# The Effects of Nuclear Weapons

'… We learned about an enemy who is sophisticated, patient, disciplined, and lethal. … We learned that the institutions charged with protecting … did not adjust their policies, plans and practices to deter or defeat it.' - Thomas H. Kean (Chair) and Lee H. Hamilton (Vice Chair), Preface to *The 9/11 Commission Report,* National Commission on Terrorist Attacks Upon the United States, 2004.

**Friday, March 31, 2006**

Starfish fireball photograph
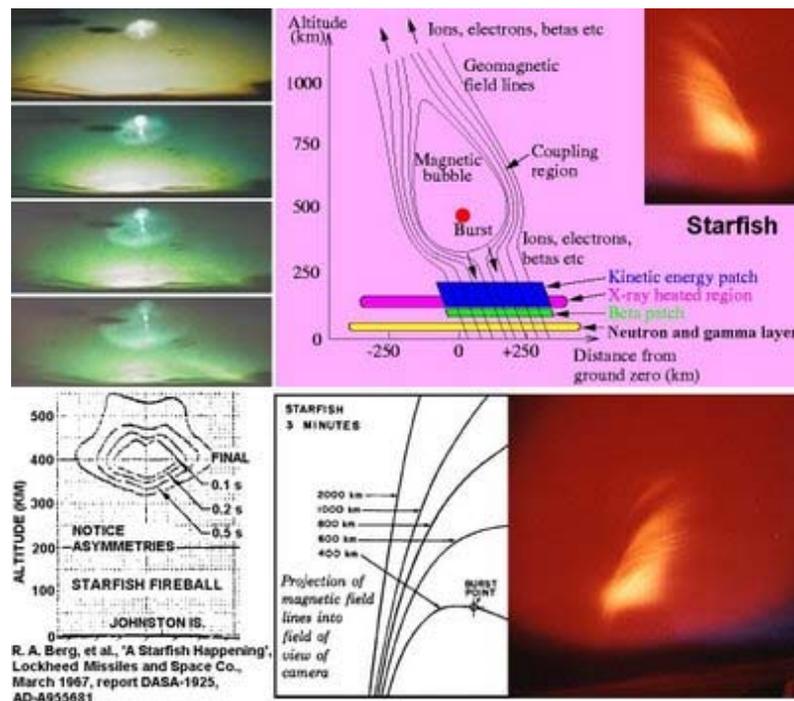
Above: seen from a mountain high above the cloud cover on Maui, the luminous *STARFISH* (1.4 Mt, 400 km, 9 July 1962) debris fireball expands in space with an initial speed of 2,000 km/sec, and has a massive vertical asymmetry due to the effects of the device and missile system.

Above: *Starfish* as seen through heavy clouds from Honolulu, Oahu, Hawaiian islands, just over 1,300 km from the 1.4 Mt detonation at 400 km altitude; for the measured EMP waveforms from this and other tests see an earlier post. For a sumary of visible and thermal effects of all the tests see another earlier post. **Below:** *Starfish* fireball (together with ionised region below burst as seen looking upward through the atmosphere from a KC-135 aircraft flying above the clouds).
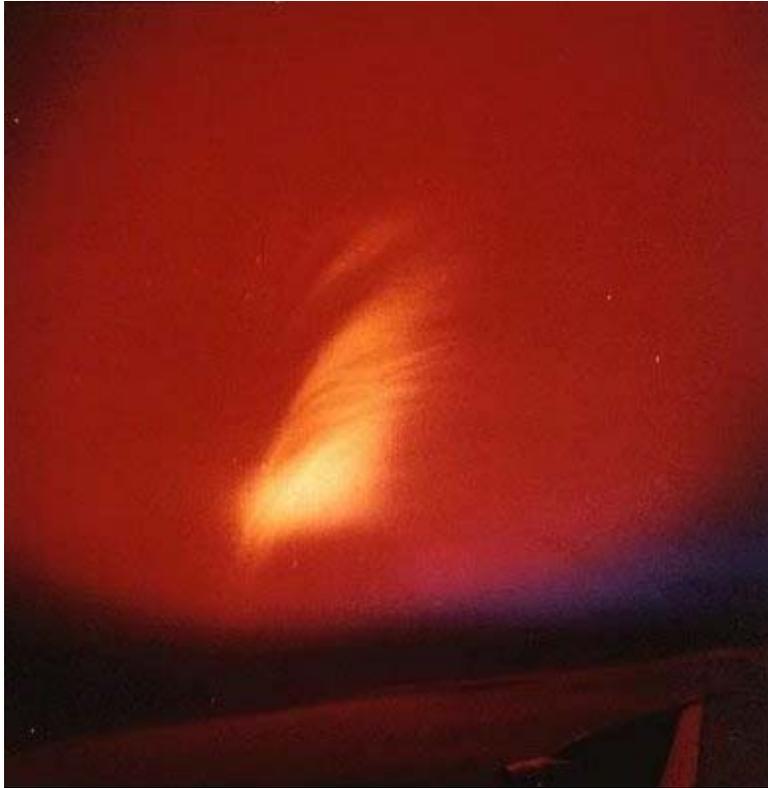
The picture above of the *Starfish* fireball is wrongly identified as just an aurora in some places on the internet. However, it is actually the debris fireball seen 3 minutes after detonation. There is air fluorescence from the atmosphere between the observer and the detonation (it is just an illusion that the glowing air appears above the fireball as well as below it, you have to remember that a large pancake shaped layer of glowing air below the fireball extends over the observer's field of view), which is excited by magnetic field-aligned radioactive fireball debris:

STARFISH H+3 MINUTES
80 mm HASSELBLAD CAMERA ON LASL KC-135
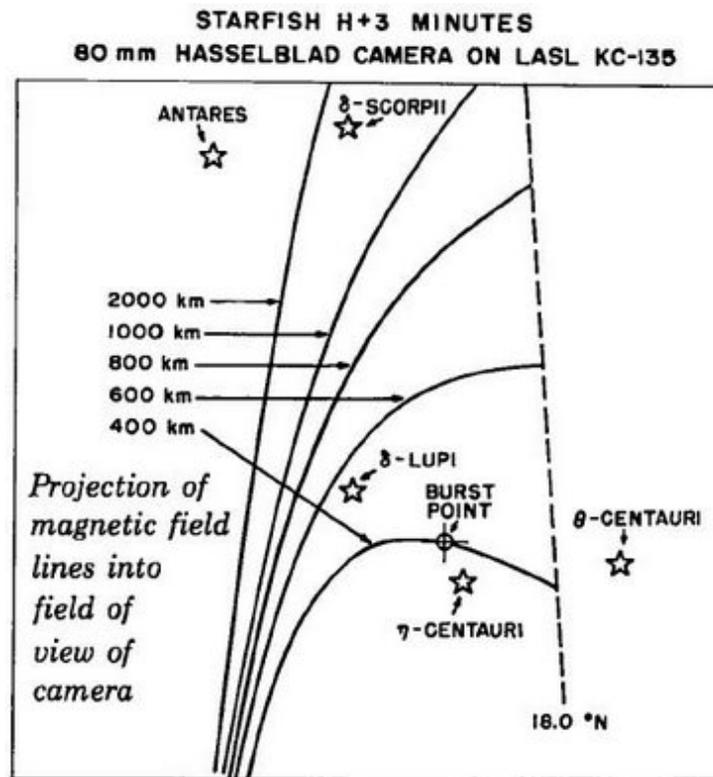
Above: this is the LA-6405 scientific analysis of the previous *Starfish* fireball photograph, showing how the fireball debris has become striated by the earth's magnetic field at 3 minutes. The debris, being ionised and thus electrically conductive, has to do more work to expand against the magnetic field (lines) than along them, so it expands preferentially along the magnetic field. However, some portion of the fireball energy is always used up expanding against the magnetic field, and this obviously creates the weak but lengthy late-time magneto-hydrodynamic (MHD) EMP discussed already. For more on the Starfish test, see the declassified preliminary report dated August 1962 online here, also DASA-1925 dated 1967 (declassified version online here), and a 1978 online report on the effects of Starfish on orbital satellites in 1962.

Credit: This illustration is taken from page 8 of Dr Herman Hoerlin's report, United States High Altitude Test Experiences, Los Alamos National Laboratory, LA-6405, 1976.

The *Starfish* test filmed from Johnston Island with a camera pointing upwards showed the outer debris fireball to be expanding at an initial rate of 2,000 km/second, and the debris had: 'separated into two parts ... the central core which expands rather slowly and ... an outer spherically expanding shell ... The diameter of the expanding shell is approximately 2 km at 500 microseconds ...' (AD-A955411, *A 'Quick Look' at the Technical Results of Starfish Prime, August 1962*.)

Within 0.04-0.1 second after burst, the outer shell - as filmed from Maui in the Hawaiian Islands (Oahu was 1,353 km from ground zero), had become elongated along the earth's magnetic field, creating an ellipsoid-shaped fireball. Visible 'jetting' of radiation up and southward was observed from the debris fireball at 20-50 seconds, and some of these jets are visible in the late time photograph of the debris fireball shown above.

'Recently analyzed beta particle and magnetic field measurements obtained from five instrumented rocket payloads located around the 1962 *Starfish* nuclear burst are used to describe the diamagnetic cavity produced in the geomagnetic field. Three of the payloads were located in the cavity during its expansion and collapse, one payload was below, and the fifth was above the fully expanded cavity. This multipoint data set shows that the cavity expanded into an elongated shape 1,840 km along the magnetic field lines and 680 km vertically across in 1.2 s and required an unexpectedly long time of about 16 s to collapse. The beta flux contained inside the cavity was measured to be relatively uniform throughout and remained at 3×10^{11} beta particles/cm^2 s for at least 7 s. The plasma continued to expand upward beyond the fully expanded cavity boundary and injected a flux measuring 2.5×10^{10} beta particles/cm^2 s at H + 34 s into the most intense region of the artificial belt. Measured 10 hours later by the Injun I spacecraft, this flux was determined to be 1×10^9 beta particles/cm^2 s.' - Palmer Dyal, 'Particle and field measurements of the *Starfish* diamagnetic cavity', *Journal of Geophysical Research,* volume 111, issue A12, page 211 (2006).

Palmer Dyal was the nuclear test Project Officer and co-author with W. Simmons of *Operation DOMINIC, FISH BOWL Series, Project 6.7, Debris Expansion Experiment,* U.S. Air Force Weapons Laboratory, Kirkland Air Force Base, New Mexico, POR-2026 (WT-2026), AD-A995428, December 1965:

'This experiment was designed to measure the interaction of expanding nuclear weapon debris with the ion-loaded geomagnetic field. Five rockets on *STARFISH* and two rockets on *CHECKMATE* were used to position instrumented payloads at various distances around the burst points. The instruments measured the magnetic field, ion flux, beta flux, gamma flux, and the neutron flux as a function of time and space around the detonations. Data was transmitted at both real and recorded times to island receiving sites near the burst regions. Measurements of the telemetry signal strengths at these sites allowed observations of blackout at 250 MHz ... the early expansion of the *STARFISH* debris probably took the form of an ellipsoid with its major axis oriented along the earth's magnetic field lines. Collapse of the magnetic bubble was complete in approximately 16 seconds, and part of the fission fragment beta particles were subsequently injected into trapped

orbits. ...

