Theoretical study of the photons rate production in the Quark-Gluon interaction at Compton scattering

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Abstract

The aim of this paper is studying and calculation the photons rate emission in quark gluon systems at Compton scattering processes according to the quantum field theory and quantum consideration. Quantum chromodynamic theory have been used to calculate the photon rate in $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems at Compton scattering due to the critical temperature $T_c = 160$ MeV with flavor number $N_f = 3$ and 6 and thermal energies T= 150MeV, 200MeV, 250MeV and 300 MeV. Photons rate is calculated depending on the estimation of the effective strength coupling α_{esc}, quantum electrodynamic constant α, photons energy E_{phot} , square charge of the quarks e^2_{QCD}, thermal energy T and Euler constant θ_{Euler} parameters using a MATLAB designed program. In both $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems, the rate of photons production are increases with decreases the effective coupling strength and increases thermal energy for one-loop predictions.

Key words

Photons rate, Quantum chromodynamic theory, Compton scattering.

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دراسة نظرية للفوتونات الناتجة في تفاعل كوارك- غلون في استطارة كومبتن

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الخلاصة

هدف البحث الحالي هو دراسة وحساب معدل الفوتونات المنبعثة في نظام كوارك – غلون في عملية استطارة كومبتن اعتماداً على نظرية المجال والاعتبارات الكمية. النظرية الكمية اللونية استعملت لحساب المعدل الفوتوني في نظام $cg \rightarrow d\gamma$ و $ug \rightarrow d\gamma$ في استطارة كومبتن نسبة الى درجة الحرارة الحرجة T_c =160 MeV والعدد النكهة N_f =3,6 والطاقات الحرارية T= 300MeV, 250MeV, 200MeV, 150MeV. لمعدل الفوتوني حسب اعتماداً على تقدير معاملات ثابت القوى الفعالة α_{esc} والثابت الكمي الديناميكي الكهربائي α وطاقة الفوتونات E_{photon} ومربع شحنة الكواركات $\sum e^2{}_{QCD}$ والطاقات الحرارية T وثابت اويلر حيث تم استخدام برنامج ماتلاب في برمجة المعادلات الرياضية المستخدمة. في كلا النظامين و$cg \rightarrow d\gamma$ و $ug \rightarrow d\gamma$ فأن معدل الفوتونات الناتجة يتزايد بتناقص ثابت القوى الفعالة وتزايد الطاقة الحرارية ولدورة واحدة.

Introduction

The fundamental forms of the matter had been interesting of scholars as long ago as the Greek philosophers in the fourth century BC, Democritus was postulating and thought the existence of atomos elementary blocks of indivisible substance [1]. Atomic of nucleus with its two different constituents represents a unique finite quantum of many body systems. The evolution of its properties can be investigated in detail by varying the finite numbers of nucleons (protons and neutrons) [2]. This leads to define elementary particle physics which is domain of physics had been used different scientific method to investigation the smallest fundamental building blocks of the matter in the universe and the elementary interactions between them [3]. Indivisible idea for the building blocks goes back to 1803 due to the atom of Dalton that's introducing in nineteen century ago. For that time, the atom is regarding as the basic of elementary particle to the building matter. On the other hands, at the 20th century, the scientist discoveries that the atom isn't an elementary particle after all, but its consists of a positively charged nucleus and negatively charged electrons orbiting the nucleus of matter. Thomson model for atom indicate that atom had been made of some protons have positive charge with electrons have negative charge [4]. Besides, Rutherford models of atom and the nucleus with the Bohr quantum theory, elementary particles of positrons, neutrinos with neutrons are invented at 1930, after short some predicted are found, that's lead to prove the existence of the neutrinos after many years [5]. The positron was discovered in 1932 by Anderson, it is the positively charged with the equal mass of the electron and opposite electric charge. It's actually predicted at few years earlier by Dirac depending on theoretical consideration. Besides that, Pauli predicted the neutrino in 1930, but proved very elusive and it was finally discovered in 1956 [6]. The sciences and technology development were supplied deferent detailed information about the matter. The elementary particle was regarded as "unbreakable" constituent consists of smaller particles. Such a change of picture of the elementary particle was repeated in the history of science [7]. Gell-Mann and Zweig introduced independently the quarks particle's to discussion the building blocks of hadronic matter in 1964. The quarks are known an indivisible fundamental elementary particles. The quarks inside the proton and neutron are held together by the strong nuclear force, which is transmitted by uncharged particles called gluons 2008 [8]. In addition, corresponding to each quark is an antiquark which has the same mass, but opposite charge. The quarks particles were found at group contain is particles have different quantum flavors number All quarks have spin $\frac{1}{2}\mathrm{h}$ However masses of an antquarks are same for the masses corresponding of quarks particle. The quarks have a new charge addition to the electric charge called color charge indicate that interaction of quarks is in the strong interaction [8]. The particles that contain quarks are called as hadrons. Hadrons were divided into two categories baryons and mesons Baryons contained of three bound quarks such as the proton and neutron and mesons that contained pairs of quark-antiquark [9]. The first theoretical approach to order all of these particles in a systematic way in terms of certain internal symmetry properties was the Standard Model of Elementary of Particle Physics which has evolved in the 1970's [10].

