Flash!

The hunt for the biggest explosions in the universe

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Prologue: The breath of Armageddon

'No, no! The adventures first' said the Gryphon in an impatient tone: 'explanations take such a dreadful time.'

Nature is cruel.

A star glitters in the full glory of its life. A clear, shining beacon of light and warmth, of life-giving energy. For millions of years this star lighted up the surrounding darkness, and planets basked in its gracious radiance. No one knows if life – the greatest wonder of the cosmos – has formed on one of these planets, but be that as it may, it is completely dependent upon this one star.

Then suddenly, it is over. Its time has run out. The star is in its death throes.

Armageddon is a Valhalla compared with what happens here. In a fraction of a second the star collapses in on itself. Trillions of tons of hot gas disappear forever through the one-way door of a black hole. Space becomes distorted, time ceases to have meaning, and matter is thrown into a frenzy. The star devours itself from the inside out. In a last agonizing scream the disappearing nucleus of the star spews out two jets of boiling, roiling matter as a desperate lifeline to the trusting world out of which it has been thrust.

With a speed of a billion kilometers an hour the two jets make their way to the outside in opposite directions. They bore burning tunnels through the outer layers of the star, which has no idea of the drama that has come to pass in its dark depths. But the star cannot continue to exist in the face of this cosmic violence. Like a Christmas bauble with a hand grenade inside, it explodes, spitting out an incredible quantity of energy that comes free from its inside.

The destruction is complete. The heavens rip open. A scorching, ball-shaped curtain of searing, glowing energy and expelled matter rushes with the speed of light to the outside. Planets evaporate like snow in the sun. Comets, moons, mountains and oceans, dead and living matter; everything is caught up in the ravaging fireball that shines more brilliantly than a hundred billion suns. What remains is a barren, abandoned battlefield, a desolate cosmic landscape of a dark void. It is the cosmic expression of the Last Judgment, the shadow of hell.

The cosmos does not trouble itself with the death of one star. Birth and death are the order of the day in the universe. Galaxies are in the process of forming; the big bang itself has just come into its own. The cosmos is still young and restless. Everything is in an uproar, balance has not yet found a firm footing. The explosion of the unfortunate star in a spiral arm of a far-removed galaxy is of no more importance than a fleeting tinseling of light upon the surface of a wave in the water, a single horror scene in the cosmic museum of curiosities.

Three billion years after the big bang the universe is still in its infancy. The Milky Way is just beginning to assume its form. There is not yet a trace of the sun and the earth. The present is still in the future, and the future stretches out over many billions of years. Billions of years during which countless stars will live and die, where matter is continually shaped and reshaped by the fundamental forces of nature, and where there will come life, intelligence, consciousness and a wonderful curiosity that will be capable of observing the very cosmos itself.

And even though the catastrophic death of the star quickly becomes history, its history is engraved in the legend of the universe far in the future, like a story that is told and retold from generation to generation or a book that is handed down through time. Within those few seconds that it took for the star to disappear from the stage, a gigantic rush of gamma radiation was blown into space. A burst of penetrating energy spread with the speed of light through the universe, like the deluge from a tidal wave that inundates the earth or the rumbling of thunder that rolls over the landscape.

The power of this gamma ray burst defies the imagination. In a few seconds more energy comes free than the sun emits in its entire life-time. It is as if a million galaxies, each with a hundred billion shining stars, are packed together in a volume no larger than one million kilometers across. And as an expanding shell of radiation, the burst propels itself through the cosmos in all directions; it blows up like a balloon and travels with the speed of light three hundred thousand kilometers in one second, a billion kilometers in an hour, nine and a half trillion kilometers in a year. Although the exploded star is long forgotten and quiet is restored to the place of the calamity, the announcement of its death is delivered to every corner of the cosmos and the message of the disaster is carried far into the future.

Hundreds of millions of years pass by. In a remote corner of the cosmos a formless cloud of hydrogen gas slowly but surely collapses under its own weight. The cloud begins to rotate faster and even faster, until it flattens out, and in the fullness of time, the contours of a resplendent, spiral-shaped galaxy become visible. Our Milky Way is born – one of the infinite number of galaxies in the universe, lost among the billions of similar galaxies.

On its trip to the ends of the universe the photons from the gamma ray burst pass by untold numbers of galaxies. Some are large and stately like the Milky Way, others are small, unsightly misformed monsters, while still others resemble an illuminated rugby ball or a flat sparkling discus – galaxies in all shapes and sizes, bunched together in small, medium and large clusters. And in between there is a measureless void, vast, extended hollows of a dark vacuum, the deep black sea in the cosmic ocean separating those little islands of light.

When the storming wave front of gamma ray photons has transversed half the distance to our Milky Way galaxy, our sun gets born on the outer rim of one of the spiral arms, five billion years ago. It is a gigantic ball of glowing hydrogen gas just like all the other stars. Fired up by nuclear fusion reactions in its interior, it converts four million tons of matter into energy every second. But for all that, the sun is no more than a pin-prick of light compared with the giant star that met such an unfortunate end – nothing more than an unremarkable little dwarf star that would be invisible to the naked eye from a distance of just fifty light years away.

