{3}\,e$	3
Charm (c)	$1.275 \pm 0.025\,GeV/c^2$	$+{}^{2}/_{3}\,e$	4
Bottom (b)	$4.18 \pm 0.03\,GeV/c^2$	$-{}^{1}/_{3}\,e$	5
Top (t)	$173.2 \pm 0.9\,GeV/c^2$	$+{}^{2}/_{3}\,e$	6

the strength coupling can be evaluated using Eq.(13) using thermal energy (200,250,300,350,400,450,500,550 and 600 MeV) to produce photons at critical temperature T_c=166.668MeV ,results are shown in table (2) for *cg→sgγ* collision system.

Table(2): Strength coupling calculation for *cg→sgγ* plasma systems using the critical temperature T_C=166.668MeV .

$T\ Mev$	200	250	300	350	400	450	500	550	600
$\alpha_s^{qg}(\mu^2)$	0.438	0.399	0.372	0.351	0.335	0.322	0.312	0.303	0.295
	6	2	0	6	7	9	2	1	2

The charge of quarks in the system *cg→sgγ* plasma at the collision processes can be estimated using the summation $\sum_i^n q_{qi}^2 = (\frac{2}{3})^2 + (\frac{-1}{3})^2 = {}^5/_9$ for *cg→sgγ* plasma system. A theoretical calculation of the spectrum of photon rate from charm quark with gluon interaction in *cg→sgγ* plasma using the Eq.(12) and MATLAP program with taken critical temperature calculation Tc=166.668MeV from table(2), fine structure $\alpha_e = \frac{1}{137}$ [20], $|I_T - I_L| \approx 1$, $\lambda_q = 0.02$ [21], $\lambda_g = 0.9$,[21] and chemical potential, Vq= 284 MeV and Vq= 568 MeV and Vq= 852 MeV, results list in tables (3), (4), and (5) and figures (1),(2), and (3), respectively.

Table (3) Photon emission rate $\Gamma_{qg}^{T}(E,P)$ from *cg→sgγ* collision at $\mathbf{N_F = 7}$, T_c=166.668MeV and V_q= 284 MeV .

E GeV	*T MeV*								
	200	250	300	350	400	450	500	550	600
0.75	1.73E-13	5.79E-13	1.40E-12	2.83E-12	5.09E-12	8.43E-12	1.31E-11	1.94E-11	2.77E-11
1.5	7.14E-15	5.33E-14	2.13E-13	5.94E-13	1.32E-12	2.52E-12	4.35E-12	6.93E-12	1.04E-11
2.25	1.79E-16	2.88E-15	1.92E-14	7.74E-14	2.25E-13	5.30E-13	1.06E-12	1.92E-12	3.18E-12
3	4.38E-18	1.49E-16	1.65E-15	9.55E-15	3.65E-14	1.05E-13	2.52E-13	5.19E-13	9.61E-13
3.75	1.05E-19	7.64E-18	1.39E-16	1.15E-15	5.79E-15	2.07E-14	5.84E-14	1.38E-13	2.86E-13
4.25	8.74E-21	1.04E-18	2.68E-17	2.81E-16	1.69E-15	6.95E-15	2.19E-14	5.68E-14	1.27E-13
5	2.08E-22	5.29E-20	2.23E-18	3.37E-17	2.64E-16	1.34E-15	5.00E-15	1.48E-14	3.73E-14
5.75	4.94E-24	2.66E-21	1.86E-19	4.01E-18	4.12E-17	2.57E-16	1.13E-15	3.88E-15	1.09E-14
6.25	4.07E-25	3.63E-22	3.54E-20	9.69E-19	1.19E-17	8.57E-17	4.22E-16	1.58E-15	4.79E-15
7	9.65E-27	1.82E-23	2.93E-21	1.14E-19	1.84E-18	1.63E-17	9.55E-17	4.09E-16	1.39E-15
7.75	2.28E-28	9.13E-25	2.42E-22	1.35E-20	2.86E-19	3.12E-18	2.15E-17	1.06E-16	4.04E-16
8.25	1.87E-29	1.24E-25	4.60E-23	3.27E-21	8.24E-20	1.03E-18	7.97E-18	4.30E-17	1.77E-16
9	4.43E-31	6.20E-27	3.79E-24	3.86E-22	1.27E-20	1.97E-19	1.79E-18	1.10E-17	5.12E-17
9.75	1.04E-32	3.10E-28	3.13E-25	4.55E-23	1.96E-21	3.74E-20	4.03E-19	2.85E-18	1.47E-17
10.25	8.60E-34	4.20E-29	5.93E-26	1.09E-23	5.64E-22	1.23E-20	1.48E-19	1.15E-18	6.45E-18

