Tropical Cyclone, Satellite and Bangladesh

Special to The Daily Star

by Dr. Anwar Hossain

THE recent devastating cyclone that struck Bangladesh coast on the 29th April causing incalculable damage to lives and property has not only drawn the attention of national and international community, with spontaneous assistance given to the victims, but raised many questions that are being debated. A large number of views has already been expressed on its manifold aspects, including the influence of environmental degradation like greenhouse effect, depletion of ozone layer etc. on the present weather fluctuations.

Weather is a complex system influenced by a number of factors and it is not easy to predict it, far to speak of tropical cyclones, which is called hurricane in the American continent and typhoon in the Far East. The breeding ground of such ripples of instability in the air, which can turn into a devastating storm, is the oceanic region between 20°S & 20°N latitude when the sea surface temperature rises above 27°C. An area of low pressure is developed where strong winds blow around a centre in an anticlockwise direction (above the equator). The region is far enough from the equator for the earth's spin to make the young storm rotate. Water vapour rises and condenses into banks of clouds intensifying the inward flow of air with the latent heat released.

In the Bay of Bengal, origin of a cyclone starts as a depression near the Andaman islands. The forces responsible for its movement and development into cyclone of various intensities are not clearly understood. Thus determination of the path of the cyclone is unpredictable. Advent of weather satellites has enabled us to obtain its picture and follow the path of it for a few days. If the depression matures into a well-organized cloud pattern, a cyclone is stated to have been formed. If the cyclone becomes severe, an eye is formed in the centre. It is an area of lowest pressure with a diameter of several miles while the cyclonic wind and cloud could be as wide as a few hundred miles. Immediately surrounding the eye, the wind is strongest and its force diminishes with the distance from the eye.

The cyclones occur equally frequently in their breeding ground, thus affecting the Philippines, China, Japan and areas around Central America both on the Atlantic and Pacific coasts. The most vulnerable area for cyclones is, however, the Indian Ocean, especially the Bay of Bengal which is surrounded by the densely populated land mass. Bangladesh is the worst target if the cyclones find its way into its waters because of the funnel effect due to its location, leading to storm surges of great height. The stronger the cyclone and its wind speed, higher is the surge and if the cyclone hits the coastal areas during high tide (as it happened in 1970), the height of the tidal surge is still higher.

The intensity of the cyclone was stronger on 29th April, 1991 but because it didn't coincide with high tide, the storm surge height was comparatively lower.

While gigantic efforts are being made to rehabilitates the cyclone affected people, all attempts should also be made to minimise the loss by preventing the cyclone to the extent possible and chalk out a comprehensive cyclone warning and preparedness programme. This needs an intensive study of the weather, including cyclones and storm surges.

