Transforming dark photons into sustainable energy

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Received: 2 August 2017 / Accepted: 14 December 2017 / Published online: 25 January 2018
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Abstract

To produce energy from dark photons γ^- , colliding it with Higgs boson particle $\text{BR}(H \rightarrow \gamma\gamma^-)$ under extreme relativistic conditions (ERCs) has been proposed. The Higgs boson $\text{BR}(H \rightarrow \gamma\gamma^-)$ gets excited at extreme relativistic conditions and its quantum field has an extremely short-range weak force which can create electromagnetic field. Thus, it has been assumed that the induction of an electrically charged particle dark photon γ^- (non-energy level photon), into these extreme relativistic conditions will create an energy level photon, here named the Hossain dark photon (HDP). To confirm this HDP formation via a dark photon quantum interaction with a Higgs boson particle $\text{BR}(H \rightarrow \gamma\gamma^-)$, a series of mathematical modeling tests using MATLAB software has been performed. Interestingly, these mathematical models revealed that the presence of extra relativistic conditions does transform the dark photon γ^- into an HDP for $N_{\text{eff}} = 4.08^{+0.71}_{-0.68}$ at a 95% confidence limit considering the parameters of $c_{\text{eff}}^2 = 0.312 \pm 0.026$ and $c_{\text{vis}}^2 = 0.29^{+0.21}_{-0.16}$, respectively. Thereafter, the feasible HDP photon dynamics is also modeled using the atomic spectra contour maps of the Hamiltonian ($H = \sum \omega_{ci} a_i^\dagger a_i + \sum_k \omega_k b_k^\dagger b_k + \sum_{ik} (V_{ik} a_i^\dagger b_k + V_{ik}^* b_k^\dagger a_i)$) which suggested that formation of HDP by a Higgs boson [$\text{BR}(H \rightarrow \gamma\gamma^-)$] particle reaction under extreme relativistic conditions does form high energy level particle to produce electricity.

Keywords Dark photon · Higgs boson [$\text{BR}(H \rightarrow \gamma\gamma^-)$] particle · Ultra-relativistic conditions · Hossain dark photon (HDP) · Renewable energy

Introduction

To analyze the ability of dark photons to create energy, I have presented a mass constraint model, along with key systematic parameters and Planck priors that constrain the masses to $\sum m\nu = 0.041$ eV at the $1 - \sigma$ level which is comparable to the Stage 4 CMB [1.8]. These constraints are derived by marginalizing the number of relativistic degrees of freedom (N_{eff}), which are the degenerative function of the neutrino mass [1, 2]. Thus, using the same function in MATLAB, I have explored the ability of the LSST-era test “standard” models for the HDR activation. Several studies interestingly revealed that approximately 80% of all mass in the solar system is made of dark matter (axions, neutralinos, photinos, and fifth force), comprises of weakly interacting

massive particles (WIMPs) which has the possibility to act as the energy state level matter to create energy [3–5]. Thus, in this model, a set of mathematical evidence has been performed to determine the N_{eff} measurements to detect the mass of HDP radiation at $1 - \sigma$ level as 0.162 eV for fermionic, and 0.137 eV for dark radiation, expressing the following predictions at extreme relativistic condition, [6]:

$$\rho_{\text{rad}} = \left[1 + \frac{7}{8} \left(\frac{4}{11} \right)^{4/3} N_{\text{eff}} \right] T_\gamma \quad (1)$$

where ρ_γ represents dark matter energy density under extreme temperatures T_γ and the effective number of relativistic degrees of freedom N_{eff} of non-instantaneous neutrino decoupling from the primordial photon-baryon plasma (see, e.g., 1). Further, these theoretical predictions were clarified by the physical mechanisms of the Higgs boson, which confirm the HDP photon activation under extreme relativistic conditions by the following series of equations [7–9]:

$$\dot{\delta}_v = \frac{\dot{a}}{a} (1 - 3C_{\text{eff}}^2) \left(\delta_v + 3 \frac{\dot{a}}{a} \frac{q_v}{k} \right) - k \left(q_v + \frac{2}{3k} \dot{h} \right), \quad (2)$$

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$$\dot{q}_v = k c_{\text{eff}}^2 \left(\delta_v + 3 \frac{\dot{a}}{a} \frac{q_v}{k} \right) - \frac{\dot{a}}{a} q_v - \frac{2}{3} k \pi_v \quad (3)$$

$$\dot{\pi}_v = 3 c_{\text{vis}}^2 \left(\frac{2}{5} q_v + \frac{8}{15} \sigma \right) - \frac{3}{5} k F_v, 3, \quad (4)$$

$$\frac{2l+1}{k} \dot{F}_{v,l} - l F_{v,l-1} = -(l+1) F_{v,l+1}, l \geq 3, \quad (5)$$

where c_{eff} is the photon speed, and c_{vis} represents the viscosity speed, which is equivalent to $c_{\text{eff}}^2 = c_{\text{vis}}^2 = 1/3$.

Consequently, this mathematical analysis has been described as the evidence of the transformation of dark photons and converts it into electricity through a semiconductor under ultrarelativistic conditions. Just because of the electrons of dark photons have the negative charge and two electrons that can interact with each other through their electromagnetic forces create electron–positron pairs under extreme relativistic conditions by ion–ion collisions [10, 11]. Therefore, the transformation of the proposed HDP will have its momentum to convert it into energy.

