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Study of Photons yield from Top-Gluon Interaction in Bremsstrahlung processes

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Abstract :

In this study, A theoretical model of the top–gluon interaction is introduced based on Quantum Chromodynamics theory (QCD). The emission rate of photons as a function of various parameters is studied. The Bag constant $B^{1/4} = 235,355$MeV, system temperature in rang (190-310MeV), fugacity of quark and gluon $\lambda_Q = 1$, $\lambda_G = 0.04$ and photon energy in rang (0.75-7.5GeV) are used to calculate the yield of photons for $tg \rightarrow d\gamma$, $tg \rightarrow b\gamma$ systems at bremsstrahlung processes. It was found for each system, the photons rate at calculated critical temperature from $B^{1/4}=235$MeV is less effective than the photons rate at calculated critical temperature from $B^{1/4}=355$MeV. For two systems, the photons emission rate is directly proportional to both the flavor number and system temperature and inversely proportional to the energy of photon and the coupling strength.

Keywords: quark-gluon interaction, photon emission, Quantum Chromodynamics, bremsstrahlung.

دراسة إنتاج الفوتونات من تفاعل الكلون -الأعلى في عمليات برامشتيلنج

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مستخلص:

في هذه الدراسة، تم تقديم اموذج نظري للتفاعل بين الجلوونات والكوارك الأعلى استنادًا إلى نظرية الكروموديناميكية (QCD). الكمية. حيث تم دراسة معدل انبعاث الفوتونات كدالة لمختلف المعلمات. استخدام ثابت $B^{(1/4)}=235,355$MeV، ودرجة حرارة النظام في ضمن مدى (190-310MeV)، وعامل المزاوجة للكوارك والغلوون $\lambda_Q=1$، $\lambda_G=0.04$ على التوالي وطاقة الفوتون ضمن المدى (0.75-7.5GeV) لحساب إنتاج الفوتونات لأنظمة $tg \rightarrow b\gamma$، $tg\rightarrow d\gamma$ في عمليات برامشتيلنج. وقد وجد أن معدل الفوتونات عند درجة الحرارة الحرجة المحسوبة من $B^{(1/4)}=235$MeV أقل فعالية من معدل الفوتونات عند درجة الحرارة الحرجة المحسوبة من $B^{(1/4)}=355$MeV لكل نظام. بالنسبة للنظامين، فإن معدل انبعاث الفوتونات يتناسب طرديًا مع كل من رقم النكهة ودرجة حرارة النظام ويتناسب عكسيًا مع طاقة الفوتون وقوة الاقتران.

Introduction

The study of fundamental particles of matter is a crucial aspect of physics.[1]. Based on the Bose-Einstein and Fermi-Dirac statistics, elementary particles can be classified into two types: fermions and bosons. [2]. Fermions are particles having spin 1/2 and bosons have integer spin [3]. Fermions are classified into leptons and quarks. In 1964, the concept of quarks was independently proposed by Gell-Mann and George Zweig as the fundamental constituents of hadronic matter [4]. They're grouped into three generations, each with its own pair: the up and down quarks form the foundation of the first generation, while the second generation is made up of the strange and charm quarks. And then, we have the top and bottom quarks, which belong to the third generation [5]. Any particle that contains quarks is called a hadron. Hadrons are divided into two main categories: the first is known as baryons, which consist of three quarks such as proton and neutron. The second category is called mesons, which consist of bound pairs of a quark and an antiquark [6]. Bosons are mediating particles responsible for transmitting the fundamental interactions between elementary particles. Photons mediate the electromagnetic interaction; gluons are responsible for the strong interaction, and the W and Z bosons mediate the weak interaction [7]. QCD explains the strong interaction between quarks [8]. The quarks interact strongly, their interactions are mediated by the exchange of color charges through gluons. The types of color charge are three: red, blue, and green. The rule that allows quarks to form a hadron is that they are color neutral [9]. QCD) is an asymptotically free theory, meaning that its coupling constant varies with distance. At extremely short distances, quarks behave as nearly free particles due to the weakening of the strong force[10] . Photon production can occur through various processes, including Compton scattering, annihilation, and bremsstrahlung [11]. In this study, the photon emission rate for the bremsstrahlung processes in the $\mathrm{t}g \rightarrow \mathrm{d}\gamma$, $\mathrm{t}g \rightarrow \mathrm{b}\gamma$ systems is calculated and analyzed.