While the sun forms out of a rotating cloud of gas and matter, small cold cinders remain that circle the sun as cooled globes of gas or dark stony clumps, caught forever in the grip of gravity. On one of these cinders there are oceans of liquid water and drops of organic molecules that come down out of interplanetary space . There is now life on earth.

Whether or not life on earth is unique, we do not know. Or if the flash of gamma rays in its journey through space skims over other inhabited planets, no one can tell. But as the cosmic message comes relentlessly closer, the first multi-cellular organisms are in the oceans of the earth, the land is coloured green by the unremitting progression of the plant world and the amphibians creep up onto dry land. By the time the gamma ray photons reach the Local Supercluster – that extended swarm of galaxies of which our Milky Way is one – the reign of voracious dinosaurs holds sway upon the earth.

But the show is not over. There is another cosmic drama waiting to play itself out on this little planet of ours. A big ten-kilometer comet bores into the crust of the earth, playing havoc with the climate and doing the giant reptiles in, once and for all. Compared with the fireball caused by a gamma ray burst, this is a micro-catastrophe; a pebble hit by a grain of sand. But the aftermath upon the earth's biosphere is horrific: ninety per cent of all biological species die, and the evolution of life takes a new turn. The time of the mammals is upon us.

The racing gamma ray photons take no notice of all these happenings. Inexhaustibly they criss-cross the Local Supercluster, and with each passing second they come three hundred thousand kilometers closer to earth. When at last, in the far distance, our Milky Way galaxy becomes visible as a hazy smudge of light against the black starry sky, the earth's savannahs are peopled with the first predecessors of humans. But there are still a few hundred million years to go.

In the wink of a cosmic eye people learn to make tools, they discover fire, they develop voices and languages and begin for the first time to look in wonderment at the night sky and the stars above their heads that seem to exude eternal peace and perpetual rest. Primitive folk tell each other the myths of the constellations; Greek philosophers deliberate over the god-like perfection of the cosmos, and a Polish canon, who dares to question, contends that the earth is not the center of the universe. As the gamma flash passes the Pleiades, it is less than five hundred light years from the earth.

Now things really start moving. While the photons from the dead star race in the direction of the earth, Galileo Galilei looks for the first time at the star-laden firmament through a telescope, Isaac Newton drafts the law of gravity and William Herschel discovers that forms of light exist which cannot be observed by the human eye. The industrial revolution, the detection of the expanding universe, the first timorous steps on the way to space travel . . . As the gamma rays leave the bright star Capella behind, the first scientific satellites are launched and astronomers begin to study the cosmos through the use of invisible wavelengths.

And finally the speeding gamma ray flash zooms past Alpha Centauri, the neighboring star of the sun. The ten billion year trip of the gamma ray flash is almost at its end; there are less than four years to go before that signal sent out from the dying star reaches our living planet. In the meantime, artificial satellites are keeping an eye on the cosmos, and at the Kennedy Space Center in Florida preparations are underway for launching Vela 4, a military satellite equipped with gamma ray detectors.

On Sunday, the 2nd of July, 1967, a shower of gamma radiation blows through the solar system unseen and unheard, photons from billions of years ago and billions of light years away. Each one is a hundred thousand times as energetic as the visible photons of the sun. The greatest portion streams unhindered between the planets, and races on with the speed of light further into the dark heavens. A much smaller number enters the atmosphere of the earth, where they are absorbed by air molecules. And at last, a scant handful of gamma ray photons penetrate the detectors on the Vela satellite. The first detection of a cosmic gamma ray burst is now a fact. The mystery for man is just beginning.

1 The sky watchers of Los Alamos

'You don't know much', said the Duchess; 'and that's a fact'.

Ray Klebesadel turned over another page. The numbers danced before his eyes. The pile of computer printouts, accordion-folded, was at least two inches thick. It looked like this was going to go on for some time. 'OK', he said, 'the next one I have is May 22nd, at18.23.' Expectantly, he looked up from the paper at the man sitting across the table from him.

Roy Olson also had a big pile of computer printouts lying in front of him. He slid his finger down the rows of numbers. 'No, I don't have that one', he answered after a couple of seconds. 'The next one I have is May 25th at 04.17.' Now it was Klebesadel's turn. There was something on May 24th but nothing on the 25th. 'Nope; but maybe you have something on May 27th at 23.42?'

In their drab office at the Los Alamos National Laboratory in New Mexico it was still and stuffy. The date was March 1969; spring had just begun and nature was in full bloom. Outside the room, talking and laughter could be heard; a car door slammed shut. Don't get distracted. Keep going. Next line; the date, the time. Is it only on my list or do you have it too? How did we ever get started with all this?[1]

Ray and Roy worked through all the observational data from the two Vela 4 satellites. The analysis was done by hand; computers at that time were bulky and primitive. Line after line, page after page, searching for a phenomenon that both satellites had picked up at the same time. Ray had the readings from Vela 4A, Roy had the ones from Vela 4B. But up until now there was not one single event that showed up on both lists.