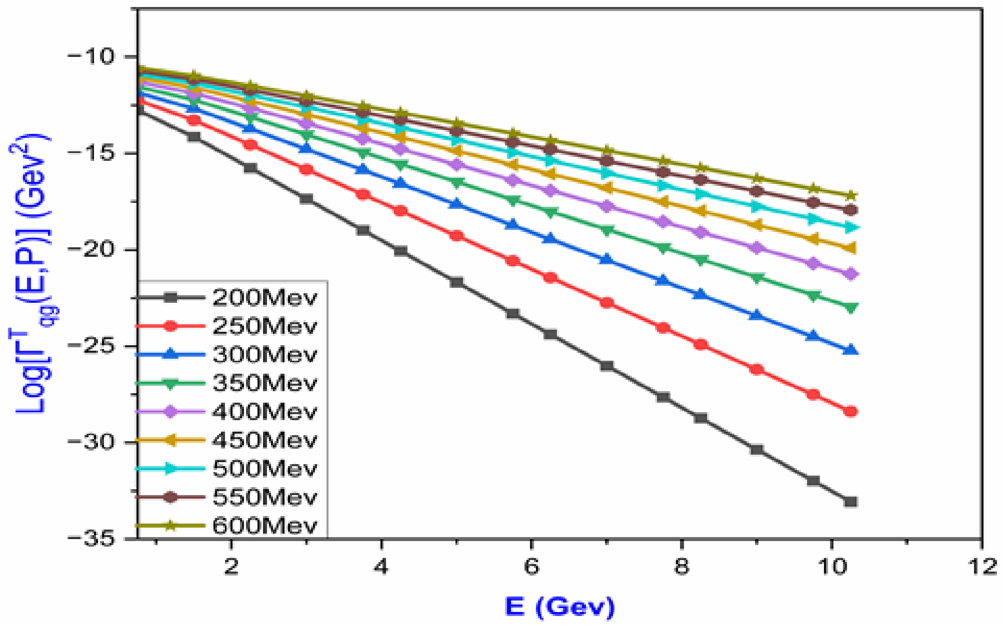

Figure (1) Photon emission rate $\Gamma^{T}_{qg}(E,P)$ from $cg\rightarrow sg\gamma$ collision at V_q= 284 MeV

Table (4) Photon emission rate $\Gamma^{T}_{qg}(E,P)$ from $cg\rightarrow sg\gamma$ collision at N_F = 7 , T_c=166.668MeV and V_q= 568 MeV .