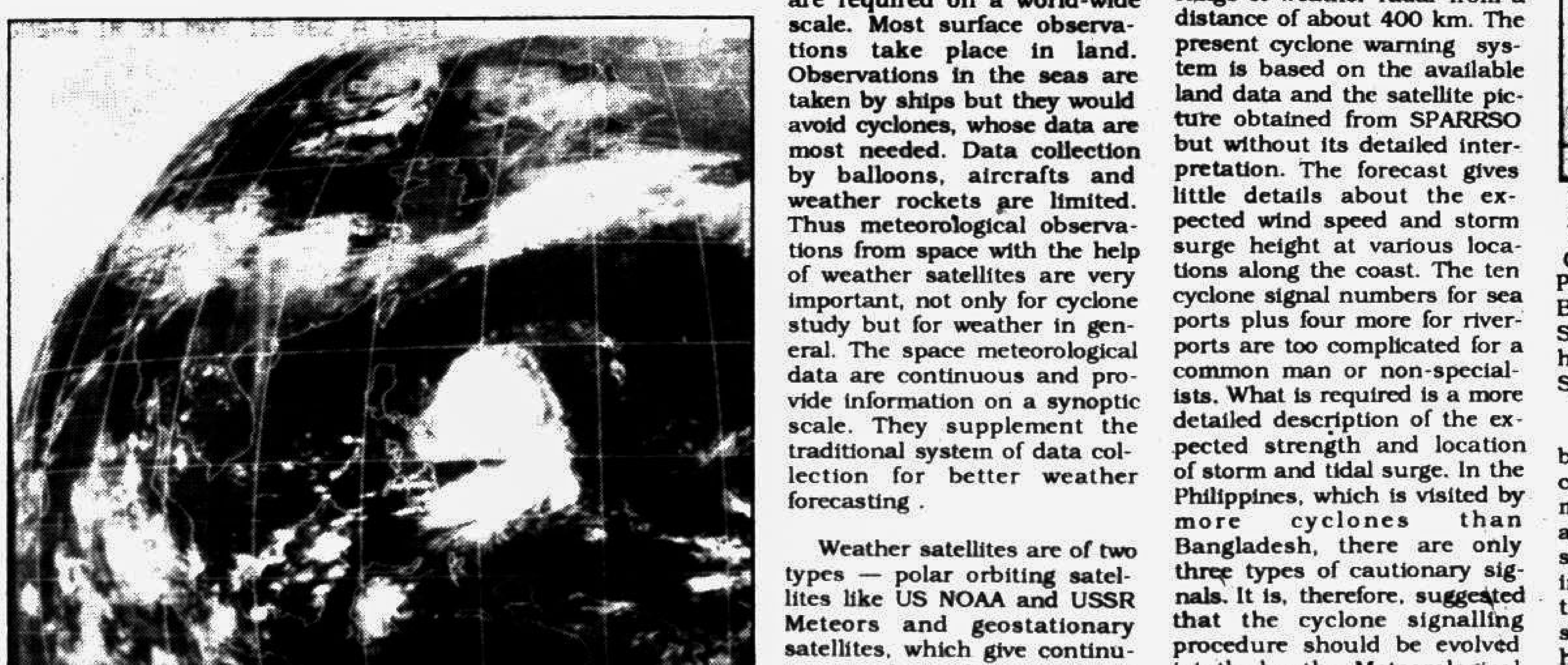


Fig 2. Picture taken from a Japanese geostationary satellite on May 12, 1991 as received at the SPARRSO ground station showing the extent of its coverage. A cyclonic storm near the Philippines is visible in the picture.

Study of Cyclone

The United States and many other countries, including Bangladesh, have made studies on Monsoon and Cyclone Dynamics but no corelationship could be established between the steering current of the cyclone and the latter's intensity. Recently various statistical and numerical methods have been applied to forecast cyclone paths and their structure with promising results. Mathematical equations have also been developed to calculate storm surge height for a particular type of cyclone with a given track an wind speed distribution. These need verification.

As for experiments trying to modify a cyclone in its early stage of formation, the US have made attempts to minimise the windspeed of cyclones in the Atlantic by spraying silver iodide in the cyclone cloud. Results appeared promising but there was a chance that cyclone could change course which might be advantageous to one country but harmful to another.

It is therefore suggested that both theoretical & experimental studies on the formation of cyclones and its tracking could be undertaken jointly be affected countries, perhaps under the auspices of WMO. In the case of Bay of Bengal, India, Bangladesh and Burma and perhaps Sri Lanka could take part in such a study. The study can include receiving global data, aircraft reconnaissance over cyclones and tropical disturbances and verification of the various theoretical models proposed. Recent cyclone has drawn the attention of developed countries, the UN and its agencies on various cyclone reconstruction programmes and funds have been allocated for the purpose. A small portion of the fund could be earmarked for collection of previous data and a long-term study.

Role of Weather Satellites

Weather is a global phenomenon and for better forecasting, accurate observations are required on a world-wide scale. Most surface observations take place in land. Observations in the seas are taken by ships but they would avoid cyclones, whose data are most needed. Data collection by balloons, aircrafts and weather rockets are limited. Thus meteorological observations from space with the help of weather satellites are very important, not only for cyclone study but for weather in general. The space meteorological data are continuous and provide information on a synoptic scale. They supplement the traditional system of data collection for better weather forecasting.