Theory

The photon emission rate resulting from quark–gluon interactions, for photons with momentum P and energy E is given by [12].

$$\Phi_{QG}^{Br}(E,P) = -\frac{F_g(E)}{(2\pi)^3}\, Im\xi_i^f(E,P) \quad (1)$$

Here, F_g (E) represents the gluon distribution function, and Im ξ_i^f (E,P) is the imaginary part of the photon self-energy arising from interaction quark–gluon , which is given by [13].

$$Im\xi_i^f(E,P) = \left(\frac{N}{\pi^4} C_{ca}\right) g_E^2\, g_C^2\, |L_{hl}| \frac{T}{E_\gamma^2} \int_0^\infty |L_{hl}|\, [F_a(P) - (EF_q + PF_q)]\, [(P+E)^2 + P^2]\, dp \quad (2)$$

Casmir factor, defined as C_{ca}, which is given by14]].

$$C_{ca} = \frac{1}{2}\left(N_c - \frac{1}{N_c}\right) \quad (3)$$

Where N_c represents the quarks number $N_c = 3$, $N_{ca} = 4/3$ and N represents degeneracy factor N ≈3, by introducing $\sum q^2$ is the total electric charge for the quarks in the system, Equation (2) an be simplified as follows.

$$Im\xi_i^f(E,P) = \left(\frac{8}{\pi^4}\right) g_E^2\; g_C^2\; \frac{T}{2E_\gamma^2} \sum q^2 \int_0^\infty |L_{hl}|\, [F_a(P) - (EF_q + PF_q)]\, [E^2 + 2EP + 2P^2]\, dp \quad (4)$$

Integration of self-energy [15]

$$|L_{hl}| = |L_h - L_l| \quad (5)$$

Where L_h and L_l are represented dimensionless constants, by inserting Eq.(5) into Eq. (4) reduced to.

$$Im\xi_i^f(E,P) = 8\,\frac{1}{\pi^4}\; g_E^2\; g_C^2\; |L_h - L_l| \frac{T}{2E_\gamma^2} \sum q^2 \int_0^\infty [F_a(P) - (E+P)F_q]\, [E^2 + 2P^2 + 2PE]\, dp \quad (6)$$

The Jüttner distribution function, which describes quarks, is given by [16]

$$F_a(P) = \frac{\lambda_Q}{e^{\frac{P}{T}} + \lambda_Q} \qquad (7)$$

And

$$F_q\,(E+P) = \frac{\lambda_Q}{e^{\frac{(P+E)}{T}} + \lambda_Q} \cdots\cdots\cdots\cdots (8)$$

Where λ_Q denotes the quark fugacity function. By substituting Eq.s (7) and (8) into Eq (6), it simplifies to:

$$Im\xi_i^f\,(E,P) = 8\frac{1}{\pi^4}\,g_E^2\,g_C^2\,|L_h - L_l|\,\frac{T}{2E_\gamma^2}\,\sum q^2\,\int_0^\infty \frac{\lambda_Q(2P^2 + 2PE + E^2)}{e^{\frac{P}{T}} + \lambda_Q}dP - \int_0^\infty \frac{\lambda_Q(E^2 + 2P^2 + 2PE)}{e^{\frac{(P+E)}{T}} + \lambda_Q}dP \ldots\ldots (9)$$

The result of the integral part is given by

$$\int_0^\infty \frac{\lambda_Q(E^2 + 2P^2 + 2PE)}{e^{\frac{P}{T}} + \lambda_Q}dP - \int_0^\infty \frac{\lambda_Q(E^2 + 2P^2 + 2PE)}{e^{\frac{(P+E)}{T}} + \lambda_Q}dP = \left(1 - \exp(-\frac{E_\gamma}{T})\right) * [(E^2\Gamma(1) + 2(ET\,\Gamma(2) + T^2\Gamma(3))]\lambda_Q T \qquad (10)$$

By substituting Eq.(10) into Eq.(9), it simplifies to

$$Im\xi_i^f\,(E,P) = (\frac{8}{\pi^4})\,g_E^2\,g_C^2\,|L_h - L_l|\,\frac{T}{2E_\gamma^2}\,\sum q^2\;[(1-\exp(-\frac{E_\gamma}{T}))\,(E^2 + 2T(E + 2T))]\lambda_Q T \quad \ldots\ldots (11)$$

The coupling strength of electrodynamics is [17]

$$g_E^2 = 4\pi\alpha_E \cdots\cdots (12)$$

The coupling of quantum chromodynamics is given by [18]

$$g_C^2 = 4\pi\alpha_C \cdots\cdots\cdots\cdots (13)$$

By Substituting the Eqs. (12) and (13) into Eq.(11) , Eq. (11) is reduced to

$$\mathrm{Im}\xi_i^f(E,P)=\frac{128}{\pi^2}\alpha_E\alpha_C\lambda_Q|L_h-L_l|\frac{T}{2E_\gamma^2}\sum q^2\ [(1-\exp(-\frac{E_\gamma}{T}))$$

$$(E^2+2T(E+2T)))]\ldots\ldots.(14)$$

It can be assumed

$$K(E,T)=(E^2+2T(E+2T))\ldots\ldots\ldots(15)$$

Substituting Equation (15) in Equation (14)

$$\mathrm{Im}\xi_i^f(E,P)=\frac{128}{8\pi^2}\lambda_Q\alpha_E\alpha_C|L_h-L_l|\ \frac{T}{2E_\gamma^2}\sum q^2\ (1-\exp(-\frac{E_\gamma}{T}))\ K(E,T)\ldots(16)$$