Theory

Photons have been produce at the collisions of primary hard Parton as a results of momentum distributions. Photons produce at quarks interaction supply to mainly information on the protons and neutrons structure depending on the QCD theory due to the quark models [11]. The probability of amplitude for photon emission process can be describe depending on the consideration of quantum mechanics in general and on the quantum field theory and given by [12].

$$\xi_T(i \to o) = \left|\left\langle \psi_{(\vec{p}_1^{/},\ldots\ldots,\vec{p}_k^{/})} \middle| S \middle| \psi_{(\vec{p}_1,\ldots\ldots,\vec{p}_n)} \right\rangle\right|^2 \qquad (1)$$

where $|\psi_{(\vec{p}_1^{/},\ldots\ldots,\vec{p}_k^{/})}\rangle$ is the outgoing wave function state , $|\psi_{(\vec{p}_1,\ldots\ldots,\vec{p}_n)}\rangle$ is the initial wave function state and S is the S-matrix of scattering theory.

The photon production rate in Compton scattering at thermal equilibrium may be written as [13].

$$\frac{dN}{d^4x} = \frac{1}{\nu}\frac{1}{\sum_i e^{-E_i/T}}\frac{d^3P}{(2\pi)^3}\sum_{i,o} e^{-E_i/T}\left|\left\langle \varphi_{(\vec{p}_1^{/},\ldots\ldots,\vec{p}_k^{/})} \middle| S \middle| \varphi_{(\vec{p}_1,\ldots\ldots,\vec{p}_n)} \right\rangle\right|^2 = -\epsilon^2 g^{\mu\vartheta} W_{\mu\vartheta}\frac{d^3P}{2E(2\pi)^3} \quad (2)$$

To lowest order but to all orders in the strong interactions, $W_{\mu\vartheta}$ is related to the retarded photon self-energy $\prod^R_{\mu\vartheta}$ by [14].

$$\epsilon^2 g^{\mu\vartheta} W_{\mu\vartheta} = \frac{2}{e^{E_i/T}-1}\mathrm{Im}\prod\nolimits^R_{\mu\vartheta} \qquad (3)$$

where $\prod^R_{\mu\vartheta}(E,q)$ is the retarded photon self energy for the finite temperature (T), and E_i is the photons energy. Thus, one obtains the relationship between the (Lorentz - boost) invariant photon production rate (the number of photon emitted per unit time and per unit volume) and the imaginary part of the retarded polarization tensor of the photon, as given by field theory from Eqs.(2) and (3)

$$\mathbb{R}_{Compton}(\alpha_{esc}, T, E_{phot}) = E\frac{dN}{d^3Pd^4x} = -\frac{1}{(2\pi)^3}\mathrm{Im}\prod\nolimits^R_{\mu\vartheta}\frac{1}{e^{E_i/T}-1} \qquad (4)$$

where E_γ is the energy of the emitted photon and $\prod^R_{\mu\vartheta}(E,q)$ is the retarded photon self-energy for the finite temperature T. The retarded propagators self-energy with spectral representation can be written as [15].