'At altitudes above 200 kilometres ... the particles travel unimpeded for several thousands of kilometres. During the early phase of a high-altitude explosion, a large percentage of the detonation products is ionized and can therefore interact with the geomagnetic field and can also undergo Coulomb scattering with the ambient air atoms. If the expansion is high enough above the atmosphere, an Argus shell of electrons can be formed as in the 1958 and 1962 test series. ... If this velocity of the plasma is greater than the local sound or Alfven speed, a magnetic shock similar to a hydro shock can be formed which dissipates a sizable fraction of the plasma kinetic energy. The Alfven velocity is $C = B/(4*\{Pi\}*\{$Ion density, in ions per cubic metre$\})^{1/2}$, where ... B is the magnetic field ... Since the *STARFISH* debris expansion was predicted and measured to be approximately 2×10^8 cm/sec and the Alfven velocity is about 2×10^7 cm/sec, a shock should be formed. A consideration of the conservation of momentum and energy indicates that the total extent of the plasma expansion proceeds until the weapon plasma kinetic energy is balanced by the $B^2/(8\{Pi\})$ magnetic field energy [density] in the excluded region and the energy of the air molecules picked up by the expanding debris. ... An estimate of the maximum radial extent of the STARFISH magnetic bubble can be made assuming conservation of momentum and energy. The magnetic field swept along by the plasma electrons will pick up ambient air ions as it proceeds outward. ...'

Conservation of momentum suggests that the initial outward bomb momentum, $M_{BOMB}V_{BOMB}$ must be equal to the momentum of the total expanding fireball after it has picked up air ions of mass $M_{AIR\ IONS}$:

$$M_{BOMB}V_{BOMB} = (M_{BOMB} + M_{AIR\ IONS})V,$$

where V is the velocity of the combined shell of bomb and air ions. The expansion of the ionized material against the earth's magnetic field slows it down, so that the maximum radial extent occurs when the initial kinetic energy $E = (1/2) M_{BOMB}V_{BOMB}^2$ has been converted into the potential energy density of the magnetic field which stops its expansion. The energy of the magnetic field excluded from the ionized shell of radius R is simply the volume of that shell multiplied by the magnetic field energy density $B^2/(8\{Pi\})$. By setting the energy of the magnetic field bubble equal to the kinetic energy of the explosion, the maximum size of the bubble could be calculated, assuming the debris was 100% ionized.

For *CHECKMATE,* they reported: 'Expansion of the debris was

mostly determined by the surrounding atmosphere which had a density of 4.8 x 10^{10} particles/cm^3. Further details of high altitude bursts are discussed here.

The report AD-A955411, *A 'Quick Look' at the Technical Results of Starfish Prime,* August 1962, states that the test was planned for 400 km altitude to test a theory that an ionised 'pancake' of air would be caused 80 km over ground zero as a 'precursor shot' to block enemy ABM radar from accurately plotting the paths of subsequent ICBM's over the target area.

This prediction failed completely, because the major beta ray and bomb debris pancake occurred not over ground zero, but 600 km north of ground zero due to the charged radiations following the magnetic field lines as they descended. The altitude of this main pancake of ionised air was 120-150 km, not 80 km. Because the slope of the Earth's magnetic field lines over Johnston Island were about 28 degrees off horizontal, the beta pancake should have been predicted to be: (height of burst - height of pancake)/(sin 28 degrees) ~ 600 km.

It shows the poor level of physical understanding existing in 1962, because this was not predicted (they had apparently just tried to extrapolate from observations of the *Teak* test in 1958 which was at only 77 km altitude). Anyway, the pancake 600 km north of ground zero began to form at 70 milliseconds after the *Starfish* test. The magnetic field line running through the burst at 28 degrees [reference: R.A. Berg et al., *A Starfish Happening,* Lockheed Missiles and Space Co., March 1967, DASA-1925, AD-A955681, c2, p22] off vertical reached an altitude of 900 km above the magnetic equator and it also carried some beta radiation and debris initially upward to the south, where it followed the magnetic field line to its maximum and then back down into the atmosphere, creating the aurora seen from Tongatapu.

The Atomic Weapons Establishment has a page with labelled colour photos of all American tests, and another page which explains this MHD-EMP mechanism:

'Bursts below around 100km altitude produce relatively well defined fireball regions which rise and expand rapidly, examples being the *Orange* and *Bluegill* events.

