

Starfish Prime

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Coordinates: 16°28′N 169°38′W﻿ / ﻿16.467°N 169.633°W﻿ / 16.467; -169.633

Starfish Prime was a high-altitude nuclear test conducted by the United States of America on July 9, 1962, a joint effort of the Atomic Energy Commission (AEC) and the Defense Atomic Support Agency (which became the Defense Nuclear Agency in 1971). Launched via a *Thor* rocket and carrying a W49 thermonuclear warhead (manufactured by Los Alamos Scientific Laboratory) and a Mk. 4 reentry vehicle, the explosion took place 250 miles (400 kilometers) above a point 19 miles (31 kilometers) southwest of Johnston Island in the Pacific Ocean. It was one of five tests conducted by the USA in outer space as defined by the FAI. It produced a yield equivalent to 1.4 megatons of TNT.

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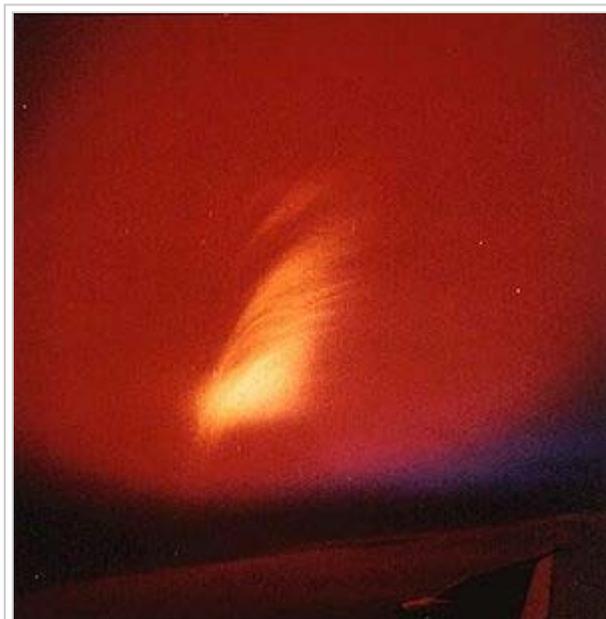
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Operation Fishbowl

Main article: Operation Fishbowl

The Starfish test was one of five high altitude tests grouped together as Operation Fishbowl within the larger Operation Dominic, a series of tests in 1962 begun in response to the Soviet announcement on August 30, 1961 that they were ending a three year moratorium on testing.^[1]

In 1958, the United States had completed six high-altitude nuclear tests, but the high-altitude tests of that year produced many unexpected results and raised many new questions. According to the U.S. Government Project Officer's Interim Report on the Starfish Prime project, "Previous high-altitude nuclear tests: TEAK, ORANGE, and YUCCA, plus the three ARGUS shots were poorly instrumented and hastily executed. Despite thorough studies of the meager data, present models of these bursts are sketchy and tentative. These models are too uncertain to permit extrapolation to other altitudes and yields with any confidence. Thus there is a strong need, not only for better instrumentation, but for



The debris fireball stretching along Earth's magnetic field [7] with air-glow aurora as seen at 3 minutes from a KC-135 surveillance aircraft



The flash created by the explosion as seen through heavy cloud cover from Honolulu 1,445 km away

further tests covering a range of altitudes and yields."^[2]

The Starfish test was originally planned as the second in the Fishbowl series, but the first launch (Bluegill) was lost by the radar tracking equipment and had to be destroyed in flight.