The Vela 4 satellites were launched on April 28th 1967 – two identi-

[1] Even though Ray Klebesadel and Roy Olson were indeed comparing the computer printouts in their Los Alamos office, the conversations related here are fictitious.

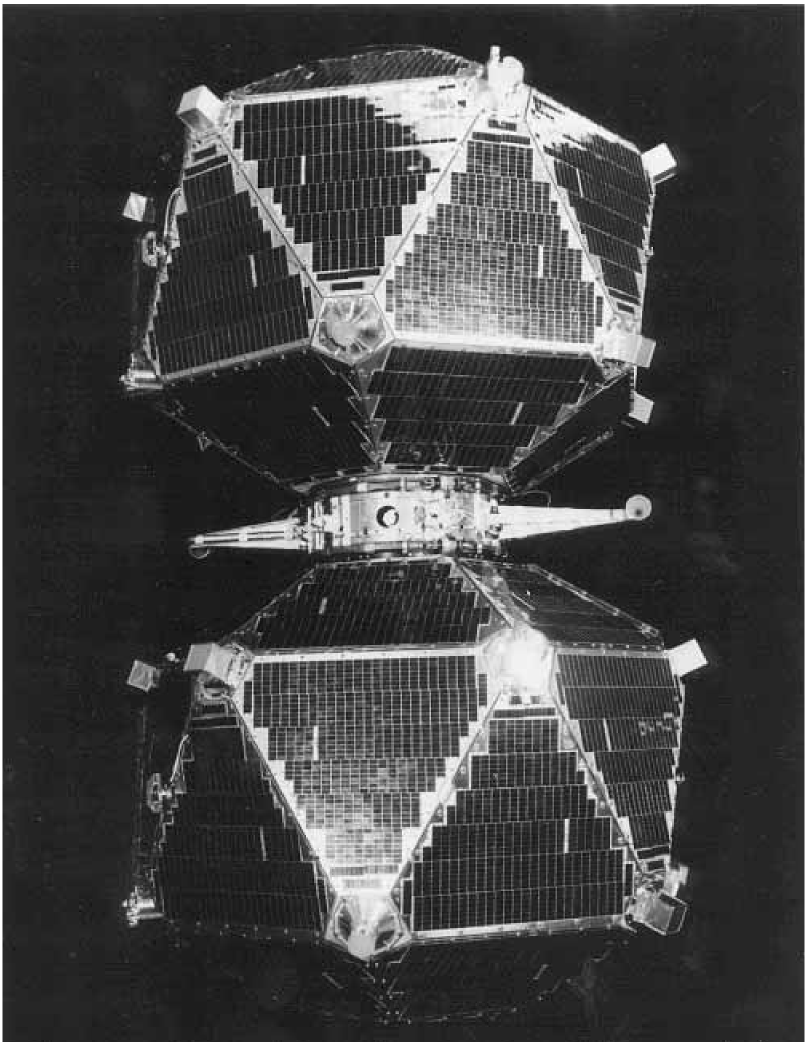
cal satellites, in high circular orbits around the earth at about an altitude of a hundred thousand kilometers. Each satellite weighed around 350 kilograms and was a good meter and a half in size. They were solidly packed with instruments for the observation of X-rays, gamma rays and electrically charged particles. Their most important job was to make sure the Russians weren't carrying out illegal nuclear tests in space.

1969 was the magical year of *flower power* and *love is peace,* but the Cold War was raging and the United States and the Soviet Union were locked in a feverish space race to show the other which one had the better technical know-how when it came to rockets. The space race, which at that time was a draw, was going to be won by America; within a couple of months Neil Armstrong and Edwin Aldrin would be the first men to set foot on the moon – perhaps the greatest technological achievement of the twentieth century. But the mood of the times said you couldn't trust those *commies*; who knows if, against all the international agreements, they wouldn't carry out nuclear tests on the far side of the moon, away from the view of the world. The Vela satellites were actually serving as nuclear policemen for the free West.

The Vela project dated back to the end of the 1950s. In 1958, the year after the world was shaken to its roots by the bleeps from the Russian Sputnik 1, for the first time within the United States there was talk of setting up a special commission to ensure the peaceful use of outer space: no war between the stars, no bombs on the moon,[2] and no nuclear tests inside or outside the atmosphere. But the politicians in Washington knew very little about bombs and nuclear weapons. They realized they had need of an expert and so they asked Sterling Colgate to serve as scientific advisor for the State Department.