'Detonations at higher altitudes [100-200 km] are in the "UV (ultraviolet radiation) fireball" regime; the debris blast wave expands and sweeps up air which becomes very hot. This then radiates UV, which is readily absorbed by the cold air in front of the blast wave, resulting in ionised air which is approximately transparent to further UV radiation from the blast wave. These bursts are therefore characterised by two "fireballs" - the debris air

blast wave expansion is preceded by a radiation/ionisation front. The radiation front will be up/down asymmetric since mean free paths are longer in the less dense air above the detonation altitude. An example is the *Checkmate* event where both fronts are clearly visible in the photograph taken from Johnston Island [*for large time-labelled* Checkmate *film stills, see* here *and* here]:
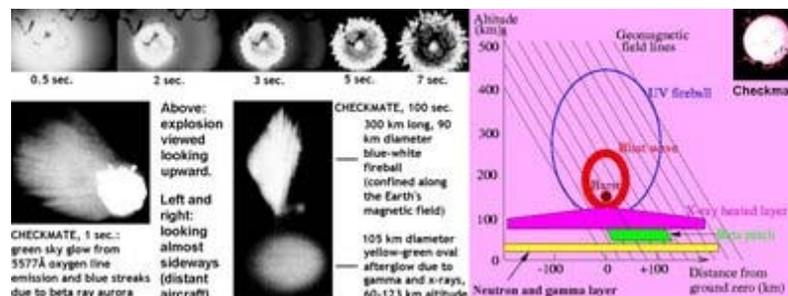

Above: *CHECKMATE* detonation horizontal view (seen from a distant aircraft) compared to the view looking upwards from Johnston Island. It was detonated during the Cuban missiles crisis: 'Observers on Johnston Island saw a green and blue circular region surrounded by a blood-red ring formed overhead that faded in less than 1 minute. Blue-green streamers and numerous pink striations formed, the latter lasting for 30 minutes. Observers at Samos saw a white flash, which faded to orange and disappeared in about 1 minute.' (Defense Nuclear Agency report DNA-6040F, AD-A136820, p. 241.)

'Detonations above the [100-200 km burst altitude] UV fireball regime are characterised by so-called "patch deposition"; the expanding debris compresses the geomagnetic field lines because the expansion velocity is greater than the Alfven speed at these altitudes. The debris energy is transferred to air ions in the resulting region of tightly compressed magnetic field lines. Subsequently the ions, charge-exchanged neutrals, beta-particles etc escape up and down the field lines. Those particles directed downwards are deposited in patches at altitudes depending on their mean free paths. These particles move along the magnetic field lines, and so the patches are not found directly above ground zero. Uncharged radiation (gamma-rays, neutrons and X-rays) is deposited in layers which are centered directly under the detonation point. The *Starfish* event (1.4 megatons at 400 km) was in this altitude regime:

Starfish
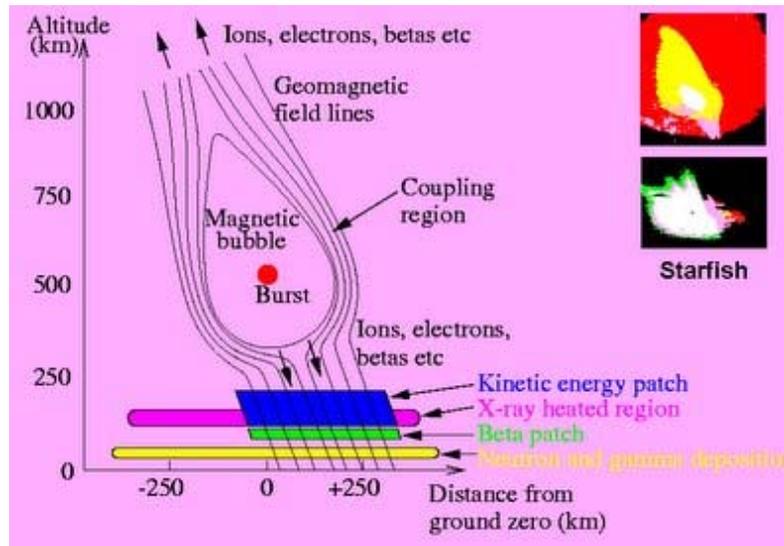
'Detonations at thousands of kilometres altitude are contained purely magnetically. Expansion is at less than the local Alfven speed, and so energy is radiated as hydromagnetic waves. Patch depositions are again aligned with the field lines.' - Atomic Weapons Establishment internet page, *Schematic summaries of some of the principal physics phenomena.*
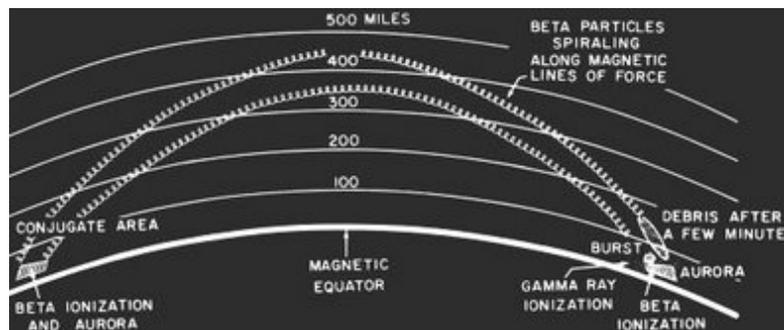
Above: 'Geomagnetically trapped MeV beta-particles generated by a high altitude nuclear burst can pose a serious threat to space-based systems, especially satellites.

'The particles may be trapped in the magnetosphere because the geomagnetic field strength is nonuniform (the field is approximately dipolar, therefore decreasing away from the Earth's surface); particles moving along a field line towards Earth will experience a retarding force due to simultaneous conservation of their magnetic moment and energy, which may eventually lead to "reflection". Such a magnetic field configuration is termed a "magnetic mirror".

'Early experiments in controlled thermonuclear fusion physics were

carried out on "mirror machines" which were magnetic bottles based on the same principal. Beta-particles trapped in the geomagnetic field may bounce back and forth along the magnetospheric field lines, never reaching the dense atmosphere below. The radiation is not confined to the injection longitude, but spreads around the Earth due to the magnetic field gradient and curvature drifts which are well known in plasma particle kinetics. This is exactly analagous to the mechanism trapping natural Van-Allen belt radiation, the differences lying only in the charged particle injection mechanism and their typical energies.

