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The Effect of Cosmic Radiation by a Stream of Alpha Particles on Solar Panels Based on Crystalline Silicon

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Annotation: The paper analyzes the bombardment of a plate of crystalline silicon, used as solar cells to generate electrical energy through the photoelectric effect, by a beam of alpha particles of cosmic radiation. The beam used has a low level of monochromaticity, an average current of 10 μA and an energy close to resonant, with a large bombardment area. In the course of the study, the effect of irradiation on the action of a solar battery, a change in its efficiency, with the calculation of expressions for subsequent generation of electric energy, was established.

Key words: Blazars, their varieties, pulsars, X-ray, radiation, magnetic field.

Introduction.

Modern solar panel technologies have been widely used in various fields of modern industry, among which the space industry, mining and research, aviation and others stand out. Each of these industries carries out its activities at high altitudes, in high layers of the atmosphere and beyond, due to which a high level of radiation activity is observed in these areas. Considering each of the areas, it is appropriate to note that in outer space, the source of radiation is stars and their varieties, quasars, blazars, pulsars, each of which is a source of radiation in the range from radio waves, infrared and visible spectrum to ultraviolet, X-ray radiation along with gamma quanta.

Along with these types of fluxes, the composition of cosmic radiation includes ionizing components in the form of heavy fast particles, including electrons, positrons, high-energy gamma quanta formed as a result of annihilation, protons, deuterons, tritons and alpha particles [1-2; 4]. Each of these particles bombard plates located in airless outer space, but at the same time, they pose a separate danger even after contact with the atmosphere, since due to the presence of a magnetic field near the planet, they accumulate, supported by the electromagnetic vectors of the planet, heading towards the poles, depending on the charge, from where a separate effect acts in the magnetic funnel, which outputs beams of particles and cosmic radiation back into outer space [3].

The described effect creates an ionosphere and a radioactive shell around the planet, as it approaches, to which the degree of exposure to the described phenomenon increases. Similar results are observed for work at the poles of the planet, where the real factor becomes even more active during the presence of the aurora borealis – the arrival of a stream of solar and cosmic radiation with strong ionization of the atmosphere, with the formation of the resulting radiation. Based on everything presented, it can be concluded that, considered, including on the scale of bombardment by alpha particles, one of the most commonly used varieties of solar cells is and makes this study relevant.

Research

The study is carried out taking into account the consideration of the situation of interaction with atoms of crystalline silicon of alpha particles present in the composition of cosmic radiation, as shown by experimental observation [1]. In the course of the study, a model for analyzing resonant nuclear reactions of Aliyev was used [5-6]. Due to this, it is appropriate to indicate the direction of radiation with a degree of monochromaticity of 1 keV for low energies, with a current of the order of 10 μA, directed to the entire area of the solar plate. After the direction of the described alpha particle beam,

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the elastic interaction stage begins, and after the inelastic interaction. In general, such a phenomenon can be described by the card game (1).

$$Si_{14}^{28} + He_2^4 \rightarrow \begin{cases} Si_{14}^{28} + He_2^4 \\ P_{15}^{31} + p_1^1 \\ Cl_{17}^{32} + e_{-1}^0 \\ P_{15}^{32} + e_{+1}^0 \\ S_{16}^{31} + n_0^1 \\ P_{15}^{30} + H_1^2 \\ P_{15}^{29} + H_1^3 \\ S_{16}^{32} \end{cases} \quad (1)$$

According to the presented model, it is possible to visually consider all the possibilities of the interaction [5-9; 11]. The first line of the card is a case of elastic interaction, when there is no interaction as such and the next possible line of the card is a reaction with the flight of a proton and the formation of phosphorus-31, then an electron with chlorine-32, then a positron with phosphorus-32, after a neutron with sulfur-31, then a deuteron with phosphorus-30, triton with phosphorus-29 and the formation of a single core of sulfur-32 by combining.