Colgate, from the family of the famous toothpaste barons, was a physicist at Los Alamos National Laboratory where, during the Second World War, and cloaked in the deepest secrecy, the atom bomb had been developed. The laboratory was brought under the aegis of the

[2] In May 2000 it was revealed that the United States Air Force actually did have plans in 1958 to explode a nuclear bomb on the moon.



The Vela satellites were launched in pairs and separated from each other when they were in space. The many-sided satellites were covered with solar cells.

Atomic Energy Commission but was kept busy a good portion of the time with commissions from the Department of Defense. If ever there was a place where people were knowledgeable about explosives, it was at Los Alamos.

Colgate must have made a strange impression upon those government representatives. They saw a rather spare man, dressed in less than fashionable clothes, who said exactly what he meant and walked a bit gawkishly, like a teenager. But he knew how to point out the weak link in the UN proposition: if a ban were ever put on nuclear testing in space, there was no possible way to control such a treaty.

During the General Meeting of the United Nations in December 1959, held in Geneva, an official Committee on the Peaceful Uses of Outer Space (COPUOS) was established and the twenty-four members of the commission drafted the first version of what would later come to be the Nuclear Test Ban Treaty – an international treaty that forbade all nuclear tests outside the earth's atmosphere. And it was on the advice of Colgate that Los Alamos got the task of developing a satellite-borne sensor system to detect illegal nuclear explosions in space. 'Vela' would be the name of the system, coming from the Spanish word *velar*, which means 'to guard.'

Even though space travel was still in its early days, serious consideration was given to the possibility that the Russians would carry out their tests at the far side of the moon so that the Americans would be unable to detect them. The enormous blast of X-rays emitted in the explosion of a nuclear weapon would indeed be concealed by the moon. But the expanding cloud from the explosion would sooner or later have to be detected and the Los Alamos physicists knew that the fission products would continue to send out gamma radiation for some time. And so it was that Colgate stood behind the idea of outfitting the Vela satellites with gamma ray detectors.

But there was another problem. How would you know for sure if X-rays or gamma rays actually came from a nuclear explosion and not from the sun or another heavenly body? 'We'll look like fools if we don't

Ray Klebsadel (on the right) discovered the existence of gamma ray bursts in 1969 from observations made with the military satellite Vela. To his left are *Graziella Pizzichini* and *Chryssa Kouveliotou*.

know more', said Colgate to the Los Alamos advisor, Edward Teller. Teller, who once described nuclear weapon research as applied astrophysics, had no difficulty in rapidly developing an astrophysics program of its own at Los Alamos. Work was soon in progress based on Colgate's theory that supernovae – exploding stars – produce powerful bursts of gamma radiation.

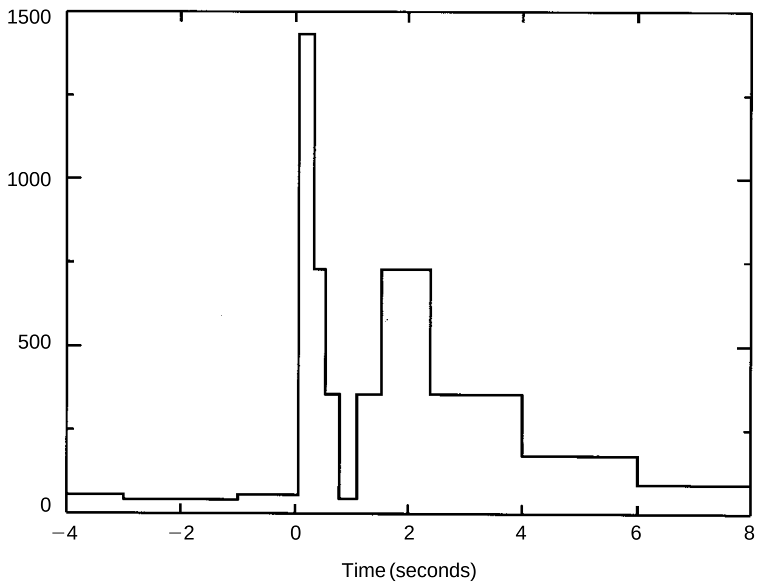
Right about this time, in 1960, Ray Klebesadel, aged 28, came to work at Los Alamos as an electrical engineer. Klebesadel had studied physics at the University of Wisconsin at Madison and his professor, who had worked on the Manhattan Project, put in a good word for him with the Los Alamos staff. Klebesadel, who had only once in his life gone for a job interview, thought that the Vela project under the auspices of the United States Air Force offered an ideal work environment. Dedication, intellectual freedom and time pressure were the key words, and as a young scientist he could be involved in every phase of the project – designing, building, launching, data analysis, and anything else that came along.

The first two Vela satellites, referred to collectively as Vela 1, went into space on the 16th of October, 1963, the same year that the Nuclear Test Ban Treaty was ratified. Vela 2, which was also composed of two identical satellites, followed on the 17th of July, 1964. The first satellites had very simple detectors which were not particularly sensitive. Moreover, the observations were divided into segments of 32 seconds. If in this period (called the time resolution) six X-ray photons or gamma ray photons were registered, you didn't know if they arrived one at a time or all at the same time.