'A Monte-Carlo model has been developed to predict the space radiation flux following a high altitude nuclear explosion. The following images show sample code outputs; the first three figures are views from above the North pole of the Earth (represented as a circle). The progress of radiation around the Earth over several minutes is apparent in the contour plots. [The accompanying illustration is labelled for debris radius of 500 km and a burst at 399 km - the precise burst altitude of *Starfish* - and shows the electron belt stretching a third of the way around the Earth's equator after 3 minutes, and completely surrounding the earth at 10 minutes after burst. The averaged beta particle radiation flux in the belt is about 2×10^{14} electrons per square metre per second at 3 minutes after burst but falls to a quarter of that at 10 minutes.]

'... the level will eventually drop off since some particles are confined to reflect close to the equator, never reaching high latitudes. Also the atmosphere effectively mops up particles that reflect below an altitude where the air density becomes appreciable. The radiation belt evolves with time, taking between days and months to return to the ambient state as particles are gradually scattered by atmospheric and magnetospheric effects.' - Atomic Weapons Establishment, Nuclear Effects Group - Artificial Radiation Belt Modelling

The Atomics Weapons Establishment also has a time-motion film of the Monte Carlo simulation of the evolution and decay of the radiation belt from *Starfish* here. This remarkable film is logarithmically scaled so you get to see the way the intensities vary above the Earth's surface from 100 seconds to nearly 100 years after the burst. As the time goes on, the radiation belt pushes up to higher altitudes and becomes more concentrated over the magnetic equator.

For the first 5 minutes, the *Starfish* radiation belt has an altitude range of about 200-400 km and reaches from 27 degrees south of the magnetic equator to 27 degrees north of it. At 1 day after burst, the radiation belt height has increased to the 600-1,100 km zone, and the average flux is 1.5×10^{12} electrons/m^2/sec. At 4 months the altitude for this average flux (plus or minus a factor of 4) has

increased to 1,100-1,500 km, and it is covering a smaller latitude range around the magnetic equator, from about 20 degrees north to about 20 degrees south. At 95 years after burst, the remaining electrons will be concentrated 2,000 km above the magnetic equator in a shell only 50 km thick, covering a latitude range of only plus or minus 10 degrees from the equator.

Glasstone and Dolan explain how test data showed these effects in *The Effects of Nuclear Weapons* 1977, pp. 45 *et seq.*: 'The geomagnetic field exerts forces on charged particles, i.e., beta particles (electrons) and debris ions, so that these particles are constrained to travel in helical (spiral) paths along the field lines. Since the earth behaves like a magnetic dipole, and has north and south poles, the field lines reach the earth at two points, called "conjugate points," one north of the magnetic equator and the other south of it. Hence, the charged particles spiraling about the geomagnetic field lines will enter the atmosphere in corresponding conjugate regions. It is in these regions that the auroras may be expected to form.

'For the high-altitude tests conducted in 1958 and 1962 in the vicinity of Johnston Island, the charged particles entered the atmosphere in the northern hemisphere between Johnston Island and the main Hawaiian Islands, whereas the conjugate region in the southern hemisphere region was in the vicinity of the Samoan, Fiji, and Tonga Islands. It is in these areas that auroras were actually observed, in addition to those in the areas of the nuclear explosions.

'Because the beta particles have high velocities, the beta auroras in the remote (southern) hemisphere appeared within a fraction of a second of those in the hemisphere where the bursts had occurred. The debris ions, however, travel more slowly and so the debris aurora in the remote hemisphere, if it is formed, appears at a somewhat later time. The beta auroras are generally most intense at an altitude of 30 to 60 miles, whereas the intensity of the debris auroras is greatest in the 60 to 125 miles range. Remote conjugate beta auroras can occur if the detonation is above 25 miles, whereas debris auroras appear only if the detonation altitude is in excess of some 200 miles.

'For bursts at sufficiently high altitudes, the debris ions, moving along the earth's magnetic field lines, are mostly brought to rest at altitudes of about 70 miles near the conjugate points. There they continue to decay and so act as a stationary source of beta particles which spiral about the geomagnetic lines of force. When the particles enter a region where the strength of the earth's magnetic field increases significantly, as it does in the vicinity of the conjugate points, some of the beta particles are turned back (or reflected). Consequently, they may travel back and forth, from one conjugate region to the other, a number of times before they are

eventually captured in the atmosphere.

'In addition to the motion of the charged particles along the field lines, there is a tendency for them to move across the lines wherever the magnetic field strength is not uniform. This results in an eastward (longitudinal) drift around the earth superimposed on the back-and-forth spiral motion between regions near the conjugate points. Within a few hours after a high-altitude nuclear detonation, the beta particles form a shell completely around the earth. In the *Argus* experiment, in which the bursts occurred at altitudes of 125 to 300 miles, well-defined shells of about 60 miles thickness, with measurable electron densities, were established and remained for several days. This has become known as the "*Argus* effect." Similar phenomena were observed after the *Starfish Prime* and other high-altitude nuclear explosions.'

We have already seen in a previous post that Dr Herman Hoerlin writes in Los Alamos National Laboratory report LA-6405, United States High Altitude Test Experiences, p. 1:

'The degrading effects of increased ionospheric ionization on commercial and aircraft communications-mainly in the LF, MF, and HF frequency ranges—extended over the whole Pacific Ocean area. They lasted for many days after the three megaton-range [high altitude] explosions [*Teak, Orange,* and *Starfish*]. They were less severe—in some cases even beneficial-for VHF and VLF frequencies, thus providing guidance for emergency situations.