In this case, silicon nuclei-28 with a mass of 27.9769265350555 a. m., phosphorus-31 with 30.9737619986777 a. m., chlorine-32 with 31.9856846666 a. m., phosphorus-32 with 31.97390764444 a. m., sulfur-31 with 30.979557012525 a. m., phosphorus-30 from 29.97831349777 a. m., phosphorus-29 from 28.981800444 a. m., sulfur-32 from 31.97207117441414 a. m. [9-11; 13-14]

1. Nuclear reaction

Each of the channels of the nuclear reaction has its own output and threshold, determined in the first case by the mass difference of the particles formed, in the second case by the critical energy achieved in this case and necessary to achieve. So, the output of the first channel is calculated in (11), the second in (13), the third in (15), the fourth in (17), the fifth in (19), the sixth in (21), the seventh in (22), the threshold of the first channel is calculated in (12), the second in (14), the third in (16), the fourth in (18), the fifth in (20), the sixth in (22) and the seventh in (24).

$$Q_1 = \left(M_{Si_{14}^{28}} + M_{He_2^4} - M_{P_{15}^{31}} - M_{p_1^1}\right)c^2 =$$

$$= (27.97692653505 + 4.0015062 - 30.97376199867 - 1.00728) * 931.5 = -2{,}43052906\ MeV (11)$$

$$T_1 = |Q_1|\left(1 + \frac{M_{He_2^4}}{M_{Si_{14}^{28}}} + \frac{|Q_1|}{2M_{Si_{14}^{28}}c^2}\right) =$$

$$= 2.430529006 * \left(1 + \frac{4.0015062}{27.97692653505} + \frac{2.430529006}{2 * 27.97692653505 * 931.5}\right) = 2.778278056\ MeV (12)$$

$$Q_2 = \left(M_{Si_{14}^{28}} + M_{He_2^4} - M_{Cl_{17}^{32}} - M_{e_{-1}^0}\right)c^2 =$$

$$= (27.97692653505 + 4.0015062 - 31.9856846666 - 0.00055) * 931.5 = -7{,}26749924\ MeV (13)$$

$$T_2 = |Q_2|\left(1 + \frac{M_{He_2^4}}{M_{Si_{14}^{28}}} + \frac{|Q_2|}{2M_{Si_{14}^{28}}c^2}\right) =$$

$$= 7{,}26749924 * \left(1 + \frac{4.0015062}{27.97692653505} + \frac{7{,}26749924}{2 * 27.97692653505 * 931.5}\right) = 8{,}307974271\ MeV (14)$$

$$Q_3 = \left(M_{Si_{14}^{28}} + M_{He_2^4} - M_{P_{15}^{32}} - M_{e_{+1}^0}\right)c^2 =$$

$$= (27.97692653505 + 4.0015062 - 31.97390764444 - 0.00055) * 931.5 = 3{,}702796903\ MeV (15)$$

$$T_3 = |Q_3|\left(1 + \frac{M_{He_2^4}}{M_{Si_{14}^{28}}} + \frac{|Q_3|}{2M_{Si_{14}^{28}}c^2}\right) =$$

$$= 3,702796903 * \left(1 + \frac{4.0015062}{27.97692653505} + \frac{3,702796903}{2 * 27.97692653505 * 931.5}\right) = 4,232666552\ MeV (16)$$

$$Q_4 = \left(M_{Si_{14}^{28}} + M_{He_2^4} - M_{S_{16}^{31}} - M_{n_0^1}\right)c^2 =$$

$$= (27.97692653505 + 4.0015062 - 30.979557012525 - 1.00866) * 931.5 = -9,11405447\ MeV (17)$$

$$T_4 = |Q_4|\left(1 + \frac{M_{He_2^4}}{M_{Si_{14}^{28}}} + \frac{|Q_4|}{2M_{Si_{14}^{28}}c^2}\right) =$$

