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## RESEARCH

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# Alpha particle fluxes and ischaemic heart disease mortality study for Bulgaria and Los Angeles, California, USA

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### ABSTRACT

According to the World Health Organization, ischemic heart disease is at the top of the list of morbid causes of death on the planet. In the present work:

- Data are given showing the alarming phenomenon – the probable impact of positively charged particles with high energy of solar origin on mortality from ischemic heart disease in Bulgaria, South-East Europe;
- A hypothetical mechanism is proposed to explain this

phenomenon; and

- This mechanism predicts at which specific points on the planet increased mortality from ischemic heart disease should have occurred on specific dates in the last 50 years with satellite data.

An example is given for Los Angeles County, California, USA, in which the described phenomenon has led to increased mortality at specific dates, fully in accordance with the proposed hypothetical mechanism.

**Key Words:** *Ischemic heart disease, Mortality, Geomagnetic field, Electromagnetic, Solar mass ejections, Alpha detector*

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### INTRODUCTION

Thunder from the clear sky. This metaphor in the Bulgarian language means an extremely rare, almost impossible event from a direction from which no danger should be expected. We now know that this is not quite the case concerning clear skies, insofar as solar ultraviolet radiation emanates from it, which can be harmful to health. This work aims to show that in addition to the potential harm through ultraviolet radiation, the Sun, which gives life, could also take life for hours.

The World Health Organization (WHO) maintains a classifier of diseases, the so-called International Classification of Diseases (ICD). In recent years, its 10th revision has been used. According to the WHO, the class of ischaemic heart diseases (hereinafter the abbreviation IHD is used), also known as coronary artery diseases, among which is a heart attack, has been at the top of the list of morbid causes of death on the planet in the years since world health statistics were kept [1]. According to the WHO, 8.9 million people died from IHD worldwide in the last pre-pandemic year, 2019 [2]. According to, morbidity and mortality from IHD (the number of

registered patients and the number of deaths from IHD per 100,000 of the population) are not evenly distributed across the planet [3]. The highest mortality rates from IHD are in a region including Central and Eastern Europe, where Bulgaria is situated. Typical for the countries in this region are the relatively small territories and the mountainous character of the relief, which increases their altitude. IHD mortality decreases in all directions as it moves away from Central and Eastern Europe.

A study was conducted, the results of which are set out below, aimed at clarifying whether IHD deaths in Bulgaria are related to external causes—disturbances in the geomagnetic field, solar radiation—corpuscular and electromagnetic (X-ray and ultraviolet radiation), the cycling of solar activity and the variations of galactic cosmic rays. A prerequisite for this kind of study is the availability of reliable data – both on possible space impacts and mortality from IHD.

More complex is the problem of the reliability of mortality data. Their obtainment requires a combination of good medical diagnostics covering the territory of the respective country, accurate

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administrative reporting, adequate national statistics, and easy access to statistical data for scientific purposes.

## MATERIAL AND METHODS

IHD mortality data for Bulgaria were obtained from a reliable statistical source—Eurostat [4]. Hourly Data on the number of deaths from IHD in the period from March 8<sup>th</sup> to March 9<sup>th</sup> 2012 were received from The National Statistical Institute of Bulgaria (NSI). Data on the daily number of IHD deaths for the interval from March 5<sup>th</sup> to March 13<sup>th</sup>, 2012 were received from the municipality of Stara Zagora, Bulgaria. Through a request from the Los Angeles County Department of Public Health, USA, data on the daily number of IHD deaths were obtained for the interval from March 1<sup>st</sup> to March 10<sup>th</sup>, 1995.

Satellite data on solar corpuscular radiation – protons and alpha particles recorded by the Geostationary Operational Environmental Satellites (GOES) series satellites were obtained from an NOAA site [5]. The satellites of the GOES series fly in geostationary orbit (above the Earth's equator), at an altitude of 36,000 kilometers above the Earth's surface, and make one lap in 24 hours, that is, they "hang" over a certain point on the surface. They do not be shaded from Earth in their circumference around it. There is one satellite of the series over each of two meridians over the east coast and the west coast of the USA.