By substituting Equation (16) into Equation (1), it simplifies to

$$R_{QG}^{Br}(E,P)=-\frac{128F_G(E)}{8\pi^5}\alpha_E\alpha_C\lambda_Q|L_h-L_l|\frac{T}{2E_\gamma^2}\sum q^2\ (1-\exp(-\frac{E_\gamma}{T}))\ K(E,T)\ldots\ldots..(17)$$

The distribution of gluons F_G (E) for $T \ll E_\gamma$ is [19].

$$F_G(E)=\frac{\lambda_G}{e^{\frac{E_\gamma}{T}}-\lambda_G}=\frac{1}{\frac{e^{E_\gamma/T}}{\lambda_G}-1}\approx\lambda_G e^{-\frac{E_\gamma}{T}}\ \cdots\cdots\cdots\ (18)$$

Where λ_G denotes the gluon fugacity function. By substituting Equation (18) into Equation (17), Equation (15) simplifies to

$$R_{QG}^{Br}(E,P)=\frac{128}{\pi^5}\alpha_E\alpha_C\lambda_Q\lambda_G\ \frac{T}{16E_\gamma^2}\ \sum q^2|L_h-L_l|\ e^{-\frac{E_\gamma}{T}}(\exp(-\frac{E_\gamma}{T})-1)\ K(E,T)\ldots\ldots\ldots(19)$$

For $T \leq E_\gamma$ T then

$$(e^{-\frac{E_\gamma}{T}}-1)\approx e^{-\frac{E_\gamma}{T}}\ \cdots\cdots\cdots\ (20)$$

Inserting Eq.20) in Eq. (19) reduced to

$$R_{QG}^{Br}(E,P)=\frac{128}{16\pi^5}\lambda_Q\lambda_G\alpha_E\alpha_C\ \frac{T}{E_\gamma^2}\ \sum q^2|L_h-L_l|\ e^{-\frac{2E_\gamma}{T}}\ K(E,T)\ldots..(21)$$

The critical temperature is [20]

$$T_C = \left[\frac{90B}{\pi^2(N_S \times N_C) + \frac{7}{4}(n_c \times n_s \times n_f)}\right]^{1/4} \cdots\cdots\cdots\cdots (22)$$

Where T_C represents the critical temperature, $B^{1/4}$ is the Bag constant, N_C , N_S are represents gluon color and number of spin and n_f,n_s,n_c are represents the flavor number , spin, and number of quark color respectively.

The coupling strength is defined as [21]

$$\alpha_c = \frac{6\pi}{(33-2N_f)\ln\frac{8T}{T_C}} \cdots\cdots\cdots\cdots (23)$$

Where T is the temperature of system.

Result

The photon emission rate resulting from quark–gluon interactions at high energies has been theoretically evaluated. We calculated the photonic yield based on the quantum chromodynamic theory and the flavor number evaluation. Taking the sum of the flavor number $N_{f_i} = \sum_{i=1}^{6} N_{f_i}$ for the systems $tg \rightarrow d\gamma$, $tg \rightarrow b\gamma$ where $N_f = 6$ for the top quark, $N_f = 2$ for the down quark and $N_f = 5$ for the bottom quark means that the flavor number of the $tg \rightarrow d\gamma$ system is $N_f = 8$ and the flavor number of the $tg \rightarrow b\gamma$ system is $N_f = 11$. The critical temperature is estimated using Equation (22) and the bag constant is employed to describe the relationship between the critical temperature T_C and the degrees of freedom of quarks and gluons. The bag constant $B^{1/4}$= 235,355MeV [22] is taken for two systems and the degree of freedom for gluons is $N_S = 2$, $N_C = 8$ and the degree of freedom for quarks are n_c=3, n_s=2, n_f=8,11 for the $tg \rightarrow d\gamma$, $tg \rightarrow b\gamma$ systems respectively. The T_c result is shown in Table 1 .