The initial Starfish launch attempt on June 20 was aborted in flight due to failure of the Thor launch vehicle. The Thor missile flew a normal trajectory for 59 seconds; then the rocket engine stopped, and the missile began to break apart. The range safety officer ordered the destruction of the missile and the warhead. The missile was between 30,000 and 35,000 feet (between 9.1 and 10.7 km) in altitude when it was destroyed. Parts of the missile and some radioactive contamination fell upon Johnston Island and nearby Sand Island and the surrounding ocean.^[3]

The Starfish Prime explosion

On 9 July 1962, at nine seconds after midnight, Johnston Island local time (which was 8 July, Honolulu time, at nine seconds after 11 p.m.), the Starfish Prime test was successfully detonated at an altitude of 400 kilometres (250 mi). The coordinates of the detonation were 16 degrees, 28 minutes North latitude, 169 degrees, 38 minutes West longitude.^[4] The actual weapon yield was very close to the design yield, which has been described by various sources at different values in the very narrow range of 1.4 to 1.45 megatons (6.0 PJ).

The Thor missile carrying the Starfish Prime warhead actually reached a maximum height of about 1100 km (just over 680 miles), and the warhead was detonated on its downward trajectory when it had fallen to the programmed altitude of 400 kilometres (250 mi). The nuclear warhead detonated at 13 minutes and 41 seconds after liftoff of the Thor missile from Johnston Island.^[5]



Another view of Starfish Prime through thin cloud, as seen from Honolulu

Starfish Prime caused an electromagnetic pulse which was far larger than expected, so much larger that it drove much of the instrumentation off scale, causing great difficulty in getting accurate measurements. The Starfish Prime electromagnetic pulse also made those effects known to the public by causing electrical damage in Hawaii, about 1,445 kilometres (898 mi) away from the detonation point, knocking out about 300 streetlights, setting off numerous burglar alarms and damaging a telephone company microwave link. The EMP-damaged microwave link shut down telephone calls from Kauai to the other Hawaiian islands.^[4]

A total of 27 small rockets were launched from Johnston Island to obtain experimental data from the Starfish Prime detonation. In addition, a large number of rocket-borne instruments were launched from a firing area at Barking Sands, Kauai in the Hawaiian Islands.^[6]

A very large number of United States military ships and aircraft were operating in support of Starfish Prime in the Johnston Island area and across the nearby North Pacific region.

A few military ships and aircraft were also positioned in the region of the South Pacific Ocean near the Samoan Islands. This location was at the southern end of the magnetic field line of the Earth's magnetic field from position of the nuclear detonation, an area known as the **southern conjugate region** for the test. In addition, an uninvited scientific expeditionary ship from the Soviet Union was stationed near Johnston Island for the test and another Soviet scientific expeditionary ship was located in the southern conjugate region near the Samoan Islands.^[7]

After the Starfish Prime detonation, bright auroras were observed in the detonation area as well as in the southern conjugate region on the other side of the equator from the detonation. According to one of the first technical reports, "The visible phenomena due to the burst were widespread and quite intense; a very large area of the Pacific was illuminated by the auroral phenomena, from far south of the south magnetic conjugate area (Tongatapu) through the burst area to far north of the north conjugate area (French Frigate Shoals). . . . At twilight after the burst, resonant scattering of light from lithium and other debris was observed at Johnston and French Frigate Shoals for many days confirming the long time presence of debris in the atmosphere. An interesting side effect was that the Royal New Zealand Air Force was aided in anti-submarine maneuvers by the light from the bomb."^[6]

In part, these auroral effects were predicted by Nicholas Christofilos, a scientist who had earlier worked on the Operation Argus high-altitude nuclear shots.

According to U.S. atomic veteran Cecil R. Coale, some hotels in Hawaii offered "rainbow bomb" parties on their roofs for Starfish Prime, contradicting some reports that the artificial aurora was unexpected.