$$\mathrm{Im}\prod\nolimits^{R,\mu}_{\mu} = -\frac{10\pi}{3}e^2\sum e^2_{QCD}\left(e^{\frac{E_i}{T}}-1\right) x \int\frac{d^3k}{(2\pi)^3}\int_{-\infty}^{\infty}dw\int_{-\infty}^{\infty}dw^{\sim}\,\delta(E-w-w^{\sim})[f_{FD(q)}(w).f_{BE(g)}(w^{\sim})]\mathrm{Tr}[\xi^{\mu}(k,\bar{k},-p)\rho^*(w,\bar{k})\rho(w-E,\bar{k}-\bar{p})\xi^{\vartheta}(-\bar{k},-k,p)] \quad (5)$$

Then, the integral in Eq.(5) may be solve and result to.

$$\mathrm{Im}\prod\nolimits^{R,\mu}_{\mu} = -4\pi\frac{5}{12\pi^2}e^2\sum e^2_{QCD}\left(e^{\frac{E_i}{T}}-1\right)\left[e^{-\frac{E_{phot}}{T}}\right]\{2m_q^2\int_k^{\mu}\frac{w_+(k)-w_-(k)}{m_q^2}dk+\Omega_{corection} \quad (6)$$

The solution to the integral in the first term of Eq.(6) leads to.

$$2\int_k^{\mu}\frac{w_+(k)-w_-(k)}{m_q^2}dk = 2\int_k^{\mu}\frac{1}{k}dk = \mathrm{Ln}\frac{\mu^2}{k^2}) \qquad (7)$$

Then Eq.(6) leads to

$$\mathrm{Im}\prod\nolimits^{R,\mu}_{\mu} = -4\pi\frac{5}{12\pi^2}e^2\sum e^2_{QCD}\left(e^{\frac{E_i}{T}}-1\right)\left[e^{-\frac{E_{phot}}{T}}\right]\left(m_q^2\mathrm{Ln}\frac{\mu^2}{k^2}+\Omega_{corection}\right) \quad (8)$$

where $\Omega_{corection}$ is the corection term is given by [16].

$$\Omega_{corection} = \int kdk\beta_{\pm}(w,k)\theta(k^2-w^2) \cong m_q^2(\tfrac{1}{2}-\theta_{Euler}) \qquad (9)$$

where $\theta_{Euler} = 0.577216$. Similarly, the production rates is taken from [17]. Inserting Eq.(9) into Eq.(8) to result is:

$$\mathrm{Im}\prod_{\mu}^{R,\mu} = -4\pi\frac{5}{12\pi^2}e^2\left(e^{\frac{E_i}{T}}-1\right)x\left[e^{-\frac{E_{phot}}{T}}\right]\left[m_q^2\mathrm{Ln}\frac{\mu^2}{k^2}+m_q^2\left(\frac{1}{2}-\theta_{Euler}\right)\right] \quad (10)$$

Substituting Eq.(10) into Eq.(4) leads to photons rate equation:

$$\mathbb{R}_{Compton}(\alpha_{esc}\,,T,E_{phot}) = \frac{1}{8\pi^4}\frac{5}{3}e^2\sum e_{QCD}^2\left[e^{-\frac{E_{phot}}{T}}\right]m_q^2\left[\mathrm{Ln}\frac{\mu^2}{k^2}+\frac{1}{2}-\theta_{Euler}\right] \quad (11)$$

where $\alpha = \frac{e^2}{4\pi}$ [18], and m_q^2 is the square of quarks masses given by [19]:

$$M^2 = \frac{g^2C_FT^2}{4} \quad (12)$$

Here $g^2 = 4\pi\alpha_{esc}$ is the strong gauge of quantum chromodynamic theory related to effective strength coupling α_{esc} , T is the thermal energy and C_F is the Casimir of quark representation and given to[20].

$$C_F = \frac{N_c^2-1}{2N_c} \quad (13)$$

where $N_c$is colour number is equal $N_c = 3$. Then the photons rate expression in Eq.(10) with $\alpha = \frac{e^2}{4\pi}$ and $g^2 = 4\pi\alpha_{esc}$ is giving the asymptotic solution:

$$\mathbb{R}_{Compton}(\alpha_{esc}\,,T,E_{phot}) = \frac{1}{8\pi^4}\frac{5}{3}\sum e_{QCD}^2\,4\pi\alpha\left[e^{-\frac{E_{phot}}{T}}\right]\frac{4\pi\alpha_{esc}T^2}{4}\frac{8}{6}\left[\mathrm{Ln}\frac{\mu^2}{k^2}+\frac{1}{2}-\theta_{Euler}\right] \quad (14)$$