TABLE 1. The result of calculating the T_c for the systems the $tg \rightarrow d\gamma$, $tg \rightarrow b\gamma$

$B^{1/4}$ (GeV)	T_c (GeV)	
	$tg \rightarrow d\gamma$	$tg \rightarrow b\gamma$
0. 235	0.12913785	0.120593004
0. 255	0.140128306	0.130856239

T (GeV)	α_c			
	$tg \to d\gamma$		$tg \to b\gamma$	
	T_c=0.12913785GeV	T_c=0.140128306GeV	T_c=0.120593004GeV	T_c=0.130856239GeV
0.190	0.4497096	0.4651177	0.6762297	0.6987521
0.210	0.432167	0.4463775	0.6505364	0.6713535
0.230	0.4173683	0.4306072	0.6288196	0.6482492
0.250	0.4046673	0.4171008	0.6101504	0.6284267
0.270	0.3936117	0.4053652	0.5938764	0.6111769
0.290	0.3838739	0.3950448	0.5795243	0.5959871
0.310	0.3752106	0.385876	0.5667417	0.5824765

The coupling strength of the quark-gluon interaction is calculated using Eq.(23) and the results of critical temperatures from Table 1 plus the values of flavor number for $tg \to d\gamma$ and $tg \to b\gamma$ systems and the temperature of the system in the range (190-310MeV). The coupling strength result is shown in Table 2.

To calculate the rate of emitted photons, the sum of the electric charges is calculated $\sum q^2$ where the electric charges of the top quark is (2/3) and the electric charges of the down and bottom quarks are (-1/3) that mean the summation of electric charge for $tg \to d\gamma$, $tg \to b\gamma$ systems is (5/9). However, the rate of Photons yield is calculated with fugacity of quark λ_Q =1and gluon $\lambda_G = 4x10^{-2}$[23] with the self-integral constant L_h =4.45, L_l = - 4.26 [24], α_E =1/137 . The system's temperature ranges from 190 to 310 MeV, and photon energy values between 0.75 and 7.5 GeV [25], the coupling strength values from Table 2 are also incorporated. The rate of photonic yield is then computed by substituting all these parameters into Eq.(21) and performing the calculations using MATLAB software. The photon emission rate resulting from the systems $tg \to d\gamma$ and $tg \to b\gamma$ is shown in Tables 3 to 6 6and Figures 1to 4.

TABLE 3. The rate of photons emission
at T_c= 0.12913785 GeV, λ_G =4, λ_Q= =1 in system has

E_γ (GeV)	$R^{Br}_{QE}(E,P)\,\frac{1}{GeV^2 fm^4}$						
	T=190MeV	T=210MeV	T=230MeV	T=250MeV	T=270MeV	T=290MeV	T=310MeV
	α_{QCD}						
	0.4497	0.4321	4173	0.4046	0.3936	0.3838	=0.3752
0.75	3.9407E-10	1.0425E-09	2.3867E-09	4.8882E-09	9.1709E-09	1.6035E-08	2.6466E-08
1.5	1.0973E-13	5.9750E-13	2.4719E-12	8.2903E-12	2.3594E-11	5.8905E-11	1.3224E-10
2.25	3.7170E-17	4.2472E-16	3.2355E-15	1.8091E-14	7.9455E-14	2.8795E-13	8.9323E-13
3	1.3220E-20	3.1872E-19	4.4947E-18	4.2121E-17	2.8700E-16	1.5176E-15	6.5376E-15
3.75	4.7930E-24	2.4433E-22	6.3923E-21	1.0062E-19	1.0659E-18	8.2417E-18	4.9411E-17
4.5	1.7542E-27	1.8928E-25	9.1968E-24	2.4342E-22	4.0133E-21	4.5426E-20	3.7942E-19
5.25	6.4543E-31	1.4750E-28	1.3318E-26	5.9310E-25	1.5228E-23	2.5247E-22	2.9398E-21
6	2.3826E-34	1.1536E-31	1.9364E-29	1.4515E-27	5.8061E-26	1.4105E-24	2.2904E-23
6.75	8.8143E-38	9.0444E-35	2.8231E-32	3.5625E-30	2.2207E-28	7.9067E-27	1.7910E-25
7.5	3.2658E-41	7.1029E-38	4.1232E-35	8.7613E-33	8.5122E-31	4.4428E-29	1.4041E-27