Weather satellites are of two types — polar orbiting satellites like US NOAA and USSR Meteors and geostationary satellites, which give continuous weather information from one point in space which is relatively stationary with respect to the earth. WMO has planned global coverage of satellite data collection with five geostationary satellites — two over the Atlantic Ocean (US GOES & European Meteosat), two over Pacific Ocean (US GOES and Japanese GMS) and one over the Indian Ocean. While the satellites over the Atlantic and Pacific Oceans are operating, the one over Indian Ocean, which was expected to be launched by USSR, has not come into existence.

The gap in global information is partially made up by INSAT of India, but India, but INSAT is a multipurpose satellite for their own use and is not hooked up to the World System. Bangladesh is at the edge of the coverage by Japanese GMS and is regularly getting the information, in addition to those from the polar orbiting satellites (NOAA series), with the help of the meteorological satellite ground stations. The first station established was an APT (Automatic Picture Transmission) unit at the Atomic Energy Centre, Dhaka in 1968. Later, more advanced receiving stations with higher resolution and better analysing facilities were set up at SPARRSO. In fact, the present Metsat ground stations can not only track approaching cyclones but provide synoptic data for early flood forecasting and other weather information.

All the tropical cyclones in the Bay of Bengal have been detected by the Ground Station of SPARRSO and methods are now available for the estimation of maximum wind speed in cyclones with reasonable accuracy.

Cyclone Forecasting

Weather satellites can track the path and development or cyclones right from the early stage of its formation until the cyclones come within the range of weather radar from a distance of about 400 km. The present cyclone warning system is based on the available land data and the satellite picture obtained from SPARRSO but without its detailed interpretation. The forecast gives little details about the expected wind speed and storm surge height at various locations along the coast. The ten cyclone signal numbers for sea ports plus four more for riverports are too complicated for a common man or non-specialists. What is required is a more detailed description of the expected strength and location of storm and tidal surge. In the Philippines, which is visited by more cyclones than Bangladesh, there are only three types of cautionary signals. It is, therefore, suggested that the cyclone signalling procedure should be evolved jointly by the Meteorological Department, SPARRSO, Water Development Board and the IWTA and perhaps the Port Authorities too. In fact, like the Cyclone Preparedness Programme, the cyclone forecasting/warning should be drafted by a Joint Committee of the above Departments/Agencies and more use should be made of the quick data interpretation facilities available with SPARRSO, and perhaps BWDB, so that, at times of emergency, an agreed, as well as more frequent and detailed, warning can be given to the persons/institutions to be affected.