The lower limit of k and μ comes from $k{\sim}gT$, and $\mu{\sim}\sqrt{2ET}$ and in which Eq.(14) becomes:

$$\mathbb{R}_{Compton}(\alpha_{esc}\,,T,E_{phot}) = \frac{10\alpha\alpha_{esc}}{9\pi^2}\sum e_{QCD}^2\ T^2e^{-\frac{E_{phot}}{T}}\left[\mathrm{Ln}\left(\frac{2E}{4\pi\alpha_{esc}T}\right)+\frac{1}{2}-\theta_{Euler}\right] \quad (15)$$

where α is the quantum electrodynamic constant is equal $(\alpha = \frac{e^2}{4\pi\varepsilon_0\hbar c} \approx \frac{1}{137})$, e_{QCD} is the electric charge of the quark. The effective of strong coupling constant at high energy collision the expression in Eq. (15) may be written as [21]:

$$\alpha_{esc}(P_{eff}) = \frac{6\pi}{(33-2N_F)\ln(\frac{`P_{eff}}{T_c})} \quad (16)$$

where P_{eff} is the effective momentum transfer, T_c is the transition temperature, and N_F is the favor number.

Results

A theoretical side based on the quantum chromodynamics is depending on the investigation and studying the photons rate production in quark gluon system at the Compton scattering processes. Quantum scenario for the change of gluon particle is adapted to the investigation and analysis of the probability of photons rate spectrum for the ug → dγ, and cg → dγ systems. The photons rate emission in quark-gluon at Compton processes have been calculated using quantum precision in Eq. (15) due to the effective strength coupling α_{esc} the quantum electro dynamic constant α, photons energy E_{phot}, square charge of the quarks e_{QCD}^2, thermal energy T and Euler constant θ_{Euler}. The effective strength coupling α_{esc} evaluation one can estimate flavour number, color charge and electric charge of quarks. The flavour number of quarks can be evaluated using the limit $1 \le N_F \le 6$ and formula $\sum_f N_f$ and inserting the values of flavors quantum numbers for qurks $N_F = 1{,}2$ and 3 for Up, Down and Charm, the results of flavor number system are 3 and 5 for ug → dγ ', and cg → dγ systems alternatively. Net, the color charge can be estimated depending on the quantum chromodynamic theory the quarks system have color charge in the limit of the color quantum number, 1 ≤ N_C ≤ 3. In order to calculate the effective strength coupling α_{esc} for the quark-gluon interaction at Compton scattering can evaluate the square charge of the quarks systems e^2_{QCD} using the summation formula $\sum e^2_{QCD} = \frac{5}{9}$ for both $ug \rightarrow d\gamma$ and, $cg \rightarrow d\gamma$ quarks systems. The effective strength coupling α_{esc} can only be determined theoretically by using the first least order precision in Eq. (16) and inserted the values of flavors 3 and 5 for $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems with critical temperature $T_c = 160$ MeV, the results of α_{esc} have been shown in Table 1.

Table 1: Theoretical estimation of the effective strength coupling α_{esc} due to critical temperature T_c=160 Mev for $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems.

system	N_f	α_{esc} (P_{eff}) *GeV*			
		P_{eff}=*1.2 GeV*	P_{eff}=*1.6 GeV*	P_{eff}=*2 GeV*	P_{eff}=*2.4 GeV*
		T= 150 MeV	T= 200 MeV	T=250 MeV	T= 300 MeV
$ug \rightarrow d\gamma$	3	α_{esc} = 0.3464GeV	α_{esc} = 0.3031GeV	α_{esc} = 0.2764GeV	α_{esc} =0. 25779GeV
$cg \rightarrow d\gamma$	6	α_{esc} = 0.4454GeV	α_{esc} = 0.3898GeV	α_{esc} = 0.3553GeV	α_{esc} = 0.3314 GeV

The total photon rate that products from quark gluon interaction depending on the quantum consideration and the quantum chromodynamics theory at various thermal energy T = 150 to 300 MeV and critical temperature T_c= 160 is the calculation of the function of photons energy $E_{Phot} = 1 \rightarrow 5$ GeV [9], and considered the interaction for one loop contributions for $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems.