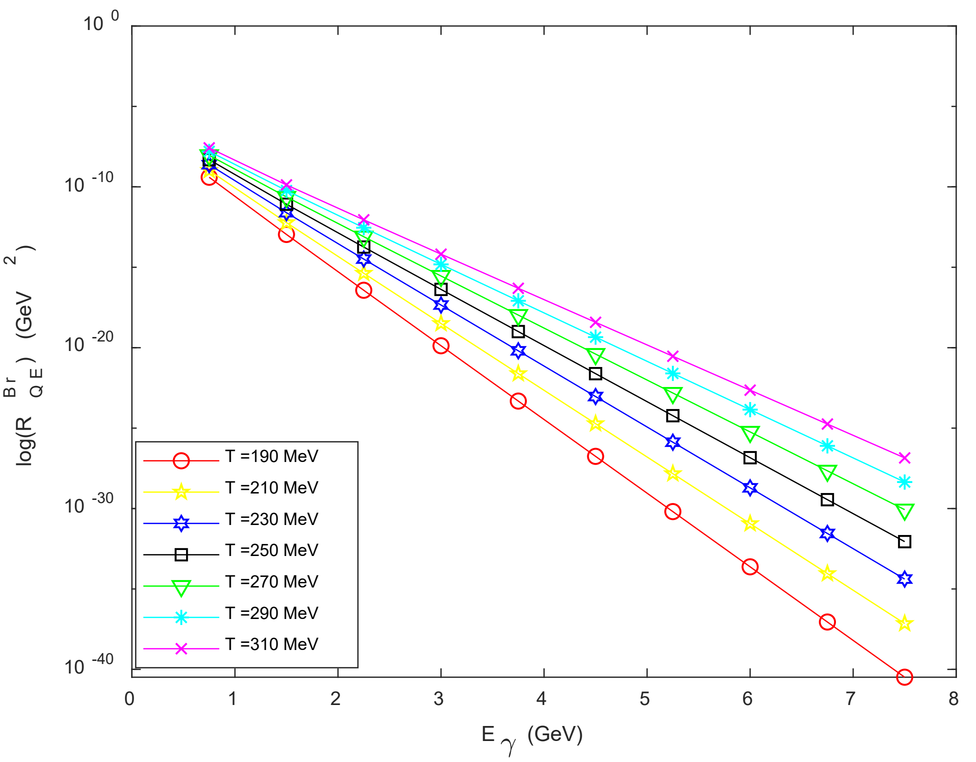

Figure 1. The rate of photons emission $R^{Br}_{QE}(E,P)$as function of E_γ
at T_c= 0.12913785GeV for tg → dγ system.

TABLE 4. The rate of photons emission at T_c=0.140128306 GeV, with $\lambda_G= 4\times 10^{-2}$, λ_Q=1 in system $tg \rightarrow d\gamma$ has $n_f = 8$.

E_γ (GeV)	$R_{QE}^{Br}(E,P)\frac{1}{GeV^2 fm^4}$						
	T=190MeV	T=210MeV	T=230MeV	T=250MeV	T=270MeV	T=290MeV	T=310MeV
	α_{QCD}						
	0.4651	0.4463	0.4306	0.41710	0.4053	0.3950	0.3858
0.75	4.0757E-10	1.0768E-09	2.4624E-09	5.0384E-09	9.4447E-09	1.6501E-08	2.7218E-08
1.5	1.1349E-13	6.1715E-13	2.5504E-12	8.5450E-12	2.4298E-11	6.0619E-11	1.3600E-10
2.25	3.8443E-17	4.3869E-16	3.3381E-15	1.8647E-14	8.1827E-14	2.9633E-13	9.1862E-13
3	1.3673E-20	3.2920E-19	4.6372E-18	4.3416E-17	2.9557E-16	1.5618E-15	6.7234E-15
3.75	4.9573E-24	2.5236E-22	6.5951E-21	1.0371E-19	1.0977E-18	8.4816E-18	5.0815E-17
4.5	1.8143E-27	1.9550E-25	9.4885E-24	2.5090E-22	4.1332E-21	4.6748E-20	3.9020E-19
5.25	6.6754E-31	1.5235E-28	1.3741E-26	6.1132E-25	1.5683E-23	2.5982E-22	3.0233E-21
6	2.4642E-34	1.1915E-31	1.9979E-29	1.4961E-27	5.9795E-26	1.4515E-24	2.3555E-23
6.75	9.1163E-38	9.3418E-35	2.9126E-32	3.6719E-30	2.2870E-28	8.1368E-27	1.8420E-25
7.5	3.3776E-41	7.3364E-38	4.2540E-35	9.0305E-33	8.7663E-31	4.5721E-29	1.4440E-27