E GeV	*T MeV*								
	200	250	300	350	400	450	500	550	600
0.75	4.26E-13	1.37E-12	3.25E-12	6.452E-12	1.142E-11	1.869E-11	2.883E-11	4.245E-11	6.021E-11
1.5	1.43E-15	1.30E-14	5.82E-14	1.740E-13	4.055E-13	8.022E-13	1.418E-12	2.310E-12	3.544E-12
2.25	4.25E-17	8.88E-16	7.00E-15	3.148E-14	9.921E-14	2.466E-13	5.190E-13	9.676E-13	1.647E-12
3	1.04E-18	4.65E-17	6.13E-16	4.003E-15	1.674E-14	5.191E-14	1.304E-13	2.805E-13	5.373E-13
3.75	2.50E-20	2.38E-18	5.203E-17	4.871E-16	2.676E-15	1.027E-14	3.063E-14	7.588E-14	1.634E-13
4.25	2.07E-21	3.26E-19	9.977E-18	1.188E-16	7.812E-16	3.452E-15	1.152E-14	3.132E-14	7.287E-14
5	4.94E-23	1.65E-20	8.335E-19	1.421E-17	1.224E-16	6.675E-16	2.636E-15	8.226E-15	2.148E-14
5.75	1.17E-24	8.31E-22	6.935E-20	1.692E-18	1.909E-17	1.284E-16	5.997E-16	2.147E-15	6.288E-15
6.25	9.69E-26	1.13E-22	1.319E-20	4.081E-19	5.511E-18	4.268E-17	2.221E-16	8.749E-16	2.765E-15
7	2.29E-27	5.68E-24	1.093E-21	4.848E-20	8.563E-19	8.163E-18	5.043E-17	2.261E-16	8.044E-16
7.75	5.42E-29	2.84E-25	9.039E-23	5.737E-21	1.326E-19	1.558E-18	1.138E-17	5.874E-17	2.334E-16
8.25	4.46E-30	3.86E-26	1.715E-23	1.382E-21	3.819E-20	5.159E-19	4.214E-18	2.383E-17	1.022E-16
9	1.05E-31	1.93E-27	1.415E-24	1.631E-22	5.898E-21	9.821E-20	9.483E-19	6.150E-18	2.956E-17
9.75	2.48E-33	9.67E-29	1.167E-25	1.924E-23	9.101E-22	1.868E-20	2.131E-19	1.585E-18	8.541E-18
10.25	2.04E-34	1.31E-29	2.211E-26	4.626E-24	2.617E-22	6.172E-21	7.875E-20	6.416E-19	3.730E-18

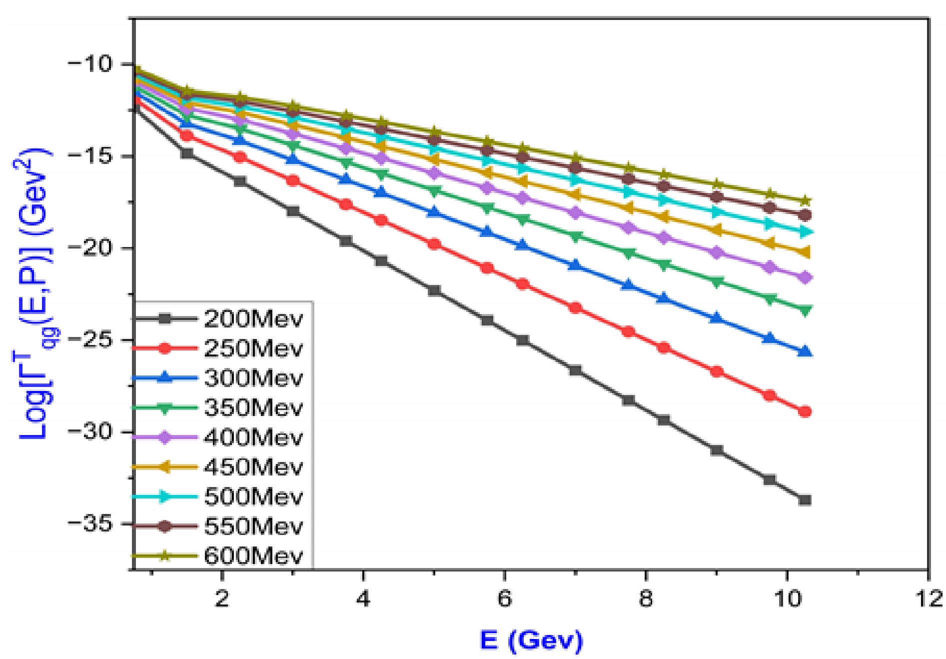

Figure (2) Photon emission rate $\Gamma^{T}_{qg}(E,P)$ from $cg \rightarrow sg\gamma$ collision at V_q= 568 MeV

Table (5) Photon emission rate $\Gamma^{T}_{qg}(E,P)$ from $cg \rightarrow sg\gamma$ collision at N_F = 7 , T_c=166.668MeV and V_q= 852 MeV .