But the Vela instrumentation became more sophisticated very quickly. The Vela 3 satellites were launched on the 20th of July, 1965, equipped with more sensitive detectors and a time resolution of half a second instead of half a minute. A little less than two years later Vela 4 followed with a time resolution of an eighth of a second. The two Vela 4 satellites were not launched with the old Atlas Agena rocket but with the more powerful Titan IIIc rocket so that they could be more massive.

In March 1969 the Vela 4 satellites circled the earth for almost a year with Vela 5 standing on the launching platform at Kennedy Space Center ready for take-off. Klebesadel had just returned from Florida after the last pre-launch check. Finally, it was possible to place the data collected from the two Vela 4 satellites next to each other . . . '18th of June, at 08.09.' 'No. 20th of June at 19.36.' 'No, but there is one at 22.18. Do you have June 24th at 03.49?' Hang in, there are still a few hundred more pages to go.

There were more than enough reasons as to why only one of the two satellites registered in most cases. Fast-moving electrically charged particles also triggered a signal from the detectors, and even though the Vela satellites were outside the radiation belts of the earth, they were bombarded regularly by high-energy particles from the sun or from the universe. On the other hand, if the cause was a nuclear explosion in



The first recording of a gamma ray burst by the Vela 4 satellite. The horizontal axis is the time, the vertical axis is the strength of signal. The burst showed a remarkable double peak.

space, an overwhelming solar flare or even an exploding star, its traces would be picked up by both satellites at the same time.

Again a new page full of numbers. 'July the 2nd, 1967, 14.19.' 'Yes! I have that one too! Precisely at the same time!'[3] Klebesadel and Olson looked at one another in astonishment. Then they placed the two computer printouts next to each other to compare the rows of numbers. At last they had a bite. No question about it: on Sunday the 2nd of July, 1967, the gamma ray detectors from both satellites picked up a strong signal; and it was a very exceptional signal, consisting of two peaks. The first one lasted less than an eighth of a second (the time resolution of Vela 4); the second peak lasted for two seconds – absolutely not what you would expect from the gamma radiation from a nuclear explosion.

Klebesadel grabbed a list to check old observation data from an

[3] Even though the conversations between Klebesadel and Olson are fictitious, the gamma ray burst on July 2, 1967, did take place at the recorded time (Universal Time).

American satellite that had registered solar flares. But on the 2nd of July there had been no solar eruptions. Nor did astronomers observe a new supernova in the sky on that day. Everything seemed to indicate that the Vela 4 detection was caused by an unknown source of cosmic gamma radiation. On closer observation, it turned out that the burst of gamma rays was also detected by the Vela 3 satellites, although the double peak was not too well defined because of the lower time resolution.

It was not surprising to find that there were sources of cosmic gamma radiation since it is actually similar to normal light, differing only in its extremely short wavelength and extremely high energy. Visible light to which our eyes are sensitive has a wavelength between 400 and 700 nanometers (one nanometer is a millionth of a millimeter). But in addition to visible light there are many kinds of electro-magnetic radiation that we cannot see, such as radio waves, microwaves, infrared radiation and ultraviolet radiation, X-rays and gamma rays.

Ultraviolet radiation is something we are all familiar with in our daily life. It is the ultraviolet (UV) radiation that makes our skin tan when we stay out in the sun. The pigment cells in the surface of the skin become activated by this UV radiation, something that does not happen in ordinary light. This tells us that UV radiation is more energetic than visible light. And if we need more proof, just remember that too much exposure to UV radiation can cause skin cancer.

Ultraviolet radiation has a shorter wavelength than visible light (between 100 and 400 nanometers) and the shorter the wavelength the higher the energy. X-rays have an even shorter wavelength (roughly between 0.01 and 10 nanometers) and are even more energetic. As anyone who has been to a dentist knows, 'soft' X-rays pass without a problem through human tissue but are somewhat restrained by teeth and bone. This is what makes it useful in medicine. 'Hard' X-rays are so energetic that living cells are impaired by them.

The most energetic radiation in all of nature is indeed gamma radiation, with wavelengths shorter than a hundredth of a nanometer (a hundred millionth of a millimeter). A gamma ray photon – a 'light particle' of gamma radiation – contains at least a few hundred thousand times more energy than a visible photon. Exposure to gamma radiation is what led to radiation sickness and death among the people of Hiroshima and Nagasaki in 1945.

Gamma radiation is rare on earth, although small quantities are emitted by radioactive materials such as uranium ore. The gamma ray photon is one of the by-products of the radioactive fission process where uranium atoms break apart to form lighter atomic nuclei. But in the universe enormous quantities of gamma radiation are produced by all sorts of explosive processes, such as solar flares and supernovae. Gamma radiation forms the rending, high tones of the cosmic symphony – shrill and penetrating.

