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Interpretation of the "Catastrophe" of Quasars on the Basis of New Decisions of the Problem of the Reverse Compton-Effect

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Abstract: In a model based on a search with increased accuracy of calculations-four times-of all the roots of the equations for the velocities of electrons in the inverse Compton effect, it is established that for new values of the roots of the equations (corresponding to the laws of conservation of momentum and energy), the recoil electrons remain ultra-relativistic, according to the authors, allows to eliminate the reverse Compton catastrophe of quasars. The maximum value of the scattering angle of the formed particles was found to explain the thin quasar jets.

Keywords: Quasar 3C273, critical temperature, inverse Compton effect, ultra relativistic electrons, limiting angle of expansion.

1. Introduction

Observations established the temperature $T_H = 4 \cdot 10^{13}$K of the quasar 3C273 [1], which is an order of magnitude higher than the theoretically possible value of the effective quasar temperature ($T_m = 5 \cdot 10^{11}$K).

The existence of a critical value of the temperature Tm is associated with the inverse Compton catastrophe: if the electron energy exceeds a certain limit, then they begin to transmit avalanche energy to the photons and cool down. In this case, jets (plasma) from high-energy particles near quasars should not be observed. But the quasar 3C273 violates this restriction [2]. Let us show that the recoil electrons can also be ultra-relativistic, whose velocity V_2 differs little from the speed of light (c = 299792458 m / s), and the new photons correspond to the temperature T_n.

2. Fundamental Equations

Let us assume that as a result of a "head-on" collision of a relativistic electron of mass m having a velocity V_1 and a relic photon characterized by a wavelength λ_1 = 1.9 mm and a frequency $\nu_1 = c / \lambda_1$, a recoil electron moving at a velocity of V_2 and a photon λ_2, frequency ν_2), corresponding to the emission of an absolutely black body with a temperature Tn. We denote the angle between the momenta of the "new" photon and the recoil electron by θ. Let us find the electron velocities V_1 and V_2 [3], [4], [5].

Based on the law of conservation of energy, we have

$$\frac{mc^2}{\sqrt{1-\frac{V_1^2}{c^2}}} + h\nu_1 = \frac{mc^2}{\sqrt{1-\frac{V_2^2}{c^2}}} + h\nu_2. \tag{1}$$

The law of conservation of momentum gives

$$\left(\frac{mV_1}{\sqrt{1-\frac{V_1^2}{c^2}}} - \frac{h\nu_1}{c}\right)^2 =$$

$$\frac{m^2V_2^2}{1-\frac{V_2^2}{c^2}} + \left(\frac{h\nu_2}{c}\right)^2 + 2\frac{mV_2}{\sqrt{1-\frac{V_2^2}{c^2}}}\frac{h\nu_2}{c}\cos\theta. \tag{2}$$

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Here h is the Planck constant. To change from the temperature of the T_H to the corresponding wavelength λ (and the frequency ν), we use the Wien law (for a Wien constant, b = 0.002897 m·K).

3. Results

The particular solutions of equations (1) and (2), using computer algebra ("MAPLE-15") and 48 significant digits, are as follows:

a) at θ = 0

V_1=0.99999999999992475405562886·c,

V_2=0.99999999999992275921124240·c.

$V_2 < V_1$,

V_1-V_2=1.9948·10^{-15} ·c;

$E_1 = 1.317668819275908 \cdot 10^{12}$ *eV*,

$E_2 = 1.300542256694272 \cdot 10^{12}$ *eV*;

б) at θ_{lim} = 2.237 · 10^{-5} degrees, or θ_{lim} = 0.0805 arc seconds

V_1 = 2.99792457999999964377706025196216527768703734293·10^8,

V_2 = 2.99792457999999964340879441659068452391039838245·10^8;

V_1=-2.99792458000022819673975171598991048332087006383·10^8 +5.96886604476345024967485772944946603117680631289·10^{-7}√-l,

V_2 = 2.99792458000022831382063246771612172685011886091·10^8 -1.13781326046821380929006019498701174815260843721·10^{-20}√-1.

V_1=-2.99792458000022819673975171598991048332087006383·10^8 -5.96886604476345024967485772944946603117680631289-10^{-7}√-1,

V_2=2.99792458000022831382063246771612172685011886091·10^8 +1.13781326046821380929006019498701174815260843721·10^{-20}√-1.

V_1 and V_2 are measured in meters per second.

The actual values of the velocities are expressed in units of c, then

V_1 = 0.99999999999999999957472132 · c,

V_2 = 0.99999999999999999957445837 · c.

V_2 <V_1,

V_1-V_2 = 2.6295 · 10^{-20} · c.

E_1 = 5.542567825934786 · 10^{13} eV,

E_2 = 5.540855169676622 · 10^{13} eV.