$$= 9,11405447 * \left(1 + \frac{4.0015062}{27.97692653505} + \frac{9,11405447}{2 * 27.97692653505 * 931.5}\right) = 10,41922045\ MeV (18)$$

$$Q_5 = \left(M_{Si_{14}^{28}} + M_{He_2^4} - M_{P_{15}^{30}} - M_{H_1^2}\right)c^2 =$$

$$= (27.97692653505 + 4.0015062 - 29.97831349777 - 2.01354) * 931,5 = -12,5017199\ MeV (19)$$

$$T_5 = |Q_5|\left(1 + \frac{M_{He_2^4}}{M_{Si_{14}^{28}}} + \frac{|Q_5|}{2M_{Si_{14}^{28}}c^2}\right) =$$

$$= 12,5017199 * \left(1 + \frac{4.0015062}{27.97692653505} + \frac{12,5017199}{2 * 27.97692653505 * 931.5}\right) = 14,29282457\ MeV (20)$$

$$Q_6 = \left(M_{Si_{14}^{28}} + M_{He_2^4} - M_{P_{15}^{29}} - M_{H_1^3}\right)c^2 =$$

$$= (27.97692653505 + 4.0015062 - 28.981800444 - 3.0155) * 931.5 = -17,5752709\ MeV (21)$$

$$T_6 = |Q_6|\left(1 + \frac{M_{He_2^4}}{M_{Si_{14}^{28}}} + \frac{|Q_6|}{2M_{Si_{14}^{28}}c^2}\right) =$$

$$= 17,5752709 * \left(1 + \frac{4.0015062}{27.97692653505} + \frac{17,5752709}{2 * 27.97692653505 * 931.5}\right) = 20,09496718\ MeV (22)$$

$$Q_7 = \left(M_{Si_{14}^{28}} + M_{He_2^4} - M_{S_{16}^{32}}\right)c^2 =$$

$$= (27.97692653505 + 4.0015062 - 31.97207117441414) * 931.5 = 5.925793732\ MeV \quad (23)$$

$$T_7 = |Q_7|\left(1 + \frac{M_{He_2^4}}{M_{Si_{14}^{28}}} + \frac{|Q_7|}{2M_{Si_{14}^{28}}c^2}\right) =$$

$$= 5,925793732 * \left(1 + \frac{4.0015062}{27.97692653505} + \frac{5,925793732}{2 * 27.97692653505 * 931.5}\right) = 6,774026614\ MeV (24)$$

Thus, based on the calculated values of the yield and the threshold of the nuclear reaction, an expression of the intermediate card (25) is obtained.

$$Si_{14}^{28} + He_2^4 \rightarrow \begin{cases} P_{15}^{32} + e_{+1}^0 \\ S_{16}^{32} \end{cases} \quad (25)$$

In fact, apart from Rutherford scattering, only the third and seventh channels will occur on the scale of inelastic channels. However, the nuclei formed in this case, directly phosphorus-32, are radioactive (26) and subject to decay.

$$t = \begin{cases} t(P_{15}^{32}) = 14.26855\ days \\ t(S_{16}^{32}) = \infty \end{cases} \quad (26)$$

2. *The outgoing Coulomb barrier*

After the nuclear reaction in the first channel, the positron and phosphorus-32 have positive charges, which leads to the situation of using the outgoing Coulomb barrier. To calculate its value, the phosphorus radius is initially determined-32 (75), followed by the value itself (76) and the tuple, its first stage is transformed into the form (77).