E GeV	*T MeV*								
	200	250	300	350	400	450	500	550	600
0.75	3.904E-12	8.727E-12	1.623E-11	2.718E-11	4.260E-11	6.372E-11	9.195E-11	1.288E-10	1.759E-10
1.5	7.332E-16	6.872E-15	3.123E-14	9.422E-14	2.209E-13	4.388E-13	7.779E-13	1.271E-12	1.953E-12
2.25	9.645E-18	2.554E-16	2.320E-15	1.140E-14	3.813E-14	9.874E-14	2.139E-13	4.075E-13	7.054E-13
3	2.501E-19	1.484E-17	2.342E-16	1.725E-15	7.864E-15	2.597E-14	6.834E-14	1.524E-13	3.002E-13
3.75	6.047E-21	7.627E-19	2.005E-17	2.137E-16	1.290E-15	5.319E-15	1.675E-14	4.332E-14	9.657E-14
4.25	5.019E-22	1.046E-19	3.848E-18	5.211E-17	3.771E-16	1.797E-15	6.348E-15	1.805E-14	4.358E-14
5	1.195E-23	5.289E-21	3.216E-19	6.249E-18	5.931E-17	3.482E-16	1.458E-15	4.766E-15	1.293E-14
5.75	2.838E-25	2.664E-22	2.676E-20	7.445E-19	9.251E-18	6.691E-17	3.319E-16	1.246E-15	3.793E-15
6.25	2.342E-26	3.628E-23	5.091E-21	1.799E-19	2.675E-18	2.228E-17	1.234E-16	5.078E-16	1.669E-15
7	5.543E-28	1.820E-24	4.217E-22	2.133E-20	4.150E-19	4.262E-18	2.792E-17	1.318E-16	4.858E-16
7.75	1.310E-29	9.121E-26	3.488E-23	2.524E-21	6.426E-20	8.135E-19	6.302E-18	3.411E-17	1.401E-16
8.25	1.079E-30	1.239E-26	6.616E-24	6.078E-22	1.851E-20	2.694E-19	2.334E-18	1.384E-17	6.173E-17
9	2.547E-32	6.198E-28	5.461E-25	7.176E-23	2.859E-21	5.129E-20	5.252E-19	3.573E-18	1.786E-17
9.75	6.009E-34	3.098E-29	4.504E-26	8.465E-24	4.412E-22	9.753E-21	1.181E-19	9.209E-19	5.161E-18
10.25	4.942E-35	4.203E-30	8.531E-27	2.035E-24	1.269E-22	3.224E-21	4.362E-20	3.728E-19	2.255E-18

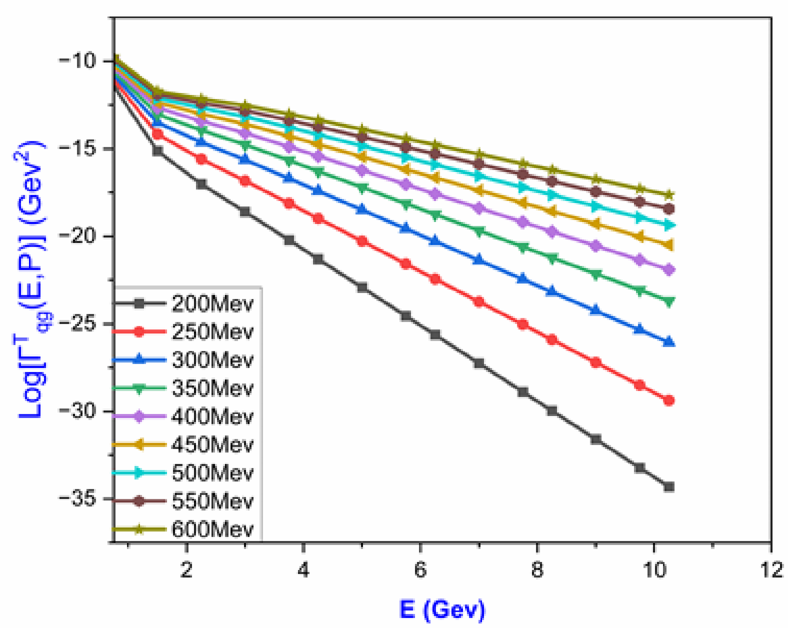

Figure (3) Photon emission rate $\Gamma_{qg}^{T}(E,P)$ from $cg \to sg\gamma$ collision at V_q= 852 MeV.