Data were used for alpha-particle and proton fluxes with energies of the range 3.8 MeV–16.1 MeV (with flux unit: (number of particles).cm<sup>2</sup>.s<sup>-1</sup>.sr<sup>-1</sup>.MeV<sup>-1</sup>). The fluxes were registered with the high energy particle sensor (Energetic Particles Sensor, EPS) and Energetic Proton, Electron, and Alpha Detector (EPEAD). The sensor and the detector detects in particular alpha particles with energies from 3.8 MeV to 500 MeV, distributed in 6 channels. The data is averaged over a 5-minute interval, during which there are up to 25 unit reports.

Data on possible space impacts were statistically processed – they were averaged by year and correlations were sought between their annual averages and the annual IHD mortality for Bulgaria.

The number of years included in the study of the dependence of annual IHD mortality in Bulgaria on corpuscular solar radiation was consistent with the longest possible continuous interval of years with satellite data [5]. The data from the GOES-13 satellite, whose flawless operation in orbit lasted the longest in the harsh conditions of space –7 years (from 2011 to 2017), was used.

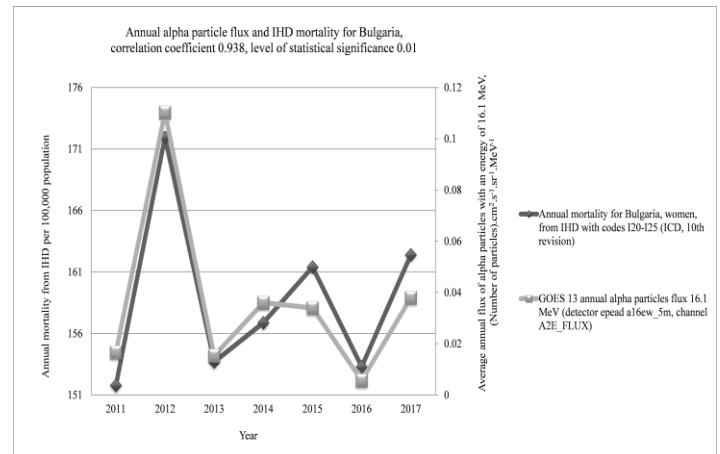
The hypothetical mechanism proposed below explaining the observed phenomenon assumes that charged particles of high energy pass through the atmosphere and reach the Earth's surface. The energy required for this was calculated from PSTAR and ASTAR databases and calculators [6, 7]. Geomagnetic field data were obtained from the Intermagnet site [8]. Galactic cosmic ray data were obtained from the NMDB database for 5 European neutron monitors [9, 10]. Data on solar activity, solar mass discharges (Solar Mass Ejections, SME), solar flares, and coronal holes were obtained from the sites [11-15]. Correlation and regression analysis were used to process the data.

## RESULTS

A high statistically significant correlation was found between the annual average alpha-particle (and proton) fluxes with high energy in the range 3.8 MeV–16.1 MeV recorded with the high energy particle sensor EPS and the annual mortality for Bulgaria by IHD (Figure 1).

Slightly higher was the correlation of IHD mortality with annual average alpha-particle fluxes, compared to that with proton fluxes.

The correlation with the annual average alpha particle flux is higher for the mortality of IHD in women compared to that for men in Bulgaria. According to data on the age of those who died from IHD, it became clear that these were mostly elderly people. Women are more affected because men in Bulgaria live shorter lives. For example, for the pre-pandemic interval 2017–2019, the average life expectancy for women in Bulgaria is 78.0 years, and for men 70.8 years, with the number of men in the age range 70-74 being 70% of the number of women [16].



**Figure 1)** There is a high correlation between mortality from IHD for women in Bulgaria according to Eurostat data and the annual flow of alpha particles in geostationary orbit recorded by the GOES-13 satellite [4, 5].

Similar relationships (with less correlation) between IHD mortality and positively charged particle fluxes recorded in geostationary orbit were found for other countries in Central and Southern Europe, where IHD mortality is the highest worldwide.