The rates of photons calculated at Compton scattering processes using Eq. (15) with inserting the values the effective strength coupling α_{esc} from Table 1, the effective momentum transfer P_{eff}, quantum flavor numbers N_f= 3 and 5 critical temperature T_c= 160 MeV and thermal energy T = 150 MeV, T = 200 MeV, T=250 MeV and T=300MeV. The data results are summarized in Tables 2 and 3 and Figs.1 and 2 for $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems at critical temperature T_c= 160 MeV.

Table 2: The result of photon rate production $\mathbb{R}_{Compton}(\alpha_{esc}, T, E_{photo})$ in ug→dγ sytem at Compton scattering due to T_c=160 MeV with flavor number N_f =3.

E_{photo} GeV	$\mathbb{R}_{Compton}(\alpha_{esc}, T, E_{phot})\frac{1}{GeV^2\,fm^4}$			
	T= 150 MeV	T= 200 MeV	T=250 MeV	T= 300 MeV
	$a_{esc} = (0.34648)$	$a_{esc} = 0.3031Gev$	$a_{esc} = 0.2764Gev$	a_{esc} =0. 25779
1	4.7191×10^{-9}	3.3117×10^{-8}	1.0936×10^{-7}	2.4352×10^{-7}
1.5	2.3386×10^{-10}	3.9600×10^{-9}	2.2726×10^{-8}	7.4933×10^{-8}
2	1.0001×10^{-11}	3.9737×10^{-10}	3.8368×10^{-9}	1.80309×10^{-8}
2.5	4.0266×10^{-13}	3.7222×10^{-11}	5.9915×10^{-10}	3.9737×10^{-9}
3	1.5701×10^{-14}	3.3640×10^{-12}	8.9921×10^{-11}	8.3822×10^{-10}
3.5	6.0048×10^{-16}	2.9750×10^{-13}	1.3180×10^{-11}	1.7232×10^{-10}
4	2.2668×10^{-17}	2.5950×10^{-14}	1.9022×10^{-12}	3.4837×10^{-11}
4.5	8.4789×10^{-19}	2.2404×10^{-15}	2.7159×10^{-13}	6.9616×10^{-12}
5	3.1490×10^{-20}	2.3390×10^{-15}	3.8460×10^{-14}	1.3790×10^{-12}

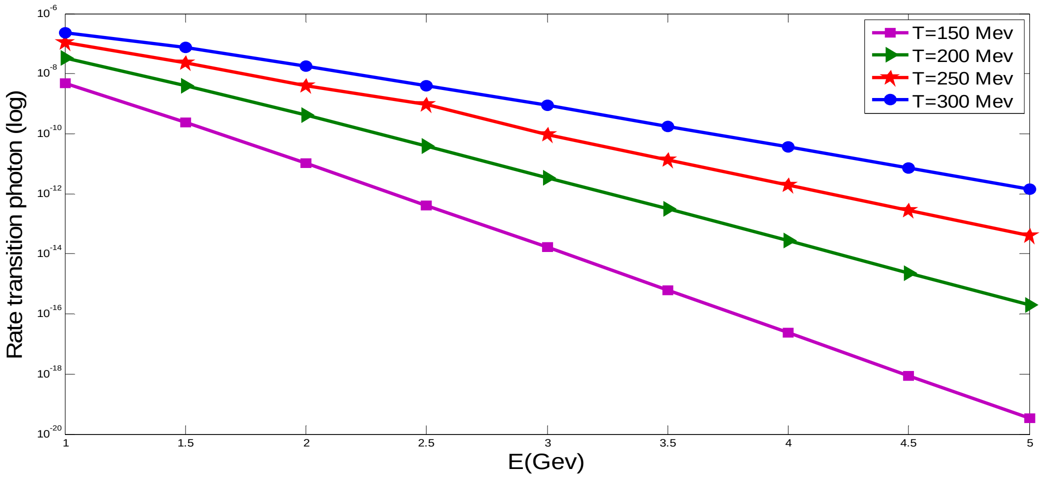

Fig. 1: Photons rate $\mathbb{R}_{Compton}(\alpha_{esc}, T, E_{photon})$ as a function of E_{Phot} for $ug \rightarrow d\gamma$ system with N_f=3, $\sum e^2 = \frac{5}{9}$, T_c= 160 MeV.