Discussion

The QCD method was used to calculate the photon emission rate from the collision of a charm quark with a gluon in a cg→sgγ plasma system based on the mathematical model using a critical temperature of Tc=166.668MeV with photon energies from 0.75 GeV to 10.25 GeV and fugacities 0.09 and 0.02 for the gluon and quark with taking into account of the chemical potential of 284 MeV, 568 MeV and 852 MeV . Coupling strength as well as photon emission were calculated using thermal energy from 200MeV to 600MeV. The results in Table (2) indicate that the coupling will decrease as the thermal energy of the collisional plasma cg→sgγ increases, which explains the confinement phenomenon and the asymptotic phenomena of charm and strange quarks in the cg→sgγ plasma, taking into account the fact that the probability of emission is greater at low coupling. Moreover, the force-coupling behavior of the cg → sgγ plasma decreases with increasing thermal energy due to the thermal energy effect in the system. It reaches a maximum of 0.4386 at 200 MeV and a minimum of 0.2952 at 600 MeV. However, the coupling behavior at 200 MeV and 600 MeV with a finite critical temperature Tc = 166.668 MeV is affected by QCD collisions with the varying thermal energy of the interaction cg→sgγ, affecting the photon emission from the collision in the plasma medium. The emission spectrum of photons from the cg → sgγ collision decreased with increasing coupling, and the photon energy was likely to be less than 2 GeV and the coupling was low. The probability of photon emission per photon energy and thermal energy of the system was obtained as a result of equation (12) defined previously and photon emission was faster with decreasing photon energy and photons would be attenuated in the QGP medium.

Furthermore ,the chemical potential between quarks affects the emission of photons from cg→sgγ plasmas. Increasing the chemical potential can lead to more intense interactions and photon emission. When the potential increases sufficiently in high-energy collisions, quarks may undergo a transfer process involving photon emission. In short, increasing the chemical potential from 284 MeV to 852 MeV between quarks results in more photons being emitted, especially at higher energy levels where quarks undergo large energy transitions or interactions.For cg→sgγ plasma, the photon emission spectrum slows down with increasing photon energy and the emission spectrum in the QGP medium decreases. In contrast, the emission spectrum in the QGP medium decreases faster at photon energy 10.25 compared to E=0.75GeV, which indicates that the system emitted photons at a largel rate at energy E=0.75 GeV. Tables (3), (4) and (5) of Figures 1, 2 and 3 show that the spectrum at lower photon energy 0.75 GeV and large chemical potential 852 MeV was larger than that at photon energy E = 10.25 GeV and chemical potential 284 MeV, indicating that it is mainly subject to thermal effects and the probability increases at lower photon energy and large chemical potential. The photon spectrum from the cg→sgγ collision slows down with increasing photon energy to decrease photon emission in the QGP collission. As a result, the emission spectrum from the collision of charm quarks with gluons increases as the thermal energy of the system increases.Generally , the photon emission from cg→sgγ plasma increased with increased chemical potential and increased thermal energy and decreased coupling and photon energy in system .As expected, the photons emission at high-energy yield around the QGP matter .In Figures (1-3) , the plotted are in same behavior with range high energy(1-10)GeV but the photons yield are increases with increases chemical potential by a factor ~10 .

Conclusion

In conclusion, the photon spectral rate through the collision process has been enhanced by the coupling, thermal energy, photon energy, and chemical potential of the QGP matter system, which gives a more stable property of the quark-gluon system configuration giving more knowledge in the formation of the quark-gluon plasma. The overall calculated photon spectrum rate produces to decreases with increasing coupling and photon energy for three values of chemical potentials. The photon spectrum of the $cg \rightarrow sg\gamma$ collision increased with increasing chemical potential and thermal energy. Furthermore, calculations predict a total photon emission increase of over 20% when the chemical potential increases from 281 MeV to 852 MeV at limited coupling. Moreover, the spectral emission increased with increasing chemical potential in the $cg \rightarrow sg\gamma$ collision in the plasma medium. Therefore, considering quark-gluon quantum chromodynamics theory plays an important role in calculating the photon rate at high energy. So, these calculation results can be supplied to improve the experimental results.

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