Pages 19–21 of "A 'Quick Look' at the Technical Results of Starfish Prime", August 1962 states [8]:

"At Kwajalein, 1,400 [nautical] miles [2,600 km; 1,600 mi] to the west, a dense overcast extended the length of the eastern horizon to a height of 5 or 8 degrees. At 0900 GMT a brilliant white flash burned through the clouds rapidly changing to an expanding green ball of irradiance extending into the clear sky above the overcast. From its surface extruded great white fingers, resembling cirro-stratus clouds, which rose to 40 degrees above the horizon in sweeping arcs turning downward toward the poles and disappearing in seconds to be replaced by spectacular concentric cirrus like rings moving out from the blast at tremendous initial velocity, finally stopping when the outermost ring was 50 degrees overhead. They did not disappear but persisted in a state of frozen stillness. All this occurred, I would judge, within 45 seconds. As the greenish light turned to purple and began to fade at the point of burst, a bright red glow began to develop on the horizon at a direction 50 degrees north of east and simultaneously 50 degrees south of east expanding inward and upward until the whole eastern sky was a dull burning red semicircle 100 degrees north to south and halfway to the zenith obliterating some of the lesser stars. This condition, interspersed with tremendous white rainbows, persisted no less than seven minutes."

"At zero time at Johnston, a white flash occurred, but as soon as one could remove his goggles, no intense light was present. A second after shot time a mottled red disc was observed directly overhead and covered the sky down to about 45 degrees from the zenith. Generally, the red mottled region was more intense on the eastern portions. Along the magnetic north-south line through the burst, a white-yellow streak extended and grew to the north from near zenith. The width of the white streaked region grew from a few degrees at a few seconds to about 5-10 degrees in 30 seconds. Growth of the auroral region to the north was by addition of new lines developing from west to east. The white-yellow auroral streamers receded upward from the horizon to the north and grew to the south and at about 2 minutes the white-yellow bands were still about 10 degrees wide and extended mainly from near zenith to the south. By about two

minutes, the red disc region had completed disappearance in the west and was rapidly fading on the eastern portion of the overhead disc. At 400 seconds essentially all major visible phenomena had disappeared except for possibly some faint red glow along the north-south line and on the horizon to the north. No sounds were heard at Johnston Island that could be definitely attributed to the detonation."

"Strong electromagnetic signals were observed from the burst, as were significant magnetic field disturbances and earth currents."^[6]

In 2006, Palmer Dyal described the particle and field measurements of the Starfish diamagnetic cavity and the injected beta flux into the artificial radiation belt in the *Journal of Geophysical Research* ^[8]. His measurements describe the explosion from 0.1 milliseconds to 16 minutes after the detonation.

After effects

While some of the energetic beta particles followed the Earth's magnetic field and illuminated the sky, other high-energy electrons became trapped and formed radiation belts around the earth. There was much uncertainty and debate about the composition, magnitude and potential adverse effects from this trapped radiation after the detonation. The weaponeers became quite worried when three satellites in low earth orbit were disabled. These man-made radiation belts eventually crippled one-third of all satellites in low earth orbit. Seven satellites were destroyed as radiation knocked out their solar arrays or electronics, including the first commercial relay communication satellite ever, Telstar.^[9] Detectors on Telstar, TRAAC, Injun, and Ariel 1 were used to measure distribution of the radiation produced by the tests.^[10]

In 1963, Brown et al. reported in the *Journal of Geophysical Research* that Starfish Prime had created a belt of MeV electrons, and Bill Hess reported in 1968 that some Starfish electrons remained for five years. Others reported that radioactive particles from Starfish Prime descended to earth seasonally and accumulated in terrestrial organisms such as fungi and lichens.

Scientific discoveries resulting

- The *Starfish* bomb contained Cd-109 tracer which helped work out the seasonal mixing rate of polar and tropical air masses. The early data are reviewed at [9].
- The *Starfish* EMP waveform measured by Richard L. Wakefield of Los Alamos led to a revolution in understanding this nuclear effect and is now available at [10]. Wakefield's 1962 report is *Measurement of time interval from electromagnetic signal received in C-130 aircraft, 753 nautical miles (1,395 km) from burst, at 11 degrees 16 minutes North, 115 degrees 7 minutes West, 24,750 feet.*

See also

- Operation Fishbowl
- List of artificial radiation belts

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External links

- Starfish Prime video

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