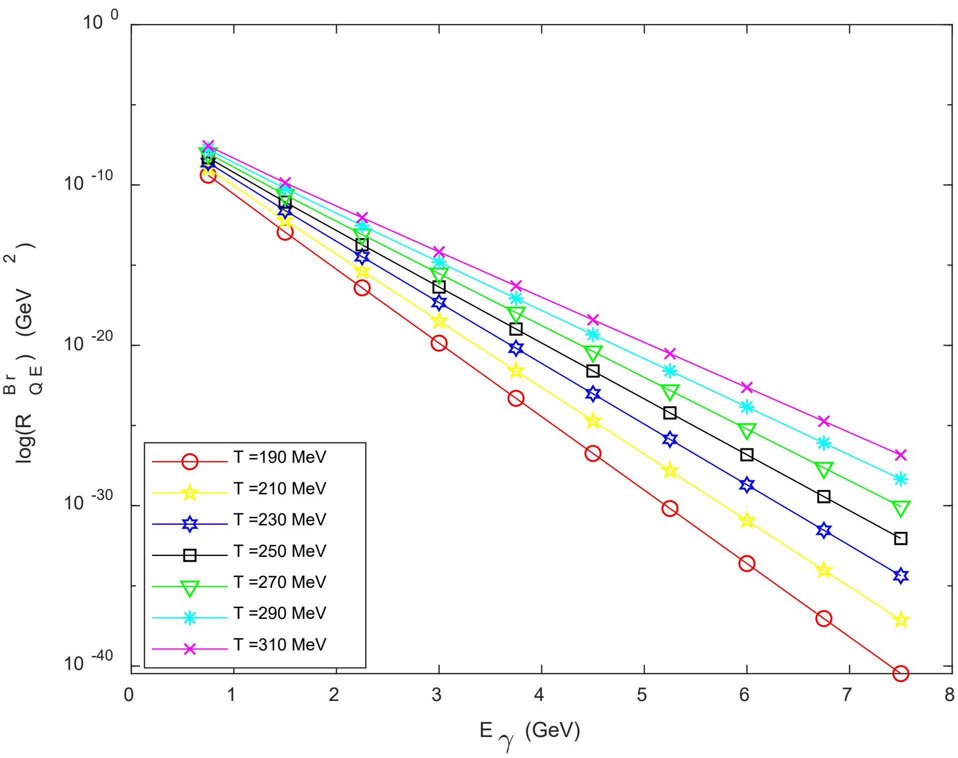

Figure 2. The rate of photons emission $R_{QE}^{Br}(E,P)$as function of E_γ at T_c= 0.140128306 GeV for $tg \rightarrow d\gamma$ system.

TABLE 5. The rate of photons emission at T_c=0.120593004 GeV, with $\lambda_G=4\times 10^{-2}$, λ_Q=1 in system $tg \rightarrow b\gamma$ has $n_f = 11$.

E_γ (GeV)	$R_{QE}^{Br}(E,P)\frac{1}{GeV^2 fm^4}$						
	T=190MeV	T=210MeV	T=230MeV	T=250MeV	T=270MeV	T=290MeV	T=310MeV
	α_{QCD}						
	0.6762	0.65053	0.6288	0.6101	0.5938	0.5795	0.56674
0.75	5.9256E-10	1.5693E-09	3.5958E-09	7.3703E-09	1.3837E-08	2.4207E-08	3.9975E-08
1.5	1.6501E-13	8.9941E-13	3.7243E-12	1.2500E-11	3.5598E-11	8.8927E-11	1.9975E-10
2.25	5.5892E-17	6.3933E-16	4.8747E-15	2.7277E-14	1.1988E-13	4.3471E-13	1.3492E-12
3	1.9879E-20	4.7977E-19	6.7718E-18	6.3510E-17	4.3302E-16	2.2911E-15	9.8748E-15
3.75	7.2073E-24	3.6779E-22	9.6308E-21	1.5171E-19	1.6082E-18	1.2442E-17	7.4633E-17
4.5	2.6378E-27	2.8491E-25	1.3856E-23	3.6703E-22	6.0553E-21	6.8578E-20	5.7310E-19
5.25	9.7053E-31	2.2202E-28	2.0066E-26	8.9426E-25	2.2977E-23	3.8115E-22	4.4404E-21
6	3.5827E-34	1.7365E-31	2.9175E-29	2.1885E-27	8.7602E-26	2.1293E-24	3.4596E-23
6.75	1.3254E-37	1.3614E-34	4.2533E-32	5.3714E-30	3.3505E-28	1.1937E-26	2.7053E-25
7.5	4.9107E-41	1.0692E-37	6.2122E-35	1.3210E-32	1.2843E-30	6.7072E-29	2.1209E-27