Fortunately for us, the earth's atmosphere forms a natural shield against this deadly radiation from the universe. Gamma rays can fly right through the human body; they cannot be restrained even by a solid plate of lead. But the atmosphere forms an impenetrable barrier simply because it is tens of kilometers thick. In spite of the thinness of the atmosphere, a gamma ray photon on its way down comes up against so many atoms that a collision is unavoidable. The gamma ray photon then loses its energy and in fact gets absorbed by the atmosphere.

Therefore, cosmic gamma radiation can only be observed by using special detectors on board high-flying balloons or satellites, such as the Vela 4 scintillators. These are little blocks made of a special material – at first a kind of plastic was used but later they were made of cesium iodide. The atoms in these scintillators emit minuscule flashes of light when they are hit by a high-energy gamma ray photon. These tiny bursts of light are amplified and detected by photomultiplier tubes and the intensity of the flashes is directly proportional to the energy of the absorbed gamma photon.

Klebesadel and Olson were not quite sure about what they should do with their discovery. It was obvious that they were dealing with an unusual source of cosmic gamma rays but it wasn't possible to say where they came from, if for no other reason than that the scintillators on board the Vela 4 satellites were not direction-sensitive. And as far as the distance of the gamma ray source was concerned, they didn't have a clue. Although no solar flares were observed on July 2nd 1967, in principle it was possible that the gamma ray photons they saw came from the sun.

The Vela 5 satellites were now waiting to be launched. Klebesadel knew that they were more sensitive and had a better time resolution of one sixty-fourth of a second. If there really was talk of a new phenomenon then the decetectors of Vela 5 would observe many more gamma ray bursts. For the moment, it was decided not to tell anyone about the mysterious phenomenon but just wait for the results from the new satellites.

Vela 5 was launched on May 23rd, 1969, which happened to be the day of the 'roll-out' of the powerful Saturn V rocket that would lift off the Apollo 11 astronauts on their way to the moon. Nobody had time to give any thought to the relatively little Titan rocket with its military payload. Even Klebasdel found the roll-out more exciting.

But there is rarely instant gratification in space experiments. The results from Vela 5 were delayed. Through a fault in the electronics the detectors were actually so sensitive that they picked up an enormous amount of background signals. It was a hopeless task to analyze by hand all the signals that were registered from the mountains of measurements collected, as Klebesadel and Olson had been doing with Vela 4. Forced by necessity, Klebesadel learned to use the computer language of Fortran and wrote a program that would search through all the data to find the occurrence of *their* phenomenon on both satellites at the same time. Finally, they found about twelve that did not coincide with any solar flares or supernova explosions. Even more encouraging was the fact that some of the new detections showed the same remarkable double peaks that were seen with the Vela 4 flashes.

The last two Vela satellites were launched on April the 8th, 1970. Originally, the Vela program was to carry out five double launchings, but because it had been so successful it was decided to put the two back-up satellites into orbit. Vela 6 had the same instrumentation on board as Vela 5. The orbits were chosen to form a complete network around the earth by placing the satellites at the largest possible distances apart, in most cases many tens of thousands of kilometers apart.

Thanks to the great distance between the satellites, plus the high time resolution of Vela 5 and 6, Klebesadel was now able to determine the direction from which the puzzling gamma ray bursts came. Just like visible light, gamma rays travel through the universe at the speed of light: 300,000 kilometers per second. A gamma ray burst coming from a given direction would be detected just a bit earlier on one Vela satellite than on the other. The difference would be no more than a few tenths of a second, but because the arrival time was accurate to within a sixty-fourth of a second, it would certainly be observable.

Now that the arrival times could be carefully compared with each other, Klebesadel and his colleagues succeeded in tracing sixteen gamma ray bursts, regardless of where in the universe they had come from. It was immediately apparent that the flashes were not caused by the sun, the moon or the planets. The sixteen bursts were distributed completely randomly over the sky. It was also clear that they were from a great distance from the earth, beyond the solar system, which meant in turn that the explosions had to be monumentally powerful.

Together with Ian Strong and Roy Olson, Ray Klebesadel wrote an article about the discovery and on June 1, 1973, it appeared in *The Astrophysical Journal Letters*. A few days later, Klebesadel presented the impressive results to the 140th meeting of the American Astronomical Society (AAS) in Columbus, Ohio. For the first time the discovery of gamma ray bursts was made known to the world.

Thirty years ago the media paid less attention to scientific events than they do now, particularly when it had to do with such abstract topics as explosions of invisible gamma rays. Today, the AAS meetings are attended by any number of journalists and the more mysterious the subject, the greater the interest. But back in 1973 Klebesadel was approached by only one journalist, from the American tabloid, *The*

National Enquirer. Armed with the knowledge that the Vela satellites were intended to trace nuclear explosions from an enemy, the reporter asked if it were not possible that the gamma ray bursts came from a nuclear war between extraterrestrial civilizations. Devoid of any experience with the popular press, Klebesadel answered with typical scientific precision that the explosions did not in any way resemble nuclear explosions as we know them but in principle, he could not rule out the possibility. And so it was that the public-at-large became aware of gamma ray bursts. The screaming headlines could make anyone believe that *Star Wars* was a reality, even four years before the movie appeared.