Table 3: The result of photon rate production $\mathbb{R}_{Compton}(\alpha_{esc}, T, E_{photon})$ in Cg→dγ sytem at Compton scattering due to T_c=160 MeV with flavor number N_f =6.

$\mathrm{E_{photo}}$ GeV	$\mathbb{R}_{\mathrm{Compton}}(\alpha_{\mathrm{esc}}, \mathrm{T}, \mathrm{E_{photon}}) \frac{1}{\mathrm{GeV^2\ fm^4}}$			
	T= 150 MeV	T= 200 MeV	T=250 MeV	T= 300 MeV
	$a_{esc} = 0.4454\mathrm{GeV}$	$a_{esc} = 0.3898\mathrm{GeV}$	$a_{esc} = 0.3553\mathrm{GeV}$	$a_{esc} = 0.3314\mathrm{GeV}$
1	4.6043×10^{-9}	3.0525×10^{-8}	9.39522×10^{-7}	1.91048×10^{-7}
1.5	2.4847×10^{-10}	4.1020×10^{-9}	2.29039×10^{-8}	7.3284×10^{-8}
2	3.0822×10^{-11}	4.2968×10^{-10}	4.07806×10^{-9}	1.88267×10^{-8}
2.5	4.5124×10^{-13}	4.1189×10^{-11}	6.54608×10^{-10}	4.28624×10^{-9}
3	1.7817×10^{-14}	3.7780×10^{-12}	9.99480×10^{-11}	9.22274×10^{-10}
3.5	6.8746×10^{-16}	3.3767×10^{-13}	1.48259×10^{-11}	1.92193×10^{-10}
4	2.6127×10^{-17}	2.9677×10^{-14}	2.15881×10^{-12}	3.92454×10^{-11}
4.5	9.8248×10^{-19}	2.5778×10^{-15}	3.10349×10^{-13}	7.90310×10^{-11}
5	3.6658×10^{-20}	2.2202×10^{-16}	4.42027×10^{-14}	1.57559×10^{-12}

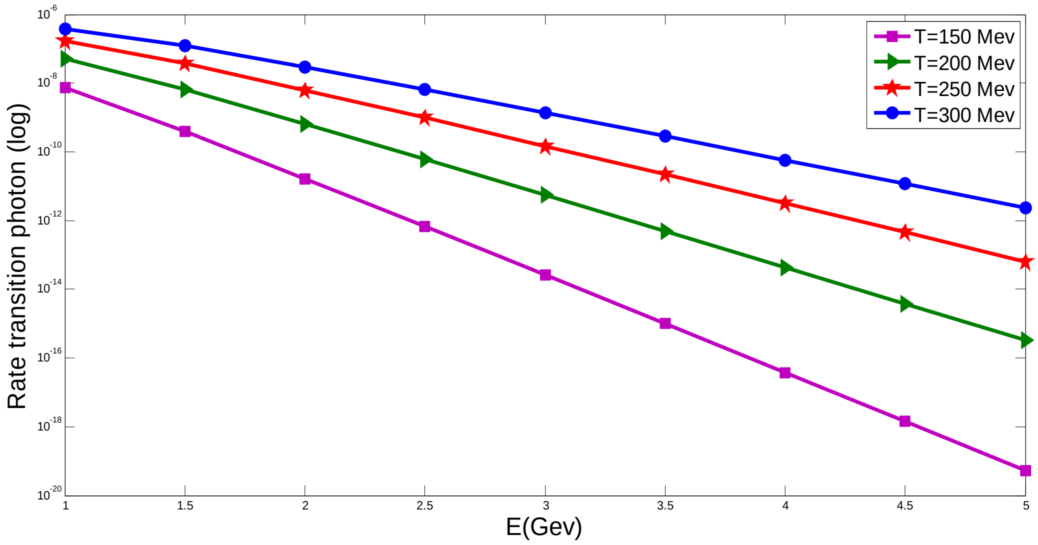

Fig. 2: Photon rate $\mathbb{R}_{Compton}(\alpha_{esc}, T, E_{phot})$ as a function of E_{Phot} for $cg \to d\gamma$ system with N_F=6, $\sum e^2 = \frac{8}{9}$ and T_c= 160 MeV.