'The formation of an artificial radiation belt of such high electron fluxes and long lifetimes as occurred after the Starfish event was unexpected; so were the damages sustained by three satellites in orbit [the Ariel, Traac, and Transit 4B satellites failed; Cosmos V, Injun I and Telstar suffered only minor degradation, moderate solar cell damage by electrons].

'However, the vast amount of knowledge gained by the observations of the artificial belts generated by *Starfish, Argus,* and the Russian high-altitude explosions [*notice that America had data on the Russian tests back in 1976, when this report was written*] far outweighed the information which would have been gained otherwise. A few extrapolations are made to effects on manned space flight under hypothetical circumstances...'

Page 26 states: 'for a satellite in a polar circular earth orbit, the daily dose would have been at the very least 60 rads in a heavily shielded vehicle at *Starfish* time plus four months'.

Judging by the Atomic Weapons Establishment computer simulation discussed above, at 4 months after *Starfish* this radiation, the radiation belt was at 1,100-1,500 km altitude, and it

covered a latitude range around the magnetic equator, from 20 degrees north to 20 degrees south. Because NASA launches rockets from near the equator to gain the speed of earth's spin, they would be exposed to to this radiation. Obviously a space rocket going to the moon will only spend seconds in the radiation belt, and at a 60 rads/day this will be trivial, but astronauts in capsules in low earth orbits, where the spacecraft remained in the radiation belts for a long time, would receive more substantial doses of radiation. I'll discuss this subject of radiation in space in a later post. There's a lot more cosmic radiation on the moon than on earth, for instance, because there is no atmosphere. The earth's atmosphere has the same mass cover shielding as being behind 10 metres of water. Radiation is a general hazard in outer space.

Click here for the DTRA (U.S. Defence Threat Reduction Agency) presentation of the effects of space burst radiation belts on low earth orbit satellites. Another report on the same topic, by Dennis Papadopoulos of the University of Maryland, is available by clicking here.

EMP is extensively discussed here, here, here, and here. E.g.:

In December 1992, the U.S. Defence Nuclear Agency spent $288,500 on contracting 200 Russian scientists to produce a 17-chapter analysis of effects from the Soviet Union's nuclear tests, which included vital data on three underwater nuclear tests in the arctic, as well three 300 kt high altitude tests at altitudes of 59-290 km over Kazakhstan. In February 1995, two of the military scientists, from the Russian Central Institute of Physics and Technology, lectured on the electromagnetic effects of nuclear tests at Lawrence Livermore National Laboratory. The Soviet Union had first suffered electromagnetic pulse (EMP) damage to electronic blast instruments in their 1949 test. Their practical understanding of EMP damage eventually led them, on Monday 22 October 1962, to detonate a 300 kt missile-carried thermonuclear warhead at an altitude of 300 km (USSR test 184). That was at the very height of the Cold War and the test was detected by America: at 7 pm that day, President John F. Kennedy, in a live TV broadcast, warned the Soviet Union's Premier Khrushchev of nuclear war if a nuclear missile was launched against the West, even by an accident: 'It shall be the policy of this nation to regard any nuclear missile launched from Cuba against any nation in the Western hemisphere as an attack by the Soviet Union on the United States, requiring a full retalitory response upon the Soviet Union.' That Russian space missile nuclear test during the Cuban missiles crisis *deliberately* instrumented the civilian power infrastructure of populated areas, unwarned, in Kazakhstan to assess EMP effects on a 570 km long civilian telephone line and a 1,000 km civilian electric power cable!

This test produced the worst effects of EMP ever witnessed (the more widely hyped 1.4 Mt, 400 km burst *STARFISH* EMP effects were trivial by comparison, because of the weaker natural magnetic field strength at Johnston Island). The bomb released 10^{25} MeV of prompt gamma rays (0.13% of the bomb yield). The 550 km East-West telephone line was 7.5 m above the ground, with amplifiers every 60 km. All of its fuses were blown by the induced peak current, which reached 2-3 kA at 30 microseconds, as indicated by the triggering of gas discharge tubes. Amplifiers were damaged, and lightning spark gaps showed that the potential difference reached 350 kV. The 1,000 km long Aqmola-Almaty power line was a lead-shielded cable protected against mechanical damage by spiral-wound steel tape, and buried at a depth of 90 cm in ground of conductivity 10^{-3} S/m. It survived for 10 seconds, because the ground attenuated the high frequency field, However, it succumbed completely to the low frequency EMP at 10-90 seconds after the test, since the low frequencies penetrated through 90 cm of earth, inducing an almost direct current in the cable, that overheated and set the power supply on fire at Karaganda, destroying it. Cable circuit breakers were only activated when the current finally exceeded the design limit by 30%. This limit was designed for a brief lightning-induced pulse, not for DC lasting 10-90 seconds. By the time they finally tripped, at a 30% excess, a vast amount of DC energy had been transmitted. This overheated the transformers, which are vulnerable to short-circuit by DC. Two later 300 kt Soviet Union space tests, with similar yield but low altitudes down to 59 km, produced EMPs which damaged military generators.
Posted by nige at 2:16 PM

2 comments:

nige said...

The mechanism for why electrons "reflect" at "mirror points" is actually that the electrons follow magnetic field lines which converge near poles, bringing electrons together into a smaller space so the electric charge density increases.