The cause of death from IHD is complex – heredity, age, gender, lifestyle, and diseases, contribute to it. The study shows that in some way positively charged particles coming from space contribute to IHD mortality, too. For Bulgaria, the contribution of positively charged cosmic radiation to IHD mortality has been estimated at 10%–15%, but a similar analysis for Malta shows a proportion of radiation in IHD mortality of up to 40% [17].

Particles of relatively small energy are constantly emitted from the Sun, spreading in all directions in the surrounding cosmos – the so-called solar wind. When they invade the Earth's atmosphere, they deviate from the geomagnetic field to the poles, where they enter deeper into the atmosphere. If solar wind particles are the cause of the increased mortality, their effects should be expected to be more noticeable in countries closer to the poles, but such an increase in mortality is not noticeable in countries near the North Geographic Pole. There are no sufficiently reliable and long sequences of mortality data in the Southern Hemisphere, so all the reasoning below is about the Northern Hemisphere.

A well-pronounced relationship between the annual average flux of positively charged high-energy particles and the annual average mortality from IHD is only noticeable for some small-scale area countries of mid-latitudes [17]. For large area countries such as

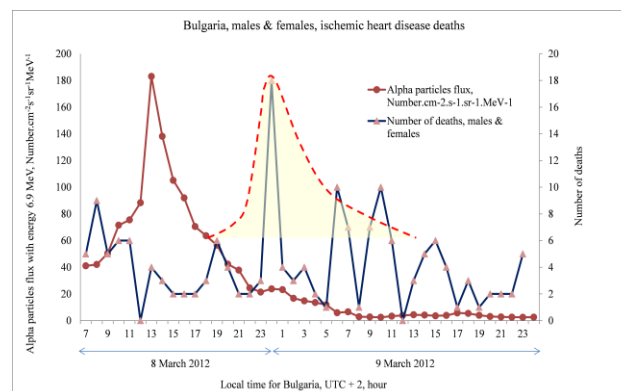
Russia, China, USA, located at the same latitude as Europe, the annual average mortality of IHD does not depend on the average annual flux of high-energy positively charged particles. This observation leads to the conclusion that if there is a lethal effect of radiation from positively charged particles of high energy on mortality, it is short-lived in time and in the form of a variable spot with a limited area on the earth's surface. The effect on mortality from such radiation is noticeable in the statistics of countries with a small area covered entirely by this impact spot but is masked in the statistics of the large countries where it affects only part of the total territory of the country. Masking is the stronger the shorter the impact and when a small part of the territory of the large country is covered by the deadly spot. The alpha radiation recorded by satellites is not continuous over time but is the result of individual short-term peaks. It is natural to expect that it is during these peaks that the detrimental effect associating alpha radiation with IHD mortality also occurs.

Mean altitude correlates positively with IHD mortality in countries where the impact of radiation on IHD mortality is noticeable [17]. This fact shows that the threat of death due to IHD hangs over our heads and that the impact of radiation on mortality from IHD increases with distance from the earth's surface. The variation in mortality from IHD with height can be explained by the health impact of invading radiation from space that reaches the Earth's surface. At high altitudes, the atmospheric layer overcome by the invading radiation is thinner and less dense, as a result of which the flux of radiation weakens less and its negative impact on living organisms at high altitude (and probably on passengers in the planes and on astronauts) is stronger.