The military character of the Vela program and the long period between the discovery of the first gamma ray flashes in the spring of 1969 and the publication in the summer of 1973 led to the rumor that the US Department of Defense kept the discovery secret and then waited four years before releasing the information. Even the Vela veteran Sterling Colgate thought for a long time that the satellite observations were the official property of the U.S. Air Force rather than the scientists at Los Alamos whose job, he thought, was only to analyze the data.

Klebesadel relegates the whole secrecy theory to the realm of fairy tales, even though he himself played a part in starting the myth. 'At the presentation of our results I showed a diagram that I made on the Vela project graph paper', he says. 'There were some codes on the paper which were totally innocuous, but the project leaders preferred that they not be made public. Upon the request of a superior I scratched them out with a penknife. But because the scratches were clearly visible, of course it was immediately believed that all sorts of secret information had been erased.'

At the same time, Klebesadel's presentation in 1973 caused a shock wave through the astronomical world. Tom Cline from NASA's Goddard Space Flight Center in Greenbelt, Maryland, was ready to tear his hair out because his detector aboard one of the IMP satellites (Interplanetary Monitoring Platforms) had picked up similar outbursts. Cline thought they came from supernova explosions and so he had not yet published anything about them. This was one time where there was no pay-off in erring on the side of caution. If he had been more assertive he would have gone down in history as the discoverer of gamma ray bursts. But he was not alone. Other astronomers also became aware that in their own satellite data there were all sorts of mysterious signals and unexplainable peaks.

How could the source of the gamma ray bursts really be determined? The answer was obvious. It was necessary to see if, at the place where the flash occurred, something very unusual would be visible – a remarkable star, for instance. Unfortunately, the positions of the gamma ray bursts in the sky were far from being accurately known. The sixteen 'localized' Vela flashes could, in the best of circumstances, be reduced to an area in the sky that was several times the apparent size of the full moon. An error box that size contains many thousands of completely ordinary stars. It is as if you were sitting in a packed concert hall and you heard somebody sneeze. If you looked in the direction the sound came from, you would only see a bevy of innocent faces.

To Kevin Hurley it was obvious that in order to determine the positions accurately, a network of space probes was necessary, placed at a distance of tens of millions of kilometers from each other. The arrival times at which a gamma ray burst registered on the various probes in the network would then differ by a number of seconds or even minutes, which would make a much more precise triangulation possible. Hurley had his first Inter-Planetary Network (IPN) ready to go and now, almost twenty-five years later, he is still imbued with the concept.

Hurley was born in New York but moved to California when he was ten. The young Kevin had from early on shown an interest in stories about the universe and so, one day his mother bought him an amateur telescope. When she took him to meet the famous astronomer Otto Struve he remembers that it made a lasting impression upon him. In the late 1960s, he went to study astronomy at the University of California at Berkeley where the Space Sciences Laboratory had just been set up. It was the golden era of space research; everything was new and money was no object. Hurley and other graduate students worked on a number of projects, one of them being balloon experiments to observe X-rays from the giant planet Jupiter. After he received his PhD in 1972 he went to Toulouse in France to work at the Centre d'Étude Spatiale des Rayonnements (CESR), where he helped develop the X-ray detectors for Russian scientific satellites.

The nine months he intended to stay there turned out to be fifteen years! Working in cooperation with the Russian Institute for Space Research in Moscow was pleasant and informal. Within a year and a half, he was free to think up a nice experiment, build the instrument and shoot the satellite off into space. It was when his director was attending a conference in Denver about cosmic rays that Hurley heard for the first time about the discovery of gamma ray bursts. It was immediately proposed that a special gamma ray detector be built for the Prognoz 6 satellite, which was launched on September 22,1977. This gamma ray detector was just the second type of instrument in the world that was especially intended to observe gamma ray bursts. It followed the one that Tom Cline placed on board the German space probe Helios 2, which was launched on the 15th of January, 1976.

It was relatively easy to put an instrument on board a Russian satellite, but to get the results quickly was a different story. The Prognoz satellites transmitted their measurements through a telemetry ship in the Black Sea. From there the tapes with the data went to the Institute for Space Research in Moscow, where they had to be copied in their entirety and then brought by diplomatic courier to the French embassy. And finally, via the embassy, the information came to Toulouse. When Hurley and his colleagues were in Moscow to examine the computer printouts, they would sometimes photograph them right in their hotel room because it saved so much time.