These regions of high electric charge density near the poles act as "mirrors" by the simple Coulomb backscatter mechanism: like charges repel.

In other words, when electric charges get near the pole, the magnetic field lines converge together, so that all the electric charges travelling along those magnetic field lines also converge into a smaller volume of space. This makes the charge density increase until it is strong enough to repel approaching particles back they way that they came (Coulomb "reflection" or "mirroring", which is similar to the Coulomb reflection of alpha particles by positive nuclei which Rutherford's assistants used in their famous

experiment of backscatter from gold foil, or you get a similar kind of effect when you fire low energy beta particles at metals, where some percentage of the beta particles are scattered back towards the source by Coulomb repulsion of atomic electrons).

A fairly clear page that illustrates all the motions of charges in Earth's magnetic field is, particularly how mirroring occurs above poles, is:

http://www.phy6.org/Education/wtrap1.html

All the charged radiation also loses some energy when it gets reflected at mirror points. If the altitude of the mirror points for the magnetic field lines in question is low in the strong charge density near the poles, then the mirror points may be within the atmosphere so that particles hit air molecules and give off auroral radiations, instead of being reflected back. The Van Allen belts are continually being replenished by charged particles from the solar wind and other charged radiation from space.

The person who first analysed the mechanism of a magnetic field trapping radiation in space was the Greek elevator engineer Nicholas Christofilos.

He invented and patented a synchrotron for high energy particle physics research, which was initially ignored by physicists, then he realised that electrons will be trapped in a fairly similar way in space by the Earth's magnetic field.

He didn't predict that such radiation belts already exist in space, and instead wanted to test his theory by putting a source of electrons into space. He impressed Edward Teller who got the American government to fund Operation Argus, sending 3 nuclear bombs into space in 1958, to see if the radiation would be trapped by the Earth's magnetic field.

While Argus was still being planned, Van Allen discovered the natural belts because he had a geiger counter in the first American space satellite, Explorer I. The count rate initially went up to the maximum rate measurable, then fell to zero, indicating that the tube was saturated (fully ionized) by such intense radiation that it could no longer give out individual pulses. The later Explorer satellites had to utilise shielded geiger counters that were less sensitive.

Explorer IV in summer of 1958 mapped out the artificial radiation belts created by the high altitude Argus nuclear tests.

7:17 PM

nige said...

Sorry, I didn't understand the "mirroring" mechanism at work at the poles. I thought it was just Coulomb repulsion due to the abundance of electric charges where the magnetic field lines are converging near the poles.

In fact, it is entirely different and very subtle indeed, see the illustrated section headed "Mirroring" at http://www.phy6.org/Education/wtrap2.html

Even a single electron spiralling around a magnetic field line will be reflected at a mirror point (without any requirement for other charges to be concentrated there):

"*Mirroring*

(drawing)

"*The fact that the magnetic force is perpendicular to magnetic field lines means that when a particle spirals around a cone of converging field lines, that force is always slightly tilted backwards (drawing).*

"*By the laws of motion, any force can always be resolved into the sum of mutually perpendicular forces, each controlling the motion in its direction. The "radial force" perpendicular to the axis of the cone (drawing) keeps the ion or electron turning in a circle around that axis, and is balanced (as noted above) by the centrifugal force of that rotation.*

"*In addition, however, there will also exist a small force parallel to the axis, repelling the particle away from the tip of the cone. That added force gradually slows down the particle's advance down the axis and finally reverses it, causing it to "mirror" and bounce back.*"

7:53 PM

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- British Home Office public civil defence manual with improvised countermeasures against gas, fire and the blast and flying debris from explosions, The Protection of Your Home Against Air-Raids (7.8 MB PDF file)
- PDF of 181 key pages from the U.K. Government official World War II history by Terence O'Brien, Civil Defence, H.M. Stationery Office, 1955; proving how exaggerations of the aerial bombing threat prior to World War II falsely made civil defence appear hopeless by predicting 121 casualties per ton of bombs (page 11) with delivery of 600 tons per day assumed (p. 96) leading to as many as 2,000,000 casualties per month of the war. Some 25%

of the bombs were assumed to be lingering mustard gas liquid, which contaminates for long periods, analogous to radioactive fallout contamination. These precise but totally misleading "predictions" prior to World War II made civil defence look hopeless, just like modern guesswork about the size and type of attack by some people who naively believe that scare mongering exaggerations will make the world peaceful and disarmed, despite the fact that in the 1930s it increased proliferation and threats from aggressors, while reducing civil defence preparedness. Anderson shelters were not even tested against explosions until mid-1939 (p. 196). These gross exaggerations of weapons effects and enemy bombing strategy are blamed by Herman Kahn for causing World War II by intimidating Prime Minister Chamberlain into appeasing aggressors while the aggressors expanded their empire and military quicker than Britain could rearm; by the time war was declared, Britain was facing a monster-sized enemy, not the smaller threat it could have handled very easily in 1935 or so. In fact, the one threat - gas - that was properly defended against (everyone in Britain was issued with gas masks), did prevent the use of gas by the Nazis (except in gas chambers), since aggressors only used weapons against which enemies had ineffective defences. The 121 casualties/ton due to no civil defence scales up to 20 kt nuclear bombs by the "two-thirds power" of yield (the "equivalent megatonnage" casualty scaling law) to predict 90,000 casualties, similar to Nagasaki. The actual casualty rate for 1940s Morrison "table" shelters in homes was well under 4 casualties per ton, equivalent to under 3,000 blast casualties for a 20 kt nuclear bomb. In WWII, the effects of bombing were massively reduced by informed civil defence duck and cover under strong tables, even where houses were demolished by blast