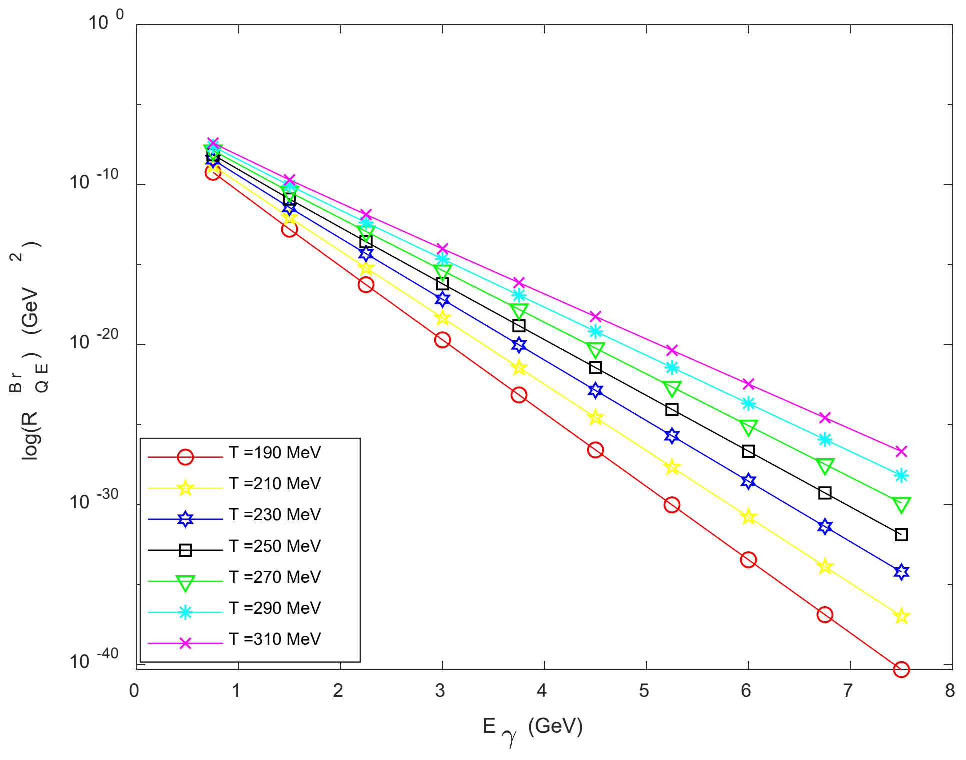

Figure 3. The rate of photons emission $R_{QE}^{Br}(E,P)$as function of $E_\gamma$at T_c=0.120593004 GeV for $tg \rightarrow b\gamma$ system.

TABLE 6. The rate of photons emission at T_c=0.130856239 GeV, with λ_G=4× 10^{-2}, λ_Q=1 in system tg → bγ has $n_f = 11$.

E_γ (GeV)	$R^{Br}_{QE}(E,P)\frac{1}{GeV^2fm^4}$						
	T=190MeV	T=210MeV	T=230MeV	T=250MeV	T=270MeV	T=290MeV	T=310MeV
	α_{QCD}						
	0.6988	0.6714	0.6482	0.6284	0.6112	0.5960	0.5825
0.75	6.1230E-10	1.6195E-09	3.7069E-09	7.5911E-09	1.4240E-08	2.4895E-08	4.1085E-08
1.5	1.7050E-13	9.2819E-13	3.8394E-12	1.2874E-11	3.6635E-11	9.1453E-11	2.0530E-10
2.25	5.7753E-17	6.5979E-16	5.0253E-15	2.8094E-14	1.2337E-13	4.4706E-13	1.3866E-12
3	2.0541E-20	4.9512E-19	6.9811E-18	6.5412E-17	4.4563E-16	2.3562E-15	1.0149E-14
3.75	7.4474E-24	3.7956E-22	9.9284E-21	1.5626E-19	1.6551E-18	1.2796E-17	7.6705E-17
4.5	2.7256E-27	2.9403E-25	1.4284E-23	3.7802E-22	6.2317E-21	7.0526E-20	5.8901E-19
5.25	1.0029E-30	2.2913E-28	2.0686E-26	9.2105E-25	2.3646E-23	3.9198E-22	4.5637E-21
6	3.7020E-34	1.7921E-31	3.0076E-29	2.2540E-27	9.0154E-26	2.1898E-24	3.5556E-23
6.75	1.3695E-37	1.4050E-34	4.3847E-32	5.5323E-30	3.4481E-28	1.2276E-26	2.7804E-25
7.5	5.0743E-41	1.1034E-37	6.4041E-35	1.3606E-32	1.3217E-30	6.8977E-29	2.1797E-27