Here θ_{lim} is the limiting (maximum) particle scattering angle (photon and recoil electron) at which the initial and final electron velocities have real, positive and ultra-relativistic values. E_1 and E_2 are the electron energies before the interaction with the photon and after the expansion of the photon and the electron.

c) θ = 0.0806 arc second

The actual values of the velocities V_1 and V_2 are absent. In this case, for both V_1 and V_2 only paired complex-conjugate roots are found.

V_1=2.99792458000000030938708750474602663511119538071· 10^8 -1.12051385274902127727133210325146185166171210903 ·10^{-8} √-1,

V_2=2.99792458000000030954957273803688345298006624625·10^8 -1.11767916061576548411134132899152874946001393449 ·10^{-8} √-1;

V_1 =-2.99792458000022876374861023805333065318487276139· 10^8 +5.99113281763605213037461727680526739816412649848· 10^{-7} √-1,

V_2=2 99792458000022888141226093718703623187034211919·10^8 -1.14205834259391486928760806009053218829304632326·10^{-20}√-1;

V_1=-2.99792458000022876374861023805333065318487276139·10^8 -5.99113281763605213037461727680526739816412649848-10^{-7}√-1,

V_2=2.99792458000022888141226093718703623187034211919·10^8 +1.142058342593914869287608060090532188293046 32326-10^{-20} $\sqrt{-1}$;

V_1=2.9979245800000003093870875047460266351111 9538071· 10^8 +1.12051385274902127727133210325146185166171 210903·$10^{-8}\sqrt{-1}$,

V_2=2.99792458000000030954957273803688345298006624625·10^8 +1.11767916061576548411134132899152874946001 393449$^{-8}\sqrt{-1}$.

V_1 and V_2 are measured in meters per second.

In Fig. 1 and Fig. 2, taking into account Eqs. (1) and (2), graphs of the functions of the scattering angle θ of the photon and the recoil electron from the initial velocity of the electron V_1 (Fig. 1) and the scattering angle θ of the photon and the "recoil" electron from the velocity of the "recoil" electron V_2 (Fig. 2). Let's pay attention to small values of admissible angles of expansion of photons and electrons (0.08 ") and values of speeds V_1 and V_2 differing little from speed of light c.

4. Conclusions

Thus, in this model, the recoil electrons remain relativistic (ultra-relativistic - $V_1 \approx V_2 \approx c$). It is possible that the above arguments will solve the problem of the inverse Compton catastrophe in the case of quasars (since the approximate equality $V_1 \approx V_2 \approx c$ has been proved), and also to clarify the physical nature of the thin jets existing near quasars (the angle θ is small, $\theta \approx 0.0805$ ").

Note. When $\theta = 0$, Eq. (2) reduces to a linear equation with respect to the particle momenta, taking this circumstance into account, the general letter solution of Eqs. (1) and (2), found using computer algebra (MAPLE-15), looks like:

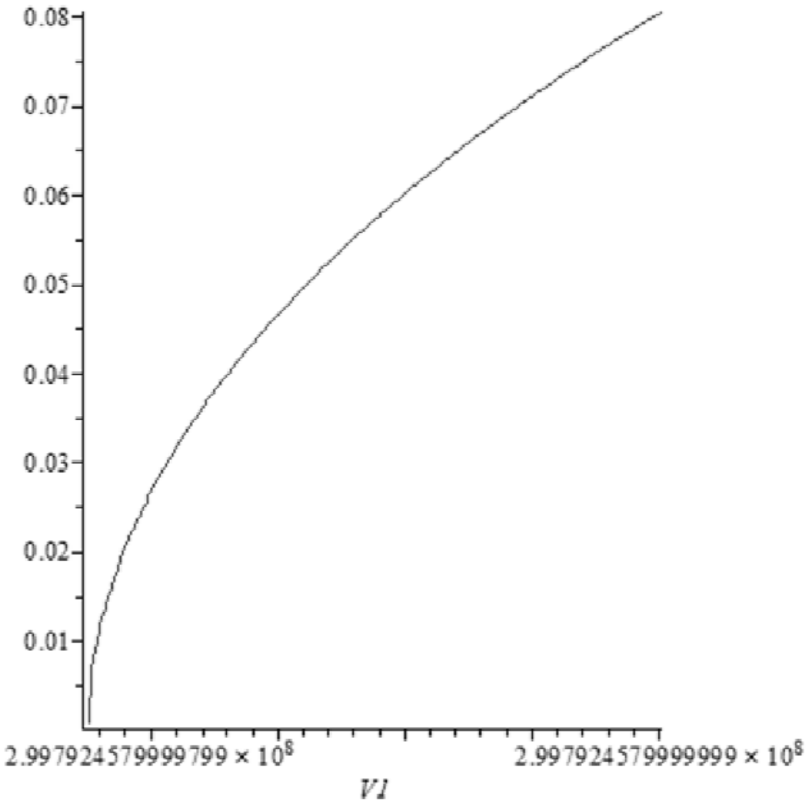

Fig. 1 Dependence of the angle θ of the photon and the "recoil" electron on the initial velocity of the electron (V_1). The speed of an electron is measured in meters per second. The angle of dispersion θ is measured in angular seconds.