- PDF of 53 key pages of civil defence material from the 1964 edition of The Effects of Nuclear Weapons, which was deleted in the 1977 (Carter Administration) edition
- PDF of key civil defence sections in the 1950, 1957, and 1962/4 editions of The Effects of Atomic/Nuclear Weapons, which were removed from the 1977 edition published under President Carter's administration
- PDF of 1959 U.S. Congressional Hearings, The Biological and Environmental Effects of Nuclear War (nuclear test data and testimony by Herman Kahn on the civil defense to make deterrence of nuclear intimidation credible)
- PDF of 1957 U.S. Congressional Hearings, The Nature of Radioactive Fallout and Its Effects on Man (experimental test of simple hand made fallout prediction system at the Tewa, Zuni, Flathead and Navajo H-bomb tests of Operation Redwing, 1957, and fallout field decontamination research at those tests)
- PDF file of some key pages from the U.K. Home Office "Civil Defence Rescue Manual" (H. M. Stationery Office, London, 1st edition, 1952), the "Civil Defence Instructors Notes, Rescue Section" (H. M. Stationery Office, London, 1st edition, 1957), and the 1960 "Civil Defence Handbook No. 7, Rescue"
- Donald R. Richmond, John T. Yelverton and E. Royce Fletcher's report, ADP005337, New Airblast Criteria for Man, comparing blast casualty rates for personnel exposed in the open (overpressure and wind pressure) to casualties among those who have taken cover in open foxholes or similar depressions which shield the blast wind pressure and associated drag and

debris hazards

- David I. Feinstein's IIT Report AD676183, Casualty Prediction Comparisons (comparing casualties among people standing up and lying prone for blast translation, flying debris, and thermal radiation in the open and inside the predominant Hiroshima-type wooden houses with those in three types of modern multistory city buildings exposed to a 10 megaton nuclear explosion, where the blast winds last 10 times longer than at Hiroshima)
- Dr Carl E. Baum's EMP theory and interaction notes
- The Atomic Heritage Foundation
- Radiation Effects Research Foundation lumps data together to cover up benefits of low dose radiation in Hiroshima and Nagasaki Life Span Study!
- DTRA (Defense Threat Reduction Agency) Nuclear testing histories (PDF files)
- Samuel Glasstone and Philip J. Dolan
- Carl F. Miller's fallout research at nuclear tests
- British Home Office Scientific Advisory Branch
- Samuel Cohen's book about the collateral damage averting, invasion-deterring neutron bomb he invented, and the lying political attacks he endured as a result
- Jerry Emanuelson's review of EMP facts, including the direct dependence of the EMP on the Earth's natural magnetic field strength at the burst location
- Essays by 1950s American nuclear weapon effects test (and neutron bomb design) experts, discrediting anti-civil defence propaganda
- Neutron bomb inventor Samuel Cohen's 2006 book on the history of the neutron bomb, the most moral weapon ever invented due to its purely military deterrent capabilities, and the pesudo-scientific propaganda war he has had to endure from the enemies of deterrence
- Karl-Ludvig Grønhaug's EMP reports page with useful PDF downloads on prompt EMP and MHD-EMP measurements from nuclear tests (Norwegian language)
- Colonel Derek L. Duke's factual book on nuclear weapons accidents, *Chasing Loose Nukes, as told to Fred Dungan*
- The H-Bomb and the birth of the Universe: 'For 100 Million years after time began, the universe was dark as pitch. The clouds of hydrogen condensed into huge nuclear fireballs. That moment-when the universe first lit up-was the moment of creation that matters...' (Discover Magazine, v. 23, No. 12, by Tim Folger)
- American *EMP Interaction* manual: comprehensive theory of both the EMP source mechanism and the EMP pick-up in cables and antenna by electromagnetic inductance (30 MB PDF file)
- British Mission to Japan, *The Effects of the Atomic Bombs at Hiroshima and Nagasaki*, H. M. Stationery Office, London, 1946 (high quality 42.5 MB pdf file).
- 1950 edition (high quality 82.7 MB PDF file) of U.S. Department of Defense book *The Effects of Atomic Weapons*
- 1957 edition (high quality 90.8 MB PDF file) of subsequently deleted sections on nuclear tests of civil defense countermeasures from U.S. Department of Defense book *The Effects of Nuclear Weapons*
- 1957 edition (low quality 30.6 MB PDF file) of entire U.S. Department of Defense book *The Effects of Nuclear Weapons*

- 1962/64 edition (high quality 188 MB PDF file) of major revised sections in the U.S. Department of Defense book *The Effects of Nuclear Weapons*
- 1962/64 edition (high quality 43.8 MB PDF file) of 74 pages of subsequently deleted material dealing with thermal ignition of houses at nuclear tests and civil defense countermeasures chapter, from the U.S. Department of Defense book *The Effects of Nuclear Weapons*
- 1977 edition (single 36.8 MB PDF file) of U.S. Department of Defense book *The Effects of Nuclear Weapons*
- U.S. Pacific nuclear test effects reports library; documents available on line as PDF files
- U.S. Department of Energy Opennet Documents Online (includes many Nevada nuclear test reports as PDF files)
- Defense Technical Information Center (DTIC)'s Scientific and Technical Information Network (STINET) Service (other declassified Nevada and Pacific test reports)
- THAAD Goes Another ABM Test

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