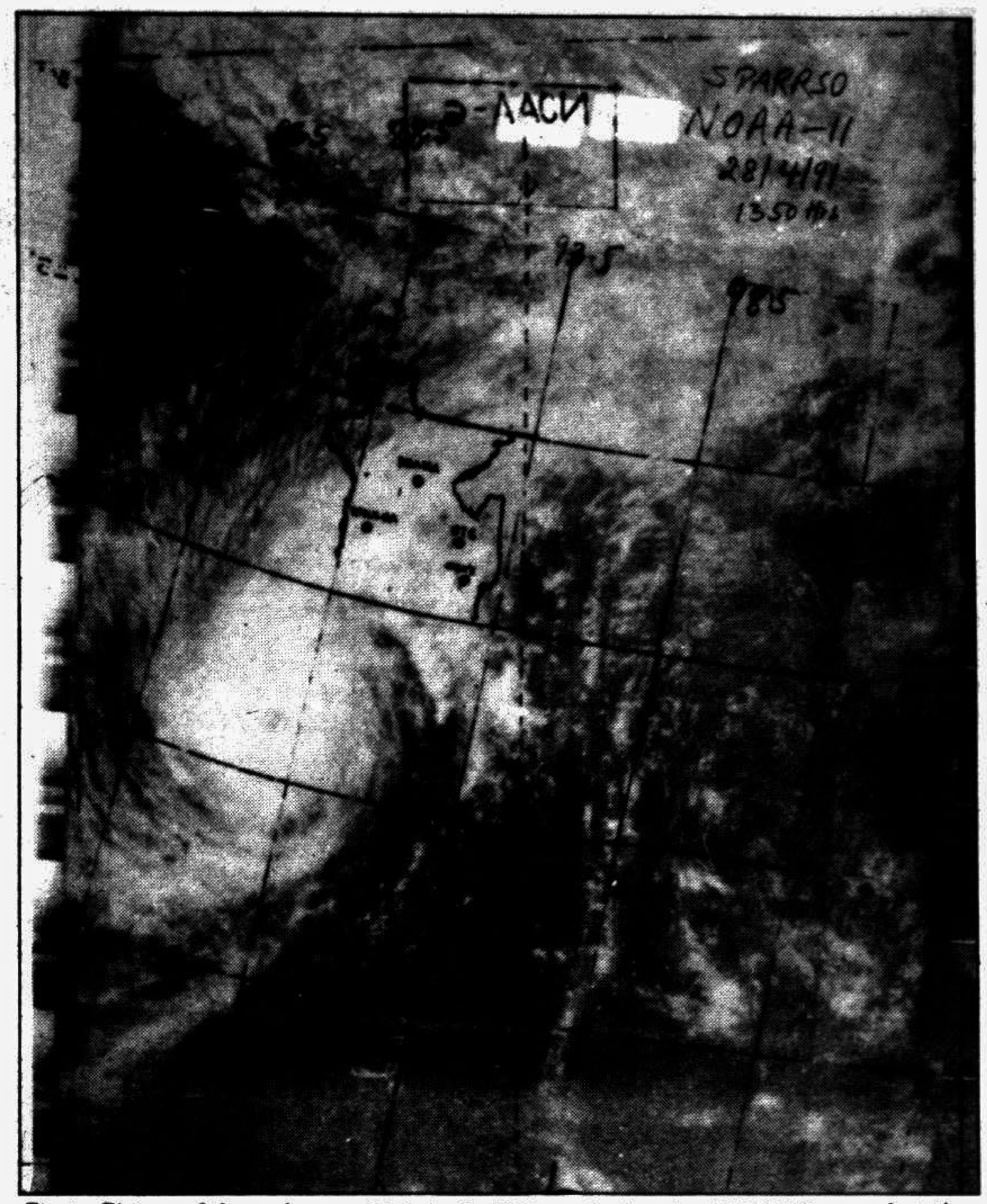


Fig 1. Picture of the cyclone on 28th April, 1991 received at the SPARRSO ground station from US NOAA —11

Bangladesh has now an elaborate and comprehensive Cyclone Preparedness Programme operated by the Bangladesh Red Crescent Society. The country should have a similar Cyclone Warning System.

Conclusion

While gigantic efforts are being made to rehabilitate the cyclone affected people and make up the loss of property and production, all attempts should also be made to minimise the loss by preventing the cyclone to the extent possible and chalk out a comprehensive cyclone warning and preparedness programme. This needs an intensive study of the weather, including cyclones and storm surges, verify various empirical models developed with previous data and conducting new experiments. Data received over land, water and air, including those form satellites should be fully utilised in order to understand the nature of cyclone, determine its track and estimate the wind speed and height of storm surges. This would enable more accurate cyclone warning system. Finally, we have to learn to live with the cyclones, of course, with maximum possible protection, and orient our living pattern with optimum land use, in conformity with nature and the environment.

Former Chairman of Bangladesh Atomic Energy Commission, Dr. Anwar Hossain who also served first as the Director General and then as the Chairman of SPARRSO, is currently serving as a UNDP/FAO Consultant on remote sensing.

ENERGY-EFFICIENT PUMPSET

New energy-efficient five-horsepower pumpsets that reduce power consumption and improve reliability and insulation life have been developed by the Bharat Heavy Electricals Limited (BHEL) for applications in the agricultural sector.

The new pumpsets have an overall efficiency of 72 per cent, an appreciable improvement over that of the best indigenously available pumpsets which are 65 per cent efficient.

This improvement in the efficiency is expected to bring about substantial savings in energy for the agricultural sector and the country at large.