Discussion

The study of photons rate in the $ug \to d\gamma$ and $cg \to d\gamma$ systems is currently the subject of great interest, with particular attention focused on the probe of quantum chromodynamic theory. Photons rate is a one of the important theoretical tools to study the nuclear structure for any nucleus. The physics of high energy is seeking to understand the matter structure and the forces by which interacts with them. It was important to calculate the photon rate at Compton scattering for forth system, because there are many background sources for the prompt photon production. The interaction of quarks with each other depending on exchange of elementary particles named gluons and that causes the strong interaction. The quark – gluon interaction in Compton processes system properties depend on the thermal energy and its density for interactions. The photon production rate is calculated depending on the S-operator method using the formula in Eq.(15) that is related to perturbative of QCD theory in falls off at large transverse momentum, P=1.2, 1.6, 2 and 2.4 GeV with thermal energy T = 150 MeV, T = 200 MeV, T=250 MeV and T=300 MeV and the critical temperature T_c= 160 MeV and is reached to hadronic phase at $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems. In order to understand and calculate the photon rate , it is the one important coefficient to the investigation of the feature of quarks and gluons and the interaction to each other in the QCD. Due to QCD theory, the effective strong coupling constant parameter α_{eff} is the scale of the QCD that is dependent to expression and discussion of the physical properties of quarks and gluons. The behaviors of strong interaction exposes different scenario at long and short distance because of the effective strength coupling leads to become distant is the short at strong force, while the gluon that is massless particle is the mediator of the strong force. Since the effective strong coupling constant $\alpha_{eff}(P_{eff})$ strongly interacted for quarks in the QCD for the four systems depends on the thermal energy or momentum transfer scale. On the other hand, the effective strong coupling constant α_{eff} increases with decreases of momentum transfer P_{eff} and with increases the thermal energy T, and make the system binds the quarks strongly to each other inside system and have small momentum transfer and thermal energy. The effective strength coupling α_{eff} decreases with increasing thermal energy T until it vanishes at the critical temperature $T_c \approx 160\text{MeV}$. The total photon transition rate is given by an integral over all energy and transfer momenta of the Compton scattering interaction. Factoring out the same coefficient of critical temperature and energy of interaction which appears in the leading logarithmic result of Eq.(16), that indicates to the contribution of inelastic quark-gluon scattering processes to the leading-order emission rate in Eq.(15). From the results, we can show that the effective strength coupling constant $\alpha_{eff}(P_{eff})$ become small when $P_{eff} \gg T_c$ and depends on the momentum transfer scale P_{eff} that is expressed by Eq.(16). Therefore, the quark-gluon Compton scattering interactions due to large momentum transfer P_{eff} should be expressed in the perturbative method. However, the behavior of quarks depend on the results of the effective strength coupling constant depends on the QCD due to the distance of the interaction is unique. This indicate that quarks behavior due to high energy at QCD is opposite to the behavior at the electromagnetism effect and that is means that the quarks at large distance are very attractive strength and quarks bind each other. The results of $\alpha_{eff}(P_{eff})$ increase with decrease of the effective momentum transfer P_{eff} and decrease with increase the thermal energy T, this refers to bind the quarks strongly to each other at system have small effective momentum transfer or have low thermal energy. On the other hand the effective strength coupling coupling $\alpha_s(P)$ for Compton scattering processes increase with increase flavor number N_f and vice versa. For Compton scattering process, the effective momentum transfer inversely proportional to the photon rate and the rate is decreasing with increasing effective momentum transfer. However, we can show that the photon rate increases with increases the effective momentum transfer and vice versa. Here, we turn to study the effect of photons energy on the photons rate in Eq. (15) for the quark- gluon interaction system at Compton processes that is illustrated in figures from (1) to (2) for the $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems, respectively. In fact the photon rate is relatively depending on the energy of photons that is show from Eq.(15) and results in Tables 2 to 3 and Figs. 1 to 2, we can show in that results that the photon rate inversely proportional to energy of photons and vice versa. Furthermore, it has been shown the photon rate decreases with increases the energy of photons that's viewed in Tables 2 to 3. Although, at high temperature, perturbative QCD has been used to study the quark-gluon Compton scattering always leads to match smoothly with the non perturbative between quark and gluon scatterings. From results, We have found that photon rate increases in Tables 2 to 3 which are highly effected by increasing thermal energies of the $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems, and decreasing with decreases the thermal energy, it seems the photon rate to be large near 300 MeV is considered to be existed at very hot temperature comparing to that in 150 Mev. At very high temperatures 300 MeV the effective coupling constant of QCD becomes weak and quark-gluon systems are collective excitations particles and should to be good approximation and become hadronic system.

