IQSY-EQEX

Cosmic-Ray Expedition to India

EQEX (standing for Equatorial Expedition) was organized as a joint Indo-American cosmic-ray research program to be carried out during the International Years of the Quiet Sun. The program involved a series of balloon flights this spring over southern India in the vicinity of the city of Hyderabad (see white dot on the accompanying map).

By Serge A. Korff

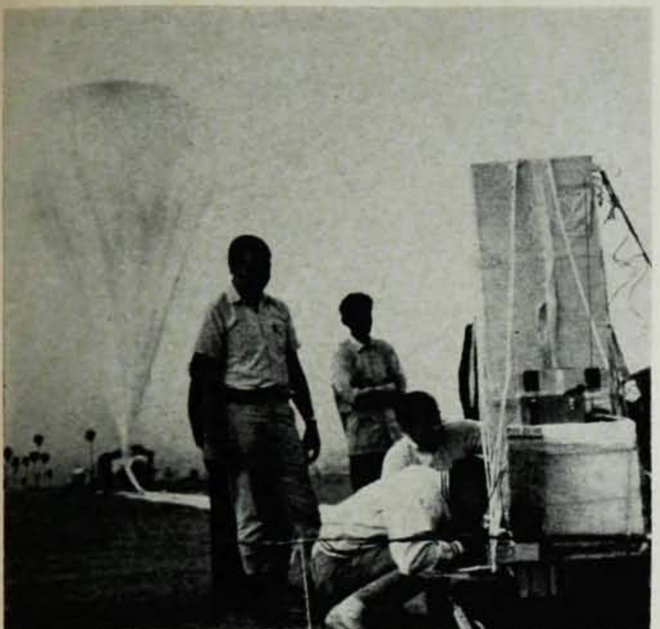
Traditionally, the study of cosmic radiation has involved problems in geographical distribution, and the studies carried out during the recent "EQEX" expedition are no exception. The necessity of such studies comes about since the primary cosmic radiation is a mixed radiation with a wide energy spectrum. If one wishes to study the effects of some one portion of this spectrum, it is possible to use the earth's magnetic field as a magnetic spectrograph to sort out certain energy intervals of the radiation. By this means one can narrow down the energy-intervals, at least to some extent. It has therefore been customary to make observations at various latitudes. The latitude of southern India is one which restricts the incident radiation to the band of incident primary energies in excess of about 15 GeV, the so-called "Stoermer cutoff" here. Since the geomagnetic equator is north of the geographic equator at these longitudes, in India one is some eight or ten degrees further south geomagnetically than geographically.

Considering next the triangular shape of India, the city furthest south for potential balloon launching, from which land recoveries are realistic, is Hyderabad. Furthermore, the region around Hyderabad is characterized by a hot, dry climate in certain seasons, and by low winds, few clouds, and good launching and recovery weather. The elevation at Hyderabad is roughly 1500 feet above sea level. A substantial educational institution, Osmania University, is located there, with some shop facilities and a large polo field suitable for balloon launchings.