Nearly 4.5 million five-horsepower pumpsets are already in use in the agricultural sector, installed in remote villages in the country, and around half a million are being added every year.

The major benefits to be accrued by installing the new pumpsets are reduced power consumption, improved reliability and reduced temperature rise with consequent increase in insulation life.

While designing the pumpsets, BHEL engineers used better quality, highly permeable indigenous steel and reliable mechanical seals to reduce losses due to friction.

Improved ventilation and fan efficiency, optimisation of geometrical parameters to reduce hydraulic losses of the pump, and reduction in leakage losses were other innovative features introduced into the design, according to a newsletter of BHEL. (TP)

Seeking the Origin of Cosmic Rays

Alan watson

WHILE you lie in bed at night over one million charged particles pass through your body. We are biologically adapted to them, so they have an insignificant effect on our well-being. These particles, mainly fast moving electrons and muons (unstable and less familiar particles), are the remnants of a cascade of similar ones created high in the atmosphere by incoming cosmic rays.

Cosmic rays are nuclei of atoms which have been accelerated to high energies within our Galaxy and elsewhere in the universe. Since their discovery over 75 years ago such rays have fascinated astrophysicists: their energy density is the same as that of starlight and the rarest particles have energies of more than 10 Joules, the kinetic energy of a tennis ball moving at 60 miles/hours.

Cosmic rays are significant in other fields, too. They are a form of background radiation which limits the sensitivity of certain archaeological dating techniques and are a significant nuisance to designers of computer memories for space applications and to astronomers using the latest change-controlled devices, known as CCDs, for stellar imaging. All ionizing radiations, especially cosmic rays, give rise to biological transitions: during the Apollo 13 lunar flight the astronauts reported flashes of light in their eyes caused either by cosmic rays exciting the cells in the retina or by the direct production of light by the particles traversing the vitreous humour of the eyeball.

It has proved very hard to discover the source or origin of cosmic rays although measurements of increasing refinement have been made over the years. We know, for example, that about one per cent of the particles are electrons and we have an accurate knowledge of the abundance of protons, helium and uranium nuclei. Isotopic analysis has also proved possible at certain energies. But this information has not been enough to solve the riddle of cosmic ray origin: the real difficulty is that the Galaxy — the system of 100 billion stars of which the Sun is one — is threaded by a weak magnetic field which bends and twists the paths of the charged cosmic rays. The magnetic field is so extensive and turbulent that it excludes all possibility of tracing the source of a particular particle by following it back along its trajectory. The cosmic ray astronomer is always working under cloudy skies!