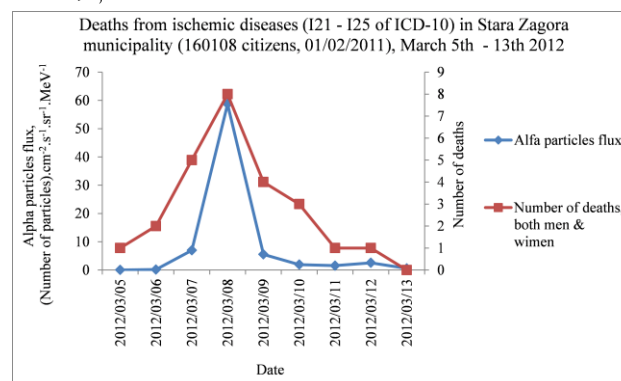
Hourly mortality information was used to follow the effects of short-lived alpha particle peaks on mortality. The data from the death certificates for Stara Zagora Municipality, Bulgaria, which noted both the cause of death and the time of the death found, showed that an increase in the number of deaths from IHD was observed when positive particles with high energy were registered around noon. The number of IHD deaths increased in the afternoon on the day of the particle invasion and often remained elevated the following day. The same conclusion is followed by the hourly mortality data from IHD for Bulgaria for a specific date March 8<sup>th</sup>, 2012, when as a result of a discharge of solar mass in the direction of the Earth (SME), a powerful flow of positively charged particles was registered at 11:15 UTC (Greenwich, Universal Time Coordinated, UTC), 13:15 local time for Bulgaria (Figures 2 and 3). The number of deaths at the national level from IHD on March 8 and 9, 2012 quadrupled in terms of their average daily number during the year. The victims are mostly elderly people. In the example, it is indicative that the source of the flow of positively charged particles that caused the increased mortality is clear—this is the Sun. Significant is the fact that the maximum of the alpha radiation flux is registered around the moment of local noon for the territory of Bulgaria.

The High Energy Proton and Alpha particles Detector (HEPAD) detector from the GOES-13 satellite is designed to detect protons with energies up to and above 0.7 GeV, as well as alpha particles with energies up to and above 3.4 GeV [5]. The detector data show that the proton fluxes rapidly decrease in magnitude as their energy

increases and are negligible for energies above 0.7 GeV. The alpha-particle fluxes at first decrease in magnitude with increasing energy, but then increase and for energies above 3.4 GeV they reach values of 1/10 of that for the fluxes with the smallest energy, i.e. particles with energies several GeV can only be alpha particles that have received a large acceleration. For comparison, the radionuclide Californium-252, a source of non-accelerated alpha radiation with the greatest energy on the Earth's surface, 6.217 MeV, emits alpha particles three orders of magnitude less energy [18].



**Figure 2)** Hourly change of the high energy flow of alpha particles from March 8, 2012, and the number of deaths from IHD in Bulgaria for March 8<sup>th</sup> and 9<sup>th</sup>, 2012.



**Figure 3)** The same phenomenon from March 8<sup>th</sup>, 2012. Diurnal average of alpha particle flow and IHD deaths for the Municipality of Stara Zagora from March 5<sup>th</sup> to March 13, 2012. The average age of the deceased—75 years.

No statistically significant correlations of IHD mortality were found for Bulgaria and the other possible space impacts listed above

#### Hypothetical mechanism of the described phenomenon

- The fluxes of high-energy alpha particles affecting the physiology of humans on the surface of planet Earth and causing death from IHD are emitted by processes on the Sun. Streams of high-energy positively charged particles have nothing to do with the solar wind, whose particles are constantly emitted in all directions and move tens of times slower.
- The lethal effects are due to particles penetrating through the atmosphere and reaching the Earth's surface. Only particles whose energy is above 2.4 GeV for protons and over 6.2 GeV for alpha particles could penetrate the atmosphere to Earth's surface [17]. As it became clear

above, with such energy in a near-Earth orbit, only alpha-particle fluxes have been recorded.