At the end of 1978 the first reliable Inter-Planetary Network became a fact. Five space probes were outfitted with gamma ray detectors: the Russian Prognoz 7, which had been orbiting the earth since October 30th, 1978, the German Helios 2, which was in an elliptical orbit around the sun, and finally, no less than three space probes used for studying Venus. NASA's Pioneer Venus Orbiter was launched on May 20th and had a detector on board that was developed by Klebesadel's team at the Los Alamos Laboratory. The Russian Venera 11 and 12 were launched on September 9th and 14th and were equipped with the detectors from Hurley's group in Toulouse. Along with all these there were also Russian Kosmos satellites circling the earth, some of which had a gamma ray detector that was built by the scientists at the Ioffe Institute in Leningrad under the guidance of Evgeny Mazets. Of course, the Vela 5 and Vela 6 satellites were still active.

By 1978 the gamma ray burst enigma was five years old, or if you asked Ray Klebesadel, actually nine years. It was high time that the mystery was solved and everybody expected that an accurate determination of the position of a gamma flash as revealed by the Inter-Planetary Network (IPN) would lead to a break-through. Indeed, Hurley and his colleagues succeeded in determining the position of gamma ray bursts with an accuracy of a few arcminutes,[4] but even with the biggest telescopes in the world there was nothing of interest to be seen in those error boxes. To use the concert hall example again: it was as if you knew from which direction the sneeze came but strangely enough, nobody seemed to be sitting there.

On Monday, March 5, 1979, the tide seemed to turn. All the space probes from the IPN on that day registered an extremely powerful and long gamma ray burst. A few weeks later when the measurements were analyzed and the direction was confirmed, the burst turned out to coincide with a curiously shaped small nebula in the Large Magellanic Cloud, a neighboring galaxy of our own Milky Way at a distance of 160,000 light years (one light year is the distance light travels in a year at the speed of 300,000 kilometers a second: about 9. 5 trillion kilometers).

The nebula had been detected and cataloged much earlier and was known to astronomers as N49. It is a remnant of a supernova eruption:

[4] An arcminute is a 60th part of an arc-degree, and a degree is a 90th part of a right angle. An arcminute is further divided into 60 arcseconds.The apparent diameter of the full moon accounts for half a degree, or 30 arcminutes.

The Russian Venera space probe, to study the planet Venus, was part of the Inter-Planetary Network.

an expanding gas shell that is formed when a star explodes. Could there indeed be a relation between supernovae and gamma ray bursts? Hurley, Cline and Klebesadel's colleague Ed Fenimore were convinced that they were on the trail of the solution to the riddle. A supernova explosion could produce a compact neutron star (see Chapter 11), and in the strong gravitational field of such a neutron star all kinds of energetic processes could be set into motion which might produce gamma radiation.

But other astronomers, including Mazets and his colleagues, didn't believe it. According to them it was a coincidental occurrence that the two events happened at the same place in the sky. If the gamma ray burst had actually taken place in the Large Magellanic Cloud, then it had to be an incredibly huge explosion, otherwise a flash that came from a distance of 160,000 light years away could never be so striking. What kind of natural phenomenon could ever, in a couple of minutes, produce as much energy as the sun sends out in a thousand years? No, it seemed more likely that the gamma ray burst came from much closer by, at a distance not more than a few hundred light years, and it would be pure chance that it seemed to come from the direction of the Large Magellanic Cloud.

The conjectures about the March 5th flash lasted for a long time. Today, no one doubts that the burst came from the Large Magellanic Cloud. But it is now known that this was no 'ordinary' gamma ray burst (to the extent that you can use such a term for a phenomenon about which so little is known), but rather, it had to do with a so-called soft gamma repeater, an object that is discussed more fully in Chapter 12. The 'ordinary' flashes continued to be a mystery, as always, and the error boxes remained empty.

Ray Klebesadel is now retired and back in Green Bay, Wisconsin. He could never have imagined that 'his' discovery would give rise to a puzzle that would keep astronomers busy for thirty years. Once in a while he visits Los Alamos and now and then he goes to a conference about gamma ray bursts, but he is no longer actively involved. The fact that he may never see the mystery solved doesn't trouble him. 'I can die happily even if it isn't explained', he says with an affable laugh.

Kevin Hurley went back to Berkeley in 1987 and now has an office in the Space Sciences Laboratory with a magnificent view of the San Francisco Bay area. On a clear day you can see the Golden Gate Bridge and the Pacific Ocean. His database of scientific publications about gamma ray bursts, with which he got involved during the 1970s more as a hobby, now contains about 5200 articles but still, up to this moment, the mystery remains.

However, there is a very important difference now compared with twenty years ago. The number of observed gamma ray bursts is no longer a few dozen, but is now up there in the thousands, and the sky positions of a great many of them are known. These break-throughs have come in the 1990s, not with Hurley's Inter-Planetary Network, which incidentally is still active, but with two very special orbiting satellites and the continued enthusiasm and dedication of a number of researchers here on earth, some of whom were still waiting to be born when Ray and Roy were plowing through their computer printouts in Los Alamos.