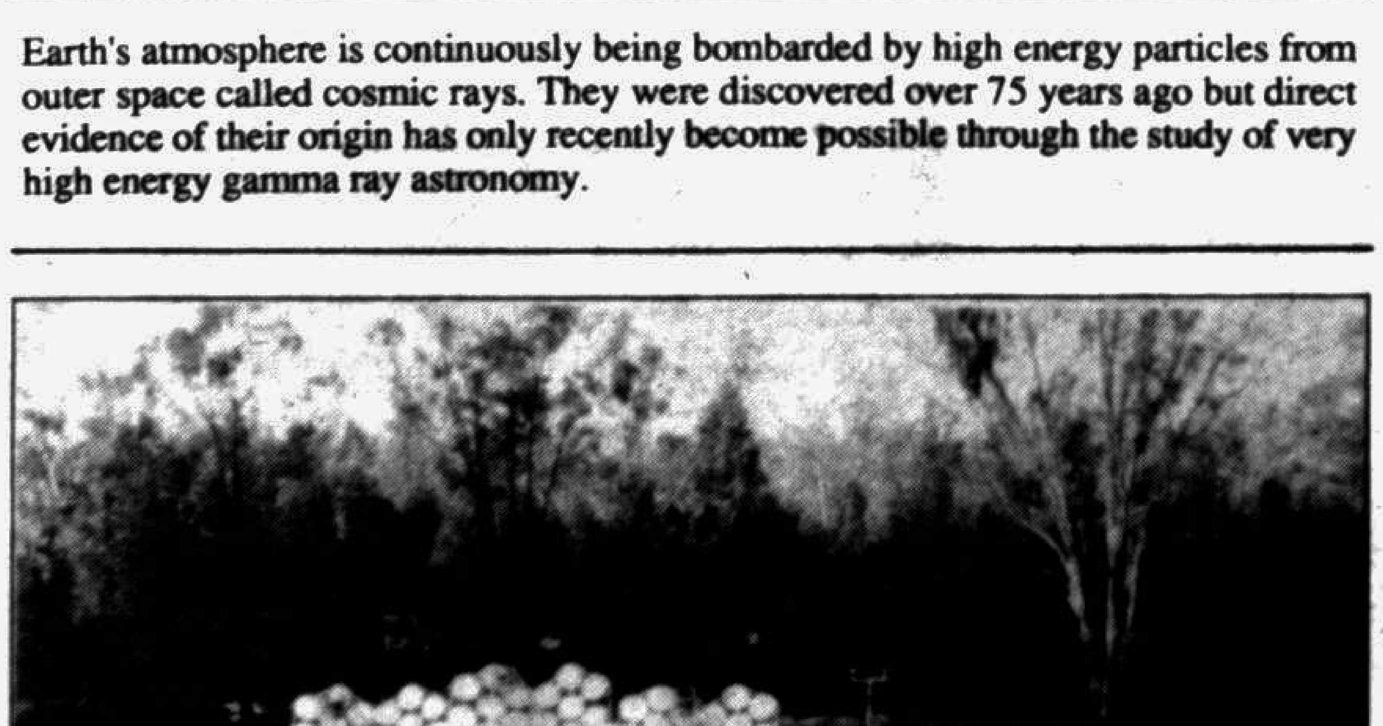
Tracers of Origin

Unlike charged cosmic rays, all types of electromagnetic radiations travel in straight lines. Hot gas in stars emits photons in the optical part of the electromagnetic spectrum and in the X-ray and infra-red bands as well. But thermal radiation is not the only process which generates photons : many of the objects which are detectable at radio wavelengths, by telescopes such as that at Jodrell Bank in northern England, radiate by a process known as synchrotron emission in which an electron, accelerated as it spirals in a magnetic field, transfers some of its energy to a radio photon. In stronger magnetic fields higher energy electrons produce photons of much shorter wavelengths: for example in the Crab nebula a great deal of the optical emission comes from electrons of about 1011 eV, (electron-volts; this level is comparable with the highest electron energies achieved in a man-made accelerator) spiralling in magnetic fields some hundreds times greater than are found in Galaxies. So, if electrons can be accelerated to 1011 eV, it is conceivable that protons and other nuclei might be accelerated to a similar energy.

Protons do not give rise to synchrotron radiation because they are too heavy, but there is another route by which they can produce photons. This is shown, following the synchrotron process, in the second diagram. When a proton of sufficiently high energy strikes another proton a large number of unstable particles called pions are created. The cloud chamber picture shows the charged pions that are produced. Pions with no charge are also formed and decay very rapidly to form two gamma rays, which are very energetic photons. Detecting them from discrete sources would provide strong evidence for the acceleration site of protons to the energies characteristic of cosmic rays. The protons are not destroyed in the pion-producing processes and, indeed, it is unlikely that all of those accelerated will interact, so gamma ray observations should be able to trace the site of cosmic ray acceleration quite accurately.

To produce gamma rays of energy E requires protons of energy several times larger than E. To study cosmic ray origin at about 1013 eV we need to observe gamma rays of 1012 eV or so. Using the known flux of protons at Earth and making assumptions about the density of gas in possible source regions, we can estimate the flux of gamma rays that may be expected. This flux estimate turns out to be very small: at 1011 eV it is about 10-10 cm- 2 s-1 or, in more familiar units, about 30 per square metre per year! Because a typical satellite cannot carry more than a few square metres of detector, it is impractical to observe such gamma rays from space. Fortunately at these energies the Earth's atmosphere, so often a deterrent to astronomy at other than optical wavelengths, actually helps to make detection of these rare, energetic gamma rays possible.