- During the day the Sun changes its height above the horizon relative to the point of observation. The highest elevation (angle) of the Sun above the horizon during the day is its culmination (local noon). During the year, the solar culmination changes. For the Northern Hemisphere from a minimum value on December 21 (early winter) reaches a maximum value on June 21 (early summer), then decreases back. When for the observation point from the Earth's surface the Sun is at its culmination, the invading particles from the Sun move through the thinnest part of the atmosphere, i.e. the probability of penetration to the Earth's surface is greatest. Alpha particles invading from space into the Earth's atmosphere with energies up to 500 MeV do not have the energy to reach the Earth's surface.
- The author of the hypothesis suggests that very high-energy alpha particles reach Earth's orbit – several GeVs that are not detected by satellites because their energy exceeds the energy range for which the sensors were constructed. They probably arise as a result of an explosive process on the Sun simultaneously or around the time of occurrence of alpha particles detected by the sensor of the satellite. An alpha particle energy of the order of a few GeV means that it is moving at a speed close to the speed of light. For example, it can be estimated that an alpha particle with a rest mass of  $6.64465723 \cdot 10^{-27}$  kg, with an energy of 7 GeV ( $1.12152411 \cdot 10^9$  J) travels at a speed of 281000 km/s and travels the distance from the Sun to Earth ( $149.6 \cdot 10^6$  km) in 8.87 min. That is, alpha particles capable of passing through the Earth's atmosphere are so fast that they arrive at the point of observation on the Earth's surface directly from the center of the solar disk.
- It can be estimated that satellite-recorded particles with an energy of 5 MeV-10 MeV reach Earth's orbit about two hours later than the hypothetical fast particles in the example above. The registered particles cannot penetrate through the atmosphere, i.e. they are only an indicator two hours late for the hypothetical particles of very high energy that reach the Earth's surface (if both hypothetical and indicator alpha particles are emitted simultaneously in a common blast on the Sun). This means that the meridian with the solar culmination at the moment of registration of the indicator radiation by the satellite is  $30^\circ$  west of the meridian, on which the hypothetical alpha radiation reached the Earth's surface two hours earlier (the Earth rotates at an angular speed of  $15^\circ/\text{hour}$ ). That is, the damage to humans from the hypothetical alpha radiation should be caused 2 hours before the detection of the indicator radiation by the satellite and the center of the deadly spot should be  $30^\circ$  east of the meridian of registration.
- Both indicator alpha particles and hypothetical fast alpha particles with energies of the order of GeV irradiate the entire sunlit part of the Earth's atmosphere. Indicator alpha particles do not reach the Earth's surface. The most permeable to hypothetical fast particles is the atmosphere above the point on the Earth's surface, for which during

the solar culmination there is a coincidence between two directions of the vector of geomagnetic induction at the point, and of the invading alpha particles. Alpha particles are then not affected by the diverting force of the geomagnetic field and are most likely to penetrate the Earth's surface, creating a deadly spot on the Earth's surface around the matching point of these two directions. The geomagnetic induction vector (geomagnetic vector) for a given point on the Earth's surface has a constant direction relative to the point. For the Northern Hemisphere, the geomagnetic vector is directed downward to the point and north and lies in the plane of its meridian (if one ignores the small discrepancy between the North geographic and the South magnetic poles). For example, for Bulgaria (Panagyurishte Geomagnetic Observatory) the inclination of the geomagnetic vector is  $59^\circ$  (the angle between the geomagnetic vector and the horizontal plane at the point of observation). A coincidence between the directions of geomagnetic induction and the flux of the invading alpha-particles with an energy of the order of GeV can be if during their emission the Sun is at a culmination and the height of the solar disk coincides with the inclination of the geomagnetic vector. For example, for Bulgaria, such a coincidence happens on April 22<sup>nd</sup> and August 21<sup>st</sup>, which are the riskiest dates for outdoor walking at noon during the year, as if a stream of fast alpha particles occurs at that time, they would reach the Earth's surface in the region of Bulgaria. The "registration point" is hereinafter referred to as the point on the Earth's surface for which the culmination of the Sun coincides with the inclination of the geomagnetic vector at the time of registration of invading alpha flux.