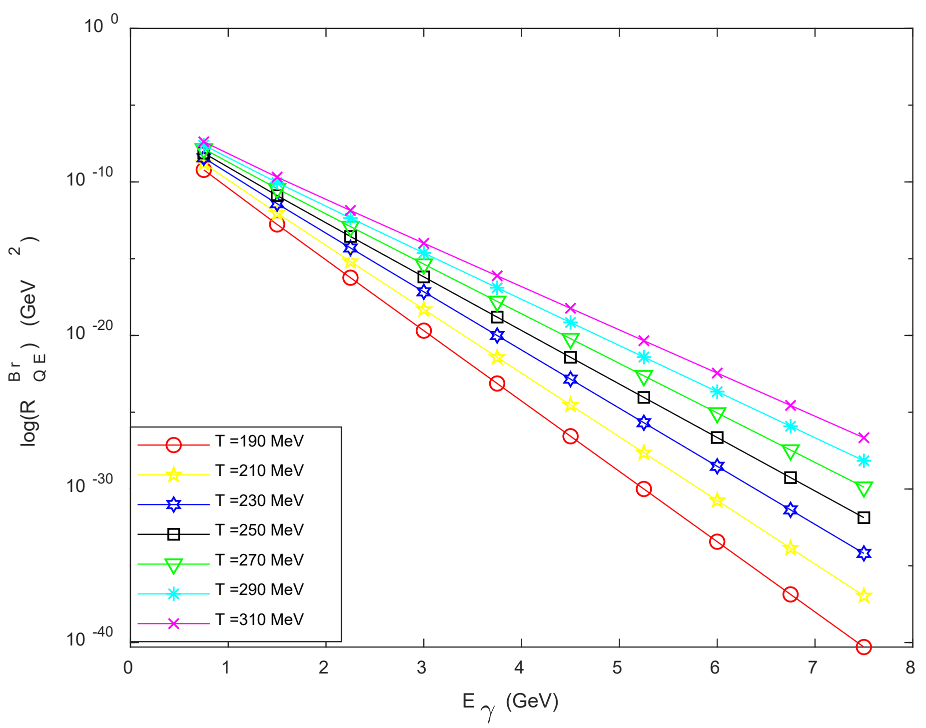

Figure 4. The rate of photons emission $R^{Br}_{QE}(E,P)$as function of E_γ at T_c=0.130856239 GeVfor tg → bγ system.

Discussion

The rate of photons emission was calculated and investigated to understand the behavior of the quark system for bremsstrahlung processes. The rate of photons emission was studied for $tg \rightarrow d\gamma$, $tg \rightarrow b\gamma$ systems based on quantum chromodynamics theory as a function of different parameters: flavor number, critical temperature, system temperature, coupling strength, fugacity of quark and gluon, square of electric charge for quark and photon energy. For each system, the rate of photon emission is affected by critical temperature, coupling strength, photon energy, and system temperature. We can observe that the coupling strength α_C decreases with the increase in system temperature from 190MeV to 310MeV due to the confinement of quarks, and this leads to an increase in photonic yield. For the $tg \rightarrow d\gamma$ system, we note , the maximum value of photonic rate at T=310MeV, E_γ=0.75GeV and T_C=0.140128306 GeV, which equals $R^{Br}_{QE}(E,P)$=2.7218E-08 $\frac{1}{GeV^2 fm^4}$ and the minimum value for photonic rate at T=190MeV E_γ=7.5GeV and T_C=0.12913785GeV, which equal $R^{Br}_{QE}(E,P)$= 3.2658E-41 and the same idea for $tg \rightarrow b\gamma$ system means that the photonic rate increases with increasing critical temperature and system temperature, and decreasing coupling strength, corresponding to it decreasing with increasing photon energy.

On the other hand, if we compare between $tg \rightarrow d\gamma$ and $tg \rightarrow b\gamma$ systems in terms of the critical temperature parameter, we found that the critical temperature T_c for the $tg \rightarrow d\gamma$ system is large compared to the critical temperature for the $tg \rightarrow b\gamma$ system, and this difference was affected on the coupling strength value as shown in Table 2. Furthermore, we can see that the coupling strength values for the first system decrease at a lower rate compared to the second system. Either in terms of photon energy parameter, the photon emission rate of the two systems decreases with increasing photon energy from (0.75–7.5GeV) also, the rate of photons emitted at E_γ= 0.75GeV is faster compared to E_γ= 7.5GeV .In terms the photonic yield of two systems, we can see that the rate of photons for the $tg \rightarrow d\gamma$ system is less than the $tg \rightarrow b\gamma$

system. In general, the increase in photonic yield rate for bremsstrahlung processes is due to the increase in the critical temperature, flavor number, system temperature, and the decrease in the coupling strength of the two systems.

Conclusion

In conclusion, QCD be utilizing for constructed a theoretical model for estimated the photon emission rate in the collision of top quarks with gluon to produce down or bottom quarks ($tg \rightarrow d\gamma$, $tg \rightarrow b\gamma$) systems ,they have flavor number N_f , eight and eleven respectively.The rate of photon two bremsstrahlung processes calculate as a function of critical temperature, strength coupling, flavor number, ,photon energy, thermal energy, quarks charge, and fugacity of quark and gluon using MATLAP software.

Results show that the rate yield for both process collissions at high temperature for quark interaction with gluon has been directly proportional to the flavor number, the critical temperature, and thermal nergy of the system, and inversely proportional to the strength as well the energy of photons for both systems.

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