Theoretical treatment of electron – Positron pair with coulomb excitation in Ultrarelativistic heavy ion collisions.

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Abstract

Moving the gold ion in the accelerator beam and surrounded the flux of virtual photons. In addition to producing on electron-positron pair these photons are capable to exciting gold ions from the opposite beam. Production of electron – positron pair accompanied by an exchange of two photons between the gold ion, leading to mutual coulomb excitation of the ions. The interaction energy is proportional to Z_1Z_2, we thus expect the cross – section for coulomb excitation to become large in heavy ion reactions. Higher – order process are important in coulomb excitation with heavy-ion it is instructive to first study the explicit formula obtained in the frame of first order perturbation theory. Electron – positron production by two photons plus an exchange of two photons and lowest – order diagram for electron – positron production with coulomb break up.

Key words : Pair production ,Ultrarelativistic heavy ion collision, coulomb excitation, First order perturbation theory.

Introduction

In recent years, ultrarelativistic heavy ion collisions allow us to study of hottest and densest forms of matter. In the ultrarelativistic heavy-ion collision process when the particle collide with each other a new particle is produced is called Quark-Gluon plasma. The process of coulomb excitation is caused by the long-range electromagnetic interaction and takes place already at distance where the charge and mass distribution of the two heavy ion do not yet overlap. Columb excitation is very important process in all of heavy-ion physics. We therefore, review this topic and emphasize and difference to and advantages over usual coulomb excitation as well as the additional problems encountered in coulomb excitation with heavy ion. The excitation process is due to the time – dependence of the electromagnetic field produced at the target. A typical characteristic frequency of this field was the value $V\infty/a_c$, where $V\infty$ is the relative velocity at infinite distance and a_c the characteristic length of coulomb scattering. In order that a state with excitation energy $\Delta E = h\omega/2\pi$ be excited, we require the $W \leq \omega V\infty/a_c$. It is, therefore, useful to define the adiabatically parameter ξ by

$$\xi = \frac{\omega a_c}{V_\infty} = \eta \frac{\Delta E}{2E_{CM}}$$

For $E_{CM} = V_{CB}$, ξ has the value

$$\xi = 0.05\sqrt{A}\,\Delta E\left(\frac{R}{Z_1 \cdot Z_2}\right)^{3/2}$$

Where ΔE is in MeV and R in fm. The interaction energy is proportional to Z_1Z_2. We thus expect the cross – section for coulomb excitation to becomes large in heavy-ion reaction. In particular, first order perturbation theory may not be adequate to take account of this interaction and multiple excitation is the dominant process.

Although, higher – order process are important in coulomb excitation with heavy-ion, it is instructive to first study the explicit formulas obtain in the frame of first order perturbation theory. The cross – section for coulomb excitation is then the product of two factors, the Ruther ford cross – section and the probability P of excitation of nuclear state from the ground state. The gold ions moving in the accelerator beams are surrounded by the flux of virtual photons. In addition to producting an electron – positron pair these photons are capable of exciting gold ions from the opposite beam. Production of an electron – positron pair accompanied by an exchange of two photons between the gold ions, leading to the mutual coulomb excitation of the ions. The leading mode of the excitation is into the state of the Giant – Dipole Resonance (GDR). The collective excitation usually decays by a single neutron emission. The electron – Positron Pair production by two photons plus an exchange of two photons is the dominant lowest order diagram for electron positron pair production with coulomb breakup. The probability of the electron – positron production at a given impact parameter b in the lowest – order is independent of the probability of the excitation and breakup of the ions. This property is called factorization. The factorization holds, the total cross – section for the ultra – peripheral electron – positron with simultaneous nuclear breakup is :

$$\sigma_{e^+e^-\ \text{with mutual breakup}} = \int d^2\vec{b}\ P_{e^+e^-}(|\vec{b}|)\ P_{xnxn}(|\vec{b}|)\ P_{\text{no hadronic}}(|\vec{b}|)$$

Where ρ_{e+e-} is the probability for an e^+e^- pair production, $\rho_{nohadronic}$ is probability of no hadronic interaction happening between the nuclei, and ρ_{xnxn} is a probability of a simultaneous nuclear excitation with breakup. The probalility of having at least one coulomb excitation is then $\rho x_n\ (b) = 1 - \exp\ (-\rho^1_{xn}\ (b))$. In the reaction involving the dissociation of both ions, each individual breakup occurs independently. The probability is thus the square of the individual breakup probabilities, i.e.,

$$\rho x_n x_n\ (b) = (\rho_{xn}\ (b))^2$$

Show the probability of mutual coulomb nuclear excitation with breakup computed for 120 values of b between 5 fm and 60fm for gold ions at $\sqrt{S_{NN}}$ = 200 GeV. For

The excitation and breakup of gold ions to be likely, the impact parameter must be small (b<30fm).

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