- Calculations show that for the Northern Hemisphere, the largest latitude for which a match between the solar climax and the inclination of the geomagnetic vector is possible is  $48^\circ$  (about June 21<sup>st</sup>), and the smallest –  $28^\circ$  (about December 21<sup>st</sup>) [17]. These two geographical parallels delimit the northern and southern borders of Central and Eastern Europe and the Mediterranean where, as stated above, the morbidity and mortality of IHD is highest. The increased risk of an IHD incident outdoors around local noon is a further argument concerning the wholesomeness of the indoor lunch break ("siesta") practiced in Mediterranean countries.
- The size of the said deadly spot can be judged again from the date of the event on March 8, 2012, when rapid alpha particles supposedly reached the Earth's surface as a result of SME. The alpha particle flux indicator was recorded by GOES-13 at 11:15 UTC. The point of registration of the indicator flow is over Tunisia ( $11^\circ\text{E}$ ,  $35^\circ\text{N}$ , E-east longitude, N – north latitude). According to the proposed hypothesis, the most damaging influence was experienced by the region  $30^\circ$  east of Tunisia, with center Mesopotamia ( $41^\circ\text{E}$ ,  $35^\circ\text{N}$ ), over which the Solar culmination coincided with the inclination about 2 hours earlier when a stream of fast alpha-particles with an energy of the order of several GeV invaded the area and penetrated to the Earth's surface. The size of the dead spot can also be judged by the

fact that the detrimental effect on health is also noticeable in Bulgaria (1200 km northwest of the center of the spot).

**Case of invasion of high energy alpha particle fluxes over Los Angeles County, State of California, USA, analyzed based on the proposed hypothetical mechanism**

The choice of Los Angeles County, California, USA, as an example, is not accidental.

- The region has a high population density, i.e. it was expected that with an invasion of intense fluxes of high energy solar alpha particles, the described effect with an increased number of IHD deaths would be more noticeable for a densely populated region.
- The United States is a country with a high level of medical diagnostics and perhaps the best medical statistics in the world.
- Several intense streams of alpha particles reaching the Earth's orbit occurred between March 1<sup>st</sup> and March 10<sup>th</sup> 1995 according to data from the GOES-07 satellite, EPS sensor, channel A1. For the Los Angeles area, the geomagnetic induction vector descends from south to north with an angle (inclination) to the Earth's surface of 47.5° [17]. According to the proposed hypothetical mechanism, the maximum negative effect on the health of residents in Los Angeles County should be expected around the moments when the culmination of the Sun, increasing in spring and decreasing in autumn, coincides with the inclination of the vector of geomagnetic induction, i.e. reaching a value of 47.5°. This occurs around February 26 and October 15 [17]. At the beginning of March, the culmination of the Sun in the Los Angeles area is still close to the inclination of the geomagnetic vector for the area, when several high-magnitude alpha particle streams have been recorded during the first ten days of March 1995. According to the presented hypothetical mechanism, the alignment of the culmination

of the Sun with the inclination of the geomagnetic vector in the Los Angeles area in early March creates optimal conditions for penetrating to the Earth's surface in the Los Angeles area of alpha particles with sufficient energy from the mentioned streams.

If the hypothetical mechanism reflects reality, an increased number of IHD deaths in Los Angeles County should be expected during the above-mentioned interval of the study with intense alpha particle flows. Otherwise, (if the hypothetical mechanism does not reflect reality) such an increase should not be observed.

To test whether and to what extent the proposed hypothetical mechanism reflects reality, data on the number of IHD deaths for Los Angeles County women by days for the study interval were obtained by requesting Data Support Services of the Los Angeles County Epidemiology.

The result of the study is shown in Table 1. It can be seen from the table (columns 3 and 4) that coronary disease mortality among Los Angeles County women for the study interval correlates with satellite-recorded (indicator) alpha particle fluxes. According to the hypothesized mechanism of the described phenomenon, the registered indicator fluxes alpha particles are associated with unregistered ones with much greater energy, allowing them to reach the Earth's surface and harm the health of the people into whose bodies they fall. It can be concluded that the unrecorded alpha particle flux is proportional to that recorded since the number of deaths is proportional to the magnitude of the alpha particle flux recorded. The number of deaths also depends on the distance between the point of impact of alpha particles on the Earth's surface and Los Angeles County (column 6 of the table).