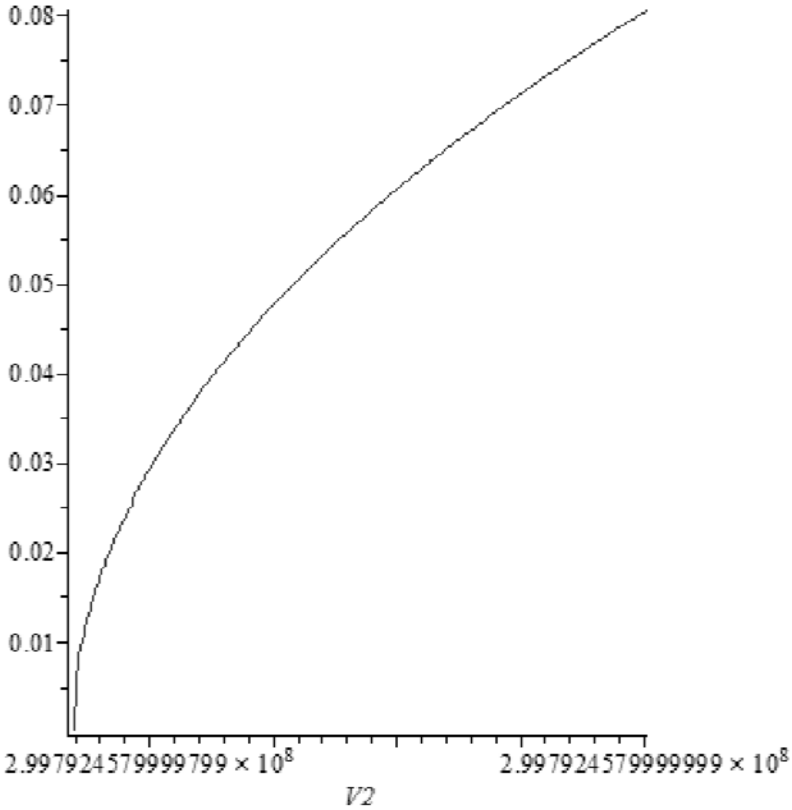

Fig. 2 Dependence of the angle θ of the photon and the "recoil" electron on the velocity of the recoil electron (V_2). The speed of an electron is measured in meters per second. The angle of dispersion θ is measured in angular seconds.

$$V2 = -\frac{1}{\nu 1+\nu 2}\left(c\left(\left(4\nu_1 h\nu_2\left(-h\nu_1^2\nu_2 + \nu_1 h\nu_2^2 + \left(h_2\nu_1^4\nu_2^2 + 2h^2\nu_1^3\nu_2^3 + h^2\nu_1^2\nu_2^4 + 2c^4m^2\nu_1^2\nu_2^2 + c^4m^2\nu_1^3\nu_2 + c^4m^2\nu_1\nu_2^3\right)^{1/2}\right)\right) / \left(2c^4m^2\nu_1\nu_2 + 4h^2\nu_1^2\nu_2^2 + m^2c^4\nu_1^2 + m^2c^4\nu_2^2\right) - \nu_2 + \nu_1\right)\right),$$

$$V2 = -\frac{1}{\nu 1+\nu 2}\left(c\left(-\left(4\nu_1 h\nu_2\left(-h\nu_1^2\nu_2 + \nu_1 h\nu_2^2 + \left(h_2\nu_1^4\nu_2^2 + 2h^2\nu_1^3\nu_2^3 + h^2\nu_1^2\nu_2^4 + 2c^4m^2\nu_1^2\nu_2^2 + c^4m^2\nu_1^3\nu_2 + c^4m^2\nu_1\nu_2^3\right)^{1/2}\right)\right) / \left(2c^4m^2\nu_1\nu_2 + 4h^2\nu_1^2\nu_2^2 + m^2c^4\nu_1^2 + m^2c^4\nu_2^2\right) - \nu_2 + \nu_1\right)\right),$$

$$V1 = c\left(1-\left(mc^2/\left(-h\nu_1 + mc^2/(1-V_2^2/c^2)^{1/2} + h\nu^2\right)\right)^2\right)^{1/2}.$$

Obviously, V_2 has a real value at $\theta = 0$ [3-5].

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