Earth's atmosphere is continuously being bombarded by high energy particles from outer space called cosmic rays. They were discovered over 75 years ago but direct evidence of their origin has only recently become possible through the study of very high energy gamma ray astronomy.



The Durham University high energy gamma-ray telescope in Narribri, Australia.

Detecting Cosmic Gamma Rays

When a photon of energy greater than about 1 MeV (twice the mass of an electron) passes through matter it can materialize to form a pair of electrons. This process can take place in the atmosphere and, if the gamma ray energy is high enough, the electrons themselves can make further gamma rays (in a process known as bremsstrahlung). The electrons do not disappear and, if the secondary gamma rays are energetic enough, a further generation of electrons is born which creates more gamma rays. The number of electrons and gamma rays multiplies rapidly and a cascade of electrons and photons is produced. This is sometimes called an extensive air shower. Now, when a charged particle moves through any medium at a speed greater than the velocity of light in that medium, light is produced by the Cerenkov effect, the electromagnetic analogue of the acoustic shock wave produced when an aeroplane flies faster than the speed of sound. The particles in the extensive air shower are so numerous that a flash of Cerenkov light is produced, lasting only about 10 billionths of a second, bright enough to be detected by relatively simple combinations of search-light mirrors and photomultipliers placed at ground level.

One of the most successful groups in this field is that led by Dr Ted Turver of the University of Durham. One of the mirror systems the group has used to observe potential sources of high energy gamma rays is shown in the first photograph. The Cerenkov light photons are produced at a small angle, (about one degree) to the direction of the incoming gamma ray so that, in effect, it produces a pool of light of radius roughly 100 metres at the observation level. Hence a mirror system only a few square metres in surface area behaves as a detector with an area some 104 times larger. The rate of detection of gamma ray photons becomes good enough for significant signals to be obtained in only a few tens of hours of observation. Observation periods, however, are restricted to clear moonless nights and the number of sources that have yet been studied in detail is rather small. Britain is, of course, a far from ideal place to make such observations, so the Durham group have had to operate their telescope in the Dugway Desert, Utah, and more recently at Narribri, Australia. Similar telescopes are operated in Arizona, Hawaii, the Crimea, India and South Africa.

About 10 objects are now known to emit gamma rays at 1012 : among these there are one radio galaxy (Cen A) and two isolated pulsars (the Crab and Vela) while the rest are examples of a class of object known as X-ray binaries, such as Her X-1 and Vela X-1. The isolated pulsars are thought to be rotating neutron stars, which are also found in X-ray binary systems. All of these (except Cen A) show characteristic periods which help to make their identification more certain, but can we be sure that the gamma rays produced by these sources are indeed gamma rays which arise from neutral pion decay? Unfortunately the answer is no. In addition to synchrotron radiation another process involving electrons gives rise to gamma rays in the electromagnetic fields about a neutron star: this is called curvature radiation and arises when a high energy electron moves along a curved magnetic field line. In the case of the Crab pulsar the Astronomer Royal, Professor Sir Graham Smith, has shown that the pulsed optical and gamma radiation from this process could explain many observational features so that the discovery of TeV gamma ray emission from this source does not firmly establish it as an emitter of cosmic ray protons.

Cygnus X-3 Cosmic Ray Origin

Among the TeV gamma ray sources is Cygnus X-3, one of the most remarkable objects in our Galaxy. It is believed to be a binary system in which a neutron star and another star, perhaps a main sequence star of about one solar mass, co-rotate. Dust clouds lying between the object and Earth prevent detection by optical telescopes, but it is known to radiate across 20 decades of frequency, from the radio band to ultra high energy gamma rays. The source lies about 400000 light years from Earth and is the most powerful Galactic X-ray source. Moreover, its radio emission occasionally increases some thousand-fold. During some of these outbursts the Jodrell Bank group at Manchester University have used their interlinked radio telescope array, MERLIN, to show that the radio emitting material is ejected in the form of two jets.