The moment of registration of the first indicator flow (March 2<sup>nd</sup>, 1995) coincides with the moment of culmination of the Sun just above Los Angeles County. The flow is of medium intensity, and the number of deaths moderately increases, but Los Angeles County likely remained on the western periphery of the deadly spot, as follows from the proposed hypothetical mechanism. At this time, the change in deaths follows exactly the change in alpha particle fluxes.

**TABLE 1.**  
**The number of women who died from IHD in Los Angeles County and alpha particle fluxes recorded near the Los Angeles area for the study interval**

Survey dates	Number of women in Los Angeles County who died from ischemic heart disease	Difference between the diurnal number of deaths and their minimum on 8 March 1995	Diurnal maximum of alpha particle flux, (number of particles).cm <sup>-2</sup> .s <sup>-1</sup> .sr <sup>-1</sup> .MeV <sup>-1</sup>	Geographical coordinates of alpha particle flux registration points	Distance from registration points of alpha radiation fluxes to Los Angeles, km
01-03-1995	17	1	5010	W123, N34.5	443.6
02-03-1995	22	6	8930	W118, N34.5	54.1
03-03-1995	21	5	6190	W124, N34.5	532.7
04-03-1995	18	2	564	W116, N35	225.5
05-03-1995	26	10	19900	W124, N35	540.4
06-03-1995	24	8	0.0796	W169, N35	Far from LA
07-03-1995	22	6	0.0597	W16, N35	Far from LA
08-03-1995	16	0	3600	E139, N35.5	Far from LA
09-03-1995	17	1	6750	E124, N36	Far from LA
10-03-1995	17	1	10.3	E91, N35.5	Far from LA

The second indicator flux (March 5<sup>th</sup>, 1995) is of considerable magnitude. At the time of its registration, the Sun's culmination has been over a point in the Pacific Ocean displaced about 500 km west of the city of Los Angeles. According to the predicted by the hypothetical mechanism, the main health impact should be expected to be in a deadly spot located east of the point of registration of the indicator flow. In line with this prediction, the number of deaths in Los Angeles County is increasing significantly as a result of the location of the county east relative to the point of registration of the stream where the spot with maximum negative health impacts is expected to be located. The larger magnitude of the indicator flux is likely related to a larger magnitude of the flux penetrating through the atmosphere alpha particles, resulting in a higher number of deaths.

That is, the number of deaths depends both on the distance between the observation point and the point of registration and on the magnitude of the stream. There has been a gradual decrease in deaths over the next two days after the impact. The last stream (March 9, 1995) was recorded at a time when the Sun was culminating in a point in the Pacific Ocean about 2,400 km west of the city of Los Angeles. Its lethal effect on the county is negligible because of the long distance. The above data allow estimation of the size of the deadly spot on the earth's surface: 1000 km–2000 km.

The moments of invasion of alpha particles are unpredictable, but the dates of maximum risk from them (the dates of coincidence of the directions of movement of the alpha particles and the geomagnetic vector) can be calculated according to the proposed hypothetical mechanism from the latitude data of the site [17]. For Los Angeles, the dates of maximum risk of defeat with alpha particles during an outdoor walk at noon were mentioned above - February 26 and October 15.

For the survey interval from March 1 to March 10<sup>th</sup>, 1995, 200 women died from IHD in Los Angeles County. For each day of the interval, the difference between the number of deaths during the day and the minimum number of deaths for this ten-day interval was calculated (columns 2 and 3 of Table 1). The sum of these differences is 40. Assuming that these 40 deaths were influenced by alpha particle fluxes in the interval studied, the contribution of alpha particle fluxes to female IHD mortality in Los Angeles County during the 10-day interval studied was 20%.

#### DISCUSSION & CONCLUSION

This work presents a study revealing an alarming phenomenon of correlation between the fluxes of solar alpha particles recorded by the satellites of the GOES series in the Earth's orbit and mortality from ischemic heart disease in Bulgaria.

The proposed hypothetical mechanism successfully indicates the dates of occurrence and explains the observed phenomenon based on data from satellite observations, as it was clarified for a remote from Bulgaria region-Los Angeles County, California, USA. The conclusion can be drawn, that the observed phenomenon is a planetary health problem.

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