$$R_{P_{15}^{32}} = 1.4 * A^{\frac{1}{3}} = 1.4 * 32^{\frac{1}{3}} = 4.444722946\ fm \quad (75)$$

$$B_k = \frac{\left|q_{P_{15}^{32}}\right|\left|q_{e_{+1}^{0}}\right|}{R_{P_{15}^{32}}} * \frac{e^2}{\hbar c} * \hbar c = \frac{15 * 1}{4.444722946} * \frac{1}{137} * 197.3 = 4.860188148\ MeV \quad (76)$$

$$Si_{14}^{28} + He_2^4 \to \begin{cases} P_{15}^{32} - 4.860415016\ eV - 3\ 378 \\ e_{+1}^{0} - 18.04904578\ MeV - 3\ 378 \\ (S_{16}^{32})_1 - 15{,}41208133\ MeV - 1\ 797\ 126 \end{cases} \quad (77)$$

To create the second stage of the card game, it is necessary to calculate the energy of sulfur-32 for the second stage from the modified parameters of phosphorus-32 of the first stage (78) and electron (79), organizing a complete view of the card game after the Coulomb barrier (80).

$$T_{(S_{16}^{32})_2} = \frac{\left(T'_{P_{15}^{32}} + Q_2^{(1)}\right) M_{e_{-1}^{0}}}{M_{(S_{16}^{32})_2} + M_{e_{-1}^{0}}} = \frac{(4.860415016 + 1.198346792) * 0.00055}{31.97207117441414 + 0.00055} = 104.2241415\ eV \quad (78)$$

$$T_{e_{-1}^{0}} = \frac{\left(T'_{P_{15}^{32}} + Q_2^{(1)}\right) M_{(S_{16}^{32})_2}}{M_{(S_{16}^{32})_2} + M_{e_{-1}^{0}}} = \frac{(4.860415016 + 1.198346792) * 31{,}97207117441414}{31.97207117441414 + 0.00055} =$$

$$= 6.058657584\ MeV \quad (79)$$

$$Si_{14}^{28} + He_2^4 \to \begin{cases} P_{15}^{32} - 4.860415016\ MeV - 3\ 378 \\ e_{+1}^{0} - 18.04904578\ MeV - 3\ 378 \\ (S_{16}^{32})_1 - 15{,}41208133\ MeV - 1\ 797\ 126 \end{cases} \to \begin{cases} (S_{16}^{32})_2 - 104.2241415\ eV - 3\ 378 \\ e_{-1}^{0} - 6.058657584\ MeV - 3\ 378 \\ e_{+1}^{0} - 18.04904578\ MeV - 3\ 378 \\ (S_{16}^{32})_1 - 15{,}41208133\ MeV - 1\ 797\ 126 \end{cases} \quad (80)$$

The analysis of the nuclei of the formed cartridge makes it possible to determine the work of phosphorus-32 (81) and sulfur-32 (82) of the first stage after the Coulomb barrier, together with the total capacities (83), and, accordingly, the total temperature for the first stage of the cartridge (84).

$$Q_{P_{15}^{32}} = 4.860415016 * 10^6 * 1.6 * 10^{-19} * 3\ 378 = 2.626957108\ nJ \quad (81)$$

$$Q_{(S_{16}^{32})_1} = 15.41208133 * 10^6 * 1.6 * 10^{-19} * 1\ 797\ 126 = 4.431592332\ mcJ \quad (82)$$

$$Q_3 = Q_{P_{15}^{32}} + Q_{(S_{16}^{32})_1} = 2.626957108 * 10^{-9} + 4.431592332 * 10^{-6} = 4.434219289\ mcJ \quad (83)$$

$$T_3 = \frac{Q_3}{m_{P_{15}^{32}} c_{P_{15}^{32}} + m_{(S_{16}^{32})_1} c_{(S_{16}^{32})_1} + m_{Si_{14}^{28}} c_{Si_{14}^{28}}} =$$

$$= 4.434219289 * 10^{-6} * \begin{pmatrix} 1.792930476 * 10^{-19} * 0.77 + \\ +9.538001503 * 10^{-17} * 0.71 + \\ +568.59456 * 0.703 \end{pmatrix}^{-1} = 11.09325871\ nK \quad (84)$$