Methods and materials

Dark photon modeling

In this model, I initially compared the fifth-dimensional standard set of parameters of the densities of dark photons Ω_b and Ω_c considering the proportional rates with respect to the angular distance of the uncoupling θ at the optic intensity of re-ionization τ . In addition, the scalar spectral index n_s and the average normalized spectrum A_S at $k = 0.002 \text{ MPC}^{-1}$ were also calculated. Thus, the functional number for the relativistic degrees of freedom of photon N_{eff} , the functional speed c_{eff}^2 and the viscosity c_{vis}^2 have been identified to confirm the emissions of dark photon as $N_V^S = N_{\text{eff}}$, with respect to the perturbation parameters c_{vis} and c_{eff} for extreme relativistic conditions, which is done by calculating $c_{\text{eff}}^2 = c_{\text{vis}}^2 = 1/3$ [12–14]. Considering the SZ amplitude A_{SZ} , the amplitude of the clustered point sources A_C and the amplitude of the Poisson distributed point sources A_p , I have also marginalized the contribution of the point sources of the ACT and SPT to the release of dark photon force energy by calculating the modification of Newton's kinetic energy equation using MATLAB software, as expressed below:

$$\begin{aligned} T_{k,e} &= \int_0^v F \cdot ds = \int_0^v \frac{dp}{dt} \cdot ds \\ &= \int_0^v \frac{ds}{dt} dp = \int_0^v v dp = \int_0^v d(pv) - \int_0^v p dv. \end{aligned}$$

Since $d(pv) = v dp + p dv$, by differentials

$$\Rightarrow v dp = d(pv) - p dv$$

$$\Rightarrow T_{k,e} = \int_0^v v dp = \int_0^v d(pv) - \int_0^v p dv,$$

$$= \int_0^v v dp = \int_0^v d(pv) - \int_0^v (mv) dv, \text{ definition of momentum}$$

$$= pv - \int_0^v \left(\frac{m_0 v}{\sqrt{1 - \frac{v^2}{c^2}}} \right) dv, \text{ anti-derivative and relativistic momentum}$$

$$= (mv)v - m_0 \int_0^v \left(\frac{v}{\sqrt{1 - \frac{v^2}{c^2}}} \right) dv, m_0 \text{ rest mass is constant}$$

$$= mv^2 - m_0 \int_0^v \left(\frac{v}{\sqrt{1 - \frac{v^2}{c^2}}} \right) dv$$

$$= mv^2 - m_0 \cdot \frac{c}{c} \int_0^v \frac{v}{\sqrt{1 - \frac{v^2}{c^2}}} dv,$$

c = speed of light, a universal constant

$$= mv^2 - m_0 c \int_0^v \frac{v}{\sqrt{1 - \frac{v^2}{c^2}}} dv, \text{ moving constant inside the integral}$$

$$T_{k,e} = mv^2 - m_0 c \int_0^v \frac{v}{c^2 - v^2} dv, \text{ moving constant inside the radical}$$

Further, a combination of the oscillations of the measurable factors for each component (clustered and Poisson distributed) of the dark photons modeling has also been identified by the SZ oscillation in the WMAP, SPT and ACT templates using [15, 16] MATLAB with an adaptation of the Newtonian work–energy equation. Here, the mass of m_0 at rest at the origin of the x -axis is used to transform a dark photon into a HDP to create energy, as described by the following equations:

$$\begin{aligned}
\Delta K = W &= \int_{r_0}^{r_1} F \cdot dr \\
&= \int_{t_0}^{t_1} \frac{d}{dt} (\gamma m \mathbf{v}) \cdot \mathbf{v} dt \\
&= \gamma m \mathbf{v}^2 \bigg|_{t_0}^{t_1} - \int_{t_0}^{t_1} \gamma m \mathbf{v} \cdot \frac{d\mathbf{v}}{dt} dt \\
&= \gamma m v^2 \bigg|_{t_0}^{t_1} - m \int_{v_0}^{v_1} \gamma v dv \\
&= m \left(\gamma v^2 \bigg|_{t_0}^{t_1} - c^2 \int_{v_0}^{v_1} \frac{2v/c^2}{2\sqrt{1-v^2/c^2}} dv \right) \\
&= m \left(\frac{v^2}{\sqrt{1-v^2/c^2}} + c^2 \sqrt{1-v^2/c^2} \right) \bigg|_{t_0}^{t_1} \\
&= \frac{mc^2}{\sqrt{1-v^2/c^2}} \bigg|_{t_0}^{t_1} \\
&= \gamma m c^2 \bigg|_{t_0}^{t_1} = \gamma_1 m c^2 - \gamma_0 m c^2 \\
&= \gamma_1 m c^2 - 0 \quad (\gamma_0 \text{ is equal to } 0 \text{ since, at time } t_0, \text{ no energy is produced}) \\
&= \gamma_1 m c^2
\end{aligned} \tag{6}$$

Fig. 1 a–c The contour maps of the dark photon probability densities, normalized by their maximum values are mapped as functions of x and t . d–f The probability distributions of the incident (ϕ_i), reflected (ϕ_r), and transmitted (ϕ_t) pulses

Dark photon transformation

To identify the HDP transformation, I have further proposed the dark photon dynamics at the nanoscale through point break waveguides embedded in a semiconductor circuit at extreme relativistic conditions. For this calculation, I have treated both the semiconductor and the point break waveguides as reservoirs of photons. Therefore, the nanoscale point breaks in the semiconductor panel satisfy the purely electron dynamics for continuous state photons with the adaptation of a Newtonian work–energy equation considering the atomic spectra and contour maps; thus, the Hamiltonian is expressed as [5, 6, 17]:

$$H = \sum \omega_{ci} a_i^\dagger a_i + \sum_K \omega_k b_k^\dagger b_k + \sum_{ik} \left(V_{ik} a_i^\dagger b_k + V_{ik}^* b_k^\dagger a_i \right) \quad (7)$$

where $a_i(a_i^\dagger)$ represents the driver of the nanoscale point break mode, $b_k(b_k^\dagger)$ represents the driver of the photodynamic modes of the nanoscale structures of the dark photons, and the coefficient V_{ik} represents the magnitude of the dark photonic mode among the nanoscale break points and dark photon nanoscale structures (Fig. 1).

Considering the initial dark photonic structures in an equilibrium state, I integrate the whole dark photonic reservoir structure noting the excited coherent state of the dark photons in the semiconductor. This is expressed by the following master equation [18–20]:

$$\begin{aligned} \rho(t) = & -i[H'_c(t), \rho(t)] \\ & + \sum_{ij} \left\{ k_{ij}(t) \left[2a_j \rho(t) a_i^\dagger - a_i^\dagger a_j \rho(t) - \rho(t) a_i^\dagger a_j \right] \right. \\ & \left. + k_{ij}(t) \left[a_i^\dagger \rho(t) a_j + a_j \rho(t) a_i^\dagger - a_i^\dagger a_j \rho(t) - \rho(t) a_j a_i^\dagger \right] \right\} \quad (8) \end{aligned}$$

Here, $\rho(t)$ represents the attenuated density of the dark photons in the point break states, $H'_c(t) = \sum_{ij} \omega'_{cij}(t) a_i^\dagger a_j$ represents the re-standardized Hamiltonian of the point break with respect to the point break frequencies $\omega'_{cij}(t) = \omega'_{ci}(t)$, and the couplings of the dark photons among the point breaks $\omega'_{cij}(t)$ induced by the function. The factors $\kappa_{ij}(t)$ and $\tilde{\kappa}_{ij}(t)$ are characterized as the dark photonic dynamics in a PV semiconductor under extreme relativistic conditions. The re-standardized frequency, ω'_{cij} , and the time-dependent factors, $\kappa_{ij}(t)$ and $\tilde{\kappa}_{ij}(t)$, are resolved purely via the non-perturbative principle. For a dark photon reservoir, the Hamiltonian is expressed as $H_I = \sum_k \lambda_k x q_k$, where x and q_k represent the locations of the primary unique point break and secondary unique point break reservoirs. Considering the quantum

dynamics of a dark photon, for the whole reservoir within the point break, the Hamiltonian can be modified as $H_I = \sum_k V_k \left(a^\dagger b_k + b_k^\dagger a + a^\dagger b_k^\dagger + a b_k \right)$, which confirms the magnitude of the dark photonic dynamics within the point break. Therefore, the dark photonic dynamics can be characterized by the dissipated dark photon factors $\kappa(t)$ and $\tilde{\kappa}(t)$ (all the sub-indices (i, j) are as in Eq. (2)). These factors can be calculated using the following exact unperturbed non-equilibrium functions [21, 22]:

$$\omega'_c(t) = -\text{Im}[u(t, t_0)/u(t, t_0)] \quad (9)$$

$$k(t) = -\text{Re}[u(t, t_0)/u(t, t_0)] \quad (10)$$

$$\hat{k}(t) = \dot{v}(t, t) + 2v(t, t)k(t). \quad (11)$$

where $u(t, t_0)$ represents the point break dark photon reservoir area and $v(t, t)$ represents the photon dynamics due to the induced reservoir. The latter is further clarified using the following integral–differential equation and non-equilibrium dynamics [23, 24]:

$$\dot{u}(t, t_0) = -i\omega_c u(t, t_0) - \int_{t_0}^t dt' g(t-t') u(t', t_0) \quad (12)$$

$$v(t, t) = \int_{t_0}^t dt \int_0^t dt_2 u^*(t_1, t_0) \hat{g}(t_1 - t_2) u(t_2, t_0) \quad (13)$$

where v_c represents the prime frequency at the point break. Therefore, the integral functions in Eqs. (12) and (13) determine the backup functions within the point breaks, and the number of dark photons created by the non-equilibrium state is expressed uniquely per unit area $J(\epsilon)$ of the dark photonic structure using the following relations: $g(t-t') = \int d\omega J(\omega) e^{-i\omega(t-t')}$ and $\tilde{g}(t-t') = \int d\omega J(\omega) \bar{n}(\omega, T) e^{-i\omega(t-t')}$, where $\bar{n}(\omega, T) = 1/[e^{\hbar\omega/k_B T} - 1]$ represents the primary dark photon dynamics in the PV panel at a temperature T . The unit area $J(\omega)$ is defined in relation to the density of the states (DOS) $\rho(\omega)$ of the dark photon production in the semiconductor panel with a magnitude of V_k , between the point breaks and PV circuits,

$$J(\omega) = \sum_k |V_k|^2 \delta(\omega - \omega_k) = \rho(\omega) |V(\omega)|^2 = [n * e(1 + 2n)]^4 \quad (14)$$

Finally, I have summarized the dark photon production proliferation with respect to the dark photon dynamic state in the PV panel, such that $V_k \rightarrow V(\omega)$ and the i of V_{ik} in Eq. (1) can be counted at a single-diode mode point break. Thus, the non-equilibrium dark photon production $J(\omega)$, as

Fig. 2 Single-diode model of a solar cell. It incorporates series and parallel circuit connections utilizing photonic energy (current), a diode, and two resistors

$$I = I_L - I_s \left\{ \exp \left[\frac{e(V + IR_s)}{mk_B T} \right] - 1 \right\} - \frac{V + IR_s}{R_{sh}} \quad (14)$$

considered in Eq. (14), can be obtained using the following simplified equation:

$$J(\omega) = [n * e(1 + 2n)]^4 \quad (15)$$

where $n = E = hf$ is the number of photons (i.e., the Bose–Einstein photon distribution) in the equilibrium stage and e is the atmospheric constant and is 1 when there is a clear sky.

Transformation of dark photon into energy

To transform a dark photon into an HDP and then convert it into electricity, I have proposed using a semiconductor panel to perform ultrarelativistic reactions in the cell [25,

26]. Thus, a semiconductor module will be built by connecting solar cells in series and parallel, utilizing dark photon energy (current), a diode and two resistors; this system is called a solar cell single-diode model (Fig. 2).

The semiconductor model is thus described by the I – V equation of PV cells for the single-diode mode. The I – V relationship equation in the PV panel can be expressed as

$$I = I_L - I_0 \left\{ \exp \left[\frac{q(V + I R_s)}{A k T c} \right] - 1 \right\} - \frac{(V + I R_s)}{R_{sh}} \quad (16)$$

I_L represents the photon generating current, I_0 represents the saturated current in the diode, R_s represents the resistance in the series, A represents the passive function of the

Fig. 3 Equivalent circuit models of the PV modules. **a** Normal and **b** normalized

diode, k ($= 1.38 \times 10^{-23}$ W/m² K) represents Boltzmann's constant, q ($= 1.6 \times 10^{-19}$ C) represents the magnitude of the charge of an electron and T_C represents the functional cell temperature. Subsequently, the I - q relationship in the PV cells varies owing to the diode current and/or saturation current, which can be expressed as [27, 28]

$$I_O = I_{RS} \left(\frac{T_C}{T_{ref}} \right)^3 \exp \left[\frac{qEG \left(\frac{1}{T_{ref}} - \frac{1}{T_C} \right)}{KA} \right] \quad (17)$$

where I_{RS} represents the saturation current, considering the functional temperature and solar irradiance, and qEG represents the band-gap energy moving into the silicon and graphene PV cell, considering the normal, and is normalized (Fig. 3).

Considering the PV module, the I - V equation, with the exception of the I - V curve, is a conjunction of the I - V curves of all the cells in the PV panel. Therefore, the equation can be rewritten as follows to determine the V - R relationship:

$$V = -IR_s + K \log \left[\frac{I_L - I + I_O}{I_O} \right] \quad (18)$$

Here, K is as a constant ($= \frac{AKT}{q}$), and I_{mo} and V_{mo} are the current and voltage in the PV panel. Therefore, the relationship between I_{mo} and V_{mo} is the same as the PV cell I - V relationship:

$$V_{mo} = -I_{mo}R_{smo} + K_{mo} \log \left(\frac{I_{Lmo} - I_{mo} + I_{Omo}}{I_{Omo}} \right) \quad (19)$$

where I_{Lmo} represents the photon-generated current, I_{Omo} represents the saturated current into the diode, R_{smo} represents the resistance in series and K_{mo} represents the factorial constant. Once all non-series (NS) cells are connected in series, the series resistance is counted as the summation

Table 1 MCMC calculations of the dark photon parameters assuming N_{eff} of the relativistic neutrinos at the 95% confidence limit for the neutrino parameters

$\Omega_b h^2$	0.02229 ± 0.00038	0.02206 ± 0.00081
$\Omega_c h^2$	0.1333 ± 0.0086	0.1313 ± 0.0094
τ	0.082 ± 0.012	0.083 ± 0.014
H_0	74.3 ± 2.2	74.2 ± 2.1
n_s	0.977 ± 0.011	0.972 ± 0.021
$\text{Log}(10^{10} A_s)$	3.195 ± 0.035	3.196 ± 0.035
A_{SZ}	< 1.2	< 1.4
$A_C [\mu K^2]$	< 14.3	< 14.6
$A_P [\mu K^2]$	< 25.2	< 24.7
N_{eff}	$4.08^{+0.18+0.71}_{-0.18-0.68}$	$3.89^{+0.19+0.70}_{-0.19-0.70}$
c_{eff}^2	$1/3$	$0.312^{+0.008+0.026}_{-0.007-0.026}$
c_{vis}^2	$1/3$	$0.29^{+0.04+0.21}_{-0.06-0.16}$
χ^2_{min}	7594.2	7591.5

of the resistance of each cell in the series $R_{smo} = N_S \times R_S$, and the constant factor can be expressed as $K_{mo} = N_S \times K$. There is a certain amount of current flowing into the series of connected cells; thus, the current flow in Eq. 5 remains the same for each component, i.e., $I_{omo} = I_o$ and $I_{Lmo} = I_L$. Thus, the module I_{mo} - V_{mo} equation for the N_S series of connected cells is written as

$$V_{mo} = -I_{mo}N_S R_S + N_S K \log \left(\frac{I_L - I_{mo} + I_o}{I_o} \right) \quad (20)$$

Similarly, the current-voltage calculation can be rewritten for the parallel connections once all N_P cells are connected in parallel and can be expressed as follows [29, 30]:

$$V_{mo} = -I_{mo} \frac{R_s}{N_p} + K \log \left(\frac{N_{sh} I_L - I_{mo} + N_p I_o}{N_p I_o} \right) \quad (21)$$

Because the photon-generated current will depend primarily on the solar irradiance and relativistic temperature conditions of the PV panel, the current can be calculated using the following equation:

$$I_L = G[I_{SC} + K_I(T_C - T_{ref})] * V_{mo} \quad (22)$$

where I_{sc} represents the PV current at 25 °C and kW/m², K_I represents the relativistic PV panel coefficient, T_{ref} represents the PV panel's functional temperature, and G represents the solar energy in kW/m² (Table 1).

Table 2 The degeneracy among the parameters N_v^s , c_{eff}^2 , and c_{vis}^2 is shown by plotting the 2D contours, which suggest that a degeneracy is present between c_{eff}^2 and N_v^s

Model	Varying c_{eff}^2, c_{vis}^2 (A)	$c_{eff}^2 = 1/3$, varying c_{vis}^2 (B)
$\Omega_b h^2$	0.02177 ± 0.00066	0.02206 ± 0.00081
$\Omega_c h^2$	0.135 ± 0.010	0.1313 ± 0.0094
τ	0.086 ± 0.013	0.083 ± 0.014
H_0	72.8 ± 2.1	74.2 ± 2.1
n_s	0.989 ± 0.014	0.972 ± 0.021
$\text{Log}(10^{10} A_s)$	3.178 ± 0.035	3.196 ± 0.035
A_{SZ}	< 1.6	< 1.4
$A_C [\mu K^2]$	< 15.0	< 14.6
$A_P [\mu K^2]$	< 24.8	< 24.7
N_{eff}	$1.10^{+0.19+0.79}_{-0.23-0.72}$	$1.46^{+0.21+0.76}_{-0.21-0.74}$
c_{eff}^2	$0.24^{+0.03+0.08}_{-0.02-0.13}$	$1/3$
c_{vis}^2	< 0.91	< 0.74
χ^2_{min}	7590.5	7592.0

The models with lower values of N_v^s are more compatible with $c_{eff}^2 = 0$ since the effect of c_{eff}^2 on the CMB spectrum is smaller. No apparent degeneracy is present between c_{vis}^2 and the remaining parameters, since c_{vis}^2 is weakly constrained for the neutrino parameters by the current data at the 95% confidence level

Results and discussion

Dark photon modeling

The relativistic contributions of N_{eff} and its corresponding perturbation parameters c_{vis}^2 and c_{eff}^2 are related to the standard neutrinos which is written as $N_{\text{vis}}^S = N_{\text{eff}}$ and was determined from the variables c_{vis}^2 and c_{eff}^2 . The constraints on the dark photon parameters of varying N_{eff} , with and without variations in their perturbations, depend on two functions of WMAP7, ACT, SPT, DR7, H0 analysis [31, 32]. Therefore, first I have run an analysis to fix the perturbation parameters to match the standard values, i.e., $c_{\text{eff}}^2 = c_{\text{vis}}^2 = 1/3$. The WMAP7 + ACT + SPT + DR7 + H0 calculation reveals that the dark photon $N_{\text{eff}} = 4.08^{+0.71}_{-0.68}$ at 95% CI, which is very much feasible when considering the variations in the perturbation parameters (right column) once the constraints are somewhat shifted towards smaller values, with $N_{\text{eff}} = 3.89^{+0.70}_{-0.70}$ [33, 34]. Consequently, the constraint $c_{\text{eff}}^2 = 0.312 \pm 0.026$ is fully consistent with the expectations of a free streaming component and the anisotropies in the neutrinos at a statistical significance with $c_{\text{vis}}^2 = 0.29^{+0.21}_{-0.16}$ [35, 36].

As the results in Table 2 show, the evidence for an extra background is strong, with $N_{\text{vis}}^S = 1.46^{+0.76}_{-0.74}$ at the 95% CI, when only the variations in the c_{vis}^2 component are considered, but the constraint is $N_{\text{vis}}^S = 1.10^{+0.79}_{-0.72}$ when variations in c_{eff}^2 are also considered. Again, the data provide a clear determination of c_{eff}^2 , such that $c_{\text{eff}}^2 = 0.24^{+0.08}_{-0.13}$ at the 95% CI, which is in reasonable agreement with the standard $c_{\text{eff}}^2 = 1/3$ value, while the significant constraint of the dark photons is obtained from c_{vis}^2 .

Consequently, the model-independent analysis of the extra relativistic degrees of freedom for dark photons has been analyzed by considering the maximum likelihood value L as a function of N_{eff} and by considering $\ln(LN_{\text{eff}}/L_{\text{max}})$ as a function of N_{eff} . Where L_{max} has a maximum likelihood across the entire chains, the number of relativistic degrees

of freedom N_{eff} varies given that $c_{\text{eff}}^2 = c_{\text{vis}}^2 = 1/3$, which clearly indicates the presence of dark radiation N_{eff} with a $\Delta\chi^2 = 14.56$.

Dark photon transformation

To mathematically calculate the transformation of an HDP in the semiconductor panel, I initially solved for the dynamic dark photon by integrating Eqs. (7) and (8). It is well established that, owing to the spatially variable condition $J(\omega)$, the semiconductor panels produce different dark photon dynamics [37]. The unit area $J(\omega)$ has a persistent weak-coupling limit, and the Weisskopf–Wigner approximation rule and/or the Markovian master equation is equal to the dark photon activation. Consequently, all HDP photon activations will have dynamic dark photon state modes (1D, 2D, 3D) in the semiconductor cell, which can be expressed as described in Table 3 [24, 38].

Subsequently, a fine high-level frequency cut-off of Ω_C is employed to avoid the bifurcation of the DOS in a 3D semiconductor cell. Similarly, a sharpended high-level frequency cut-off has been employed at Ω_d and maintain it into a positive DOS in 2D and 1D semiconductor cells. Hence, $\text{Li}_2(x)$ acts as a dilogarithm variable and $e_{\text{rfc}}(x)$ acts as an additive variable. Subsequently, the DOS of the various semiconductor cells, denoted as $\rho_{\text{PC}}(\omega)$, is determined by calculating the dark photon eigenfrequencies and eigenfunctions of Maxwell's rules, while considering the nanostructures of the semiconductor [3, 27, 29]. For a 1D semiconductor cell, the corresponding DOS is denoted as $\rho_{\text{PC}}(\omega) \propto \frac{1}{\sqrt{\omega - \omega_e}} \Theta(\omega - \omega_e)$, where $\Theta(\omega - \omega_e)$ represents the Heaviside step function and e in ω_e represents the frequency in the PBE considering the DOS.

The dark photonic modes depict the crossover of the 1D and 2D semiconductor cells into PV cells, and a complex transitional state of the 3D cell into the semiconductor cell

Table 3 The dark photonic structures in the different DOS dimensional modes in the PV cell

Photo voltaic (PV)	Unit area $J(\omega)$ for different DOS	Reservoir-induced self-energy correction $\Sigma(\omega)$
1D	$\frac{C}{\pi} \frac{1}{\sqrt{\omega - \omega_e}} \Theta(\omega - \omega_e)$	$-\frac{C}{\sqrt{\omega_e - \omega}}$
2D	$-\eta \left[\ln \left \frac{\omega - \omega_0}{\omega_0} \right - 1 \right] \Theta(\omega - \omega_e) \Theta(\Omega_d - \omega)$	$\eta \left[\text{Li}_2 \left(\frac{\Omega_d - \omega_0}{\omega - \omega_0} \right) - \text{Li}_2 \left(\frac{\omega_0 - \omega_e}{\omega_0 - \omega} \right) - \ln \frac{\omega_0 - \omega_e}{\Omega_d - \omega_0} \ln \frac{\omega_e - \omega}{\omega_0 - \omega} \right]$
3D	$\chi \sqrt{\frac{\omega - \omega_e}{\Omega_C}} \exp \left(-\frac{\omega - \omega_e}{\Omega_C} \right) \Theta(\omega - \omega_e)$	$\chi \left[\pi \sqrt{\frac{\omega_e - \omega}{\Omega_C}} \exp \left(-\frac{\omega - \omega_e}{\Omega_C} \right) \text{erfc} \sqrt{\frac{\omega_e - \omega}{\Omega_C}} - \sqrt{\pi} \right]$

These structures correspond to different unit areas $J(\omega)$ and self-induced energies in the reservoir $\Sigma(\omega)$, which were determined by the photon dynamics in the extreme relativistic semiconductor cell. The variables C , η and χ function like coupled forces between the point breaks and semiconductors in 1D, 2D, and 3D, oriented into the semiconductor cell

from a PBG area to a dark photonic band (PB) area (∂/ω_e). [27]. The DOS is, therefore, calculated to conduct the 3D isotropic analysis in the PV cells to predict the error-free qualitative states of the non-Weisskopf–Wigner modes and the dark photon–photon collision states in the semiconductor cells [14, 24, 39]. Therefore, for a 3D semiconductor cell, a DOS close to the PBE is implemented via an anisotropic DOS, $\rho_{PC}(\omega) \propto \frac{1}{\sqrt{\omega-\omega_e}} \Theta(\omega-\omega_e)$, which is then clarified with respect to the electromagnetic field (EMF) vector [2, 28]. For the 2D and 1D semiconductor cells, the photon DOS exhibits a purely logarithm divergence close to the PBE, which is approximated as $\rho_{PC}(\omega) \propto -\left[\ln\left|(\omega-\omega_0)/\omega_0\right|-1\right] \Theta(\omega-\omega_e)$, where ω_e represents the central point of the peak logarithm. The unit area $J(\omega)$ is defined as the production field of the DOS in the semiconductor cell, delineated by the fine dark photonic magnitude $V(\omega)$ within the PB and PV cell [30, 40],

$$J(\omega) = \rho(\omega)|V(\omega)|^2 \quad (23)$$

Fig. 4 The dark photonic band structure and mode of energy conversion. **a** Unit area for various DOS values for 1D, 2D and 3D semiconductor cells $J(\omega)$. **b** Dark photonic mode of the frequencies for functional tuning (∂/ω_e). **c** Dark photonic mode of the magnitude of energy released, calculated using Eq. (2)

Hereafter, I consider the PB frequency ω_c and proliferative dark photon dynamics using the function $u(t, t_0)$ for the photon structure in the equation $a(t) = u(t, t_0)a(t_0)$. It is calculated using the dissipative integro-differential equation given in Eq. (25) and is expressed as

$$u(t, t_0) = \frac{1}{1 - \Sigma'(\omega_b)} e^{-i\omega(t-t_0)} + \int_{\omega_e}^{\infty} d\omega \frac{J(\omega) e^{-i\omega(t-t_0)}}{[\omega - \omega_c - \Delta(\omega)]^2 + \pi^2 J^2(\omega)} \quad (24)$$

where $\Sigma'(\omega_b) = [\partial \Sigma(\omega)/\partial \omega]_{\omega=\omega_b}$ and $\Sigma(\omega)$ represents the reservoir-induced PB photon self-energy correction

$$\Sigma(\omega) = \int_{\omega_e}^{\infty} d\omega' \frac{J(\omega')}{\omega - \omega'} \quad (25)$$

Here, the frequency ω_b in Eq. (2) represents the dark photonic frequency mode in the PBG ($0 < \omega_b < \omega_e$) and is calculated using the pole condition $\omega_b - \omega_c - \Delta(\omega_b) = 0$, where $\lesssim \Delta(\omega) = \mathcal{P} \left[\int d\omega' \frac{J(\omega')}{\omega - \omega'} \right]$ is a principal-value integral.

Furthermore, the detailed dark photonic dynamics, given the proliferation magnitude $|u(t, t_0)|$, have been cal-

Fig. 5 Proliferation of the dynamic dark photons in the semiconductor cells. **a** Given the PB area $\langle a(t) \rangle = 5 u(t, t_0) \langle a(t_0) \rangle$, and **b** the dynamic dark photonic rate $k(t)$, plotted for the (i) 1D, (ii) 2D and (iii) 3D semiconductor cells [27, 28]

Fig. 6 Solar cell current–voltage characteristic features for the conceptual function of **a** an optimal working point for current production and **b** the current–voltage module of the current source near the short-circuit point as a voltage source in the vicinity of the open circuit point

culated and are shown in Fig. 4a for the 1D, 2D and 3D semiconductor cells with respect to various detuning δ , integrated from the PBG area to the PB area [26, 29, 36]. The dark photonic dynamic rate $\kappa(t)$ is shown in Fig. 4b, neglecting the function $\delta = 0.1\omega_e$. The calculated result indicates that dynamic dark photons are produced at a higher rate once ω_c crosses from the PBG to the PB area. Because the range of $u(t, t_0)$ is $1 \geq |u(t, t_0)| \geq 0$, I have defined the crossover area as being related to the condition $0.9 \gtrsim |u(t \rightarrow \infty, t_0)| \geq 0$. This corresponds to $-0.025\omega_e \lesssim \delta \lesssim 0.025\omega_e$, with an activation rate $\kappa(t)$ within the PBG ($\delta < -0.025\omega_e$) and in the vicinity of the PBE ($-0.025\omega_e \lesssim \delta \lesssim 0.025\omega_e$) (Fig. 5).

To convert the dark photons into HDPs, I have first considered the PB as the Fock state photon number n_0 , i.e. $\rho(t_0) = |n_0 n_0\rangle$, which is obtained theoretically through the real-time quantum feedback control [34] and then by solving Eq. (2), with consideration for the state of the dark photon activation at time t :

$$\rho(t) = \sum_{n=0}^{\infty} \mathcal{P}_n^{(n_0)}(t) |n_0 n_0\rangle \quad (26)$$

$$\begin{aligned} \mathcal{P}_n^{(n_0)}(t) &= \frac{[v(t, t)]^n}{[1 + v(t, t)]^{n+1}} [1 - \Omega(t)]^{n_0} \\ &= \sum_{k=0}^{\min\{n_0, n\}} \binom{n_0}{k} \binom{n}{k} \left[\frac{1}{v(t, t)} \frac{\Omega(t)}{1 - \Omega(t)} \right]^k \end{aligned} \quad (27)$$

where $\Omega(t) = \frac{|u(t, t_0)|^2}{1 + v(t, t)}$. Therefore, the results suggest that a Fock state photon will evolve into a different Fock state of $|n_0\rangle$ is $\mathcal{P}_n^{(n_0)}(t)$. The activation of the dark photon dissipation $\mathcal{P}_n^{(n_0)}(t)$ in the primary state $|n_0 = 5\rangle$ and the steady-state limit, $\mathcal{P}_n^{(n_0)}(t \rightarrow \infty)$, are shown in Fig. 6. Therefore, the activation of the dark photon will ultimately reach a thermal non-equilibrium state, with the dark photonic structure written as:

$$\mathcal{P}_n^{(n_0)}(t \rightarrow \infty) = \frac{[\bar{n}(\omega_c, T)]^n}{[1 + \bar{n}(\omega_c, T)]^{n+1}} \quad (28)$$