Conclusions

On the present results we can conclude that the photon rate of quark gluon at Compton scattering system results have been enabled us to elaborated and tested the quantum chromodynamic theory through the color charge. In summary, it can be concluded that is the effective strength coupling of the quark gluon interaction should be effected on the photon rate at $ug \rightarrow d\gamma$ and $cg \rightarrow d\gamma$ systems and the photons rate are large for system with less effective strength coupling and increases with decreases the photons energy. The photons rate of quark gluon strongly depend on the effective strong coupling constant α_{eff}. It increases with decreases the momentum transfer P_{eff} and increases thermal energy and flavor number N_f and vice versa. The quarks bind strongly to each other at system have small effective momentum transfer and have low thermal energy.

References

[1] G. Jones "Study of Isomers using Reactions with a 178Hf Beam" PhD. Thesis, University of Surrey, Guildford, Surrey, 2006.

[2] D. Tonev, A. Dewald, C. Fromsen J. Jolie, Linnemann A, Lisetskiy A. Mineva MN P. Pejovic, N. Pietralla and Werner, J. of Physics G, 76 (2010) 1321.

[3] S. Braibant, G. Giacomelli, M. Spurio, "Particles and Fundamental Interactions: An Introduction to Particle Physics", 2nd edition, Springer, (2012).

[4] R. Enberg, "Quantum Chromodynamics and Colour Singlet Exchange in High Energy Interactions" PhD Thesis, Uppsala University, Uppsala, Sweden, (2003).

[5] P. Franzini, Lecture Notes University of Rome Sapienza, (2005) PP81.

[6] R. Enberg, "Quantum Chromodynamics and Colour Singlet Exchange in High Energy Interactions" PhD Thesis, Uppsala University, Uppsala, Sweden, (2003).

[7] T. horaguchi, "Prompt Photon Production in Proton-Proton Collisions at $\sqrt{s} = 200\text{GeV}$" PhD Thesis, Tokyo Institute of Technology, (2006).

[8] B. Martin and G. Shaw "particle physics" Book, John Wiley & Sons Ltd (2008).

[9] S. Andrew Bull, "Strange Particle and Antiparticle Production in Proton-Beryllium Interactions at 40 GeV/c at the CERN NA57 Experiment" PhD Thesis, Particle Physics Group, School of Physics and Astronomy, University of Birmingham. (2005).

[10] W. Charles, J. Lucas, Foundations of Science, 13, 4 (2010) 1-15.

[11] T. Peitzmann, Journal of Physics: Conference Series 5, (2005) 115–126.

[12] W. Greiner, and J. Reinhardt "Field Quantization" Book,Springer – Verlag Berlin Heidelberg, (1996).

[13] P. Ruuskanen, Physics, NATO ASI Series, Series B: Vol. (1992), PP303.

[14] C. Gale and J. Kapusta, Nucl. Phys. B, 357, 65 (1991) 65-89.

[15] E. Braaten, R. Pisarski, T. Yuan, Phys. Rev. Lett., 64 (1990) 2242.

[16] B. Singh, Journal. of PACS, 75, 25 (2007) 81-87.

[17] He Z, Long, Ma Y, Ma G C. Phys. Lett. 22, 13 (2005) 1243-1245.

[18] R.Malin Renneby, C. Toft, E. Widén, Book, Chalmers University of Technology, (2012).

[19] F. Flechsig, A. Rebhan, Nucl. Phys. B 464, 279 (1996) PP19.

[20] F. Gelis, H. Niemi, P. Ruuskanen, S. Rasanen Journal of Physics. G, Nuclear and Particle Physics, 30, 8 (2004) S1031-S1036.

[21] H. Jabbar AL-Agealy, A. Aziz, M. Jassam Sahib J.Thi-Qar Sci., 4, 4 (2014) 66-70.