The temperature value of the second stage of the tuple after the Coulomb barrier is calculated by a similar calculation of the operation of sulfur-32 of the second type (85) and the total power of the second stage (86), followed by the calculation of the temperature value (87).

$$Q_{(S_{16}^{32})_2} = 104.2241415 * 1.6 * 10^{-19} * 3\ 378 = 56.331064\ fJ \quad (85)$$

$$Q_4 = Q_{(S_{16}^{32})_2} + Q_{(S_{16}^{32})_1} = 56.331064 * 10^{-15} + 4.431592332 * 10^{-6} = 4.431592388 \text{ мкДж} \quad (86)$$

$$T_4 = \frac{Q_4}{m_{P_{15}^{32}} c_{P_{15}^{32}} + m_{(S_{16}^{32})_1} c_{(S_{16}^{32})_1} + m_{Si_{14}^{28}} c_{Si_{14}^{28}}} =$$

$$= 4.431592388 * 10^{-6} * \begin{pmatrix} 1.792930476 * 10^{-19} * 0.77 + \\ +9.538001503 * 10^{-17} * 0.71 + \\ +568.59456 * 0.703 \end{pmatrix}^{-1} = 11.08668689\, nK \quad (87)$$

For particles, a similar work is carried out with the calculation of the work performed for the electron (88) and positron (89) after the Coulomb barrier, together with the following velocities and currents of the electron (90-91) and positron (92-93).

$$Q'_{e_{-1}^{0}} = 6.058657584 * 10^{6} * 1.6 * 10^{-19} * 3\,378 = 3.274583251\, nJ \quad (88)$$

$$Q'_{e_{+1}^{0}} = 18.04904578 * 10^{6} * 1.6 * 10^{-19} * 3\,378 = 9.755148263\, nJ \quad (89)$$

$$v_{e_{-1}^{0}} = c\sqrt{1-\left(\frac{1}{1+\frac{E_{e_{-1}^{0}}}{m_{e_{-1}^{0}}c^2}}\right)^2} = 299\,792\,458 * \sqrt{1-\left(\frac{1}{1+\frac{6.058657584*10^{6}*1.6*10^{-19}}{0.00055*1.66*10^{-27}*299\,792\,458^2}}\right)^2} =$$

$$= 298\,878\,118.294995 \frac{m}{s} \quad (90)$$

$$I_{e_{-1}^{0}} = n_{e_{-1}^{0}} e S_{e_{-1}^{0}} v_{e_{-1}^{0}} = 3\,378 * 1.6 * 10^{-19} * 1.62688 * 298\,878\,118.294995 = 0.262802365\, mcA \quad (91)$$

$$v_{e_{+1}^{0}} = c\sqrt{1-\left(\frac{1}{1+\frac{E_{e_{+1}^{0}}}{m_{e_{+1}^{0}}c^2}}\right)^2} = 299\,792\,458 * \sqrt{1-\left(\frac{1}{1+\frac{18.04904578*10^{6}*1.6*10^{-19}}{0.00055*1.66*10^{-27}*299\,792\,458^2}}\right)^2} =$$

$$= 299\,678\,008.670249 \frac{m}{s} \quad (92)$$

$$I_{e_{+1}^{0}} = n_{e_{+1}^{0}} e S_{e_{+1}^{0}} v_{e_{+1}^{0}} = 3\,378 * 1.6 * 10^{-19} * 1.62688 * 299\,678\,008.670249 = 0.16196997\, mcA \quad (93)$$

Thus, the analysis of the nuclear reaction consists.

Conclusion.

During the study, it was proved that exposure to cosmic radiation and, in particular, bombardment with alpha particles has a negative effect on the effect of the entire plate as a whole. In this case, nuclei of radioactive phosphorus and sulfur are formed, increasing their amount over time, as well as turning the plate into a source of gamma radiation in small quantities. However, this process takes place over a long time, so it takes 13,992,887,670 years 22 days 1 hour 42 minutes 20.09399 seconds for the plate to completely fail.

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