To probe HDP production, I have further proposed to analyze the coherent states of the dark photons by solving Eq. (2) for the activation state of the dark photons, which can be expressed as

$$\rho(t) = D[\alpha(t)] \rho_T[v(t, t)] D^{-1}[\alpha(t)] \quad (29)$$

where $D[\alpha(t)] = \exp\{\alpha(t)\alpha^\dagger - \alpha^*(t)\alpha\}$ represents the displacement driver with $\alpha(t) = u(t, t_0)\alpha_0$ and

$$\rho_T[v(t, t)] = \sum_{n=0}^{\infty} \frac{[v(t, t)]^n}{[1 + v(t, t)]^{n+1}} |nn\rangle \quad (30)$$

Here ρ_T represents a thermal state with a mean particle number $v(t, t)$, and Eq. (17) reveals that the primary breakpoint of the cavity state will evolve into a displaced thermal state [37, 41], which is a mixture of the displaced numerical states $D[\alpha(t)]|n\rangle$. Thus, the dark photon activation representation, Eq. (29), can be written as

Fig. 7 *I*–*V* characteristics of the PV module at various temperatures and a constant solar irradiance. **a** Current–voltage–power simulation considering the maximum power point tracking, and **b** the simulation

results for the *I*–*V* and *P*–*V* characteristics at varying solar irradiances (200–1000 W/mm²) in 200 W/mm² increments, with a constant module temperature (25 °C)

$$m|\rho(t)|n = J(\omega) = e^{-\Omega(t)|\alpha_0|^2} \frac{[\alpha(t)]^m [\alpha^*(t)]^n}{[1 + v(t, t)]^{m+n+1}} \\ = \sum_{k=0}^{\min\{m,n\}} \frac{\sqrt{m!n!}}{(m-k)!(n-k)!k!} \left[\frac{v(t, t)}{\Omega(t)|\alpha_0|^2} \right]^k \quad (31) \\ = [n * e(1 + 2n)]$$

where the activation of an HDP in the semiconductor panel ($m|\rho(t)|n$) shall indeed evolve into an extreme relativistic thermal state $[1 + v(t, t)]^{m+n+1}$ with the non-equilibrium condition $[\alpha(t)]^m [\alpha^*(t)]^n$. Simply, it can be said that HDP production in semiconductor panels is viable with the implementation of Higgs boson quantum collisions under extreme relativistic conditions and produces energy.

Transform dark photon into energy

To convert an HDP into electricity under extreme relativistic conditions, a single-diode semiconductor panel consisting of a small disk semiconductor attached via wire to a circuit consisting of a positive and a negative film of silicon placed under a thin slice of glass and attached to graphene has been used. The semiconductor panel must have an open circuit point such that the current and voltage are at a maximum and an open circuit voltage V_{oc} . In addition, the maximum power point can be determined using the maximum current and voltage calculation immediately after capturing a HDP [38, 41]. The power delivered by a semiconductor PV panel will thus have the capability to reach a maximum value at the points (I_{mp} , V_{mp}) [36, 40]. To confirm the semiconductor

panel's capability of such current–voltage flow, the optimal working points and the dark functionality under the illuminating state of the semiconductor panel has been analyzed.

To determine the results of the *I*–*V* and *P*–*V* features of the PV panel for the relativistic temperatures from 25 to 45 °C using 5 °C increments and a constant solar irradiance 800 W/nm², the short-circuit current (I_{sc}) constant is considered at constant level. Simply, once the temperature increases due to the relativistic temperature, both the open circuit voltage (V_{oc}) and maximum power output of the *P*–*V* module increase in the semiconductor panel, and the result will be a non-linear flow of electrical energy in the *P*–*V* module (Fig. 7).

Conclusions

Dark photon is modeled by implementing a Higgs boson quantum collision under extreme relativistic conditions to transform it into an activated photon (HDP) to create energy. Thus, a series of mathematical calculations (dark photon modeling, dark photon transformation, dark photon conversion into energy) have been performed using MATLAB software that suggest that the transformation of dark photons into HDP by Higgs boson $[BR(H \rightarrow \gamma\gamma^-)]$ particle collisions under extreme relativistic conditions (ERC) is quite feasible. Simply, it can be said that the HDP formation from a dark photon is just a high-energy photo-physical reaction that activates the dark photon into an energy level photon, which would be a new field of energy science. Indeed, it will

open a new door in science for better understanding of this hidden power.

Acknowledgements This research was supported by Green Globe Technology under Grant RD-02017-02 for building a better environment. Any findings, predictions, and conclusions described in this article are solely performed by the authors and we confirm that there is no conflict of interest for publishing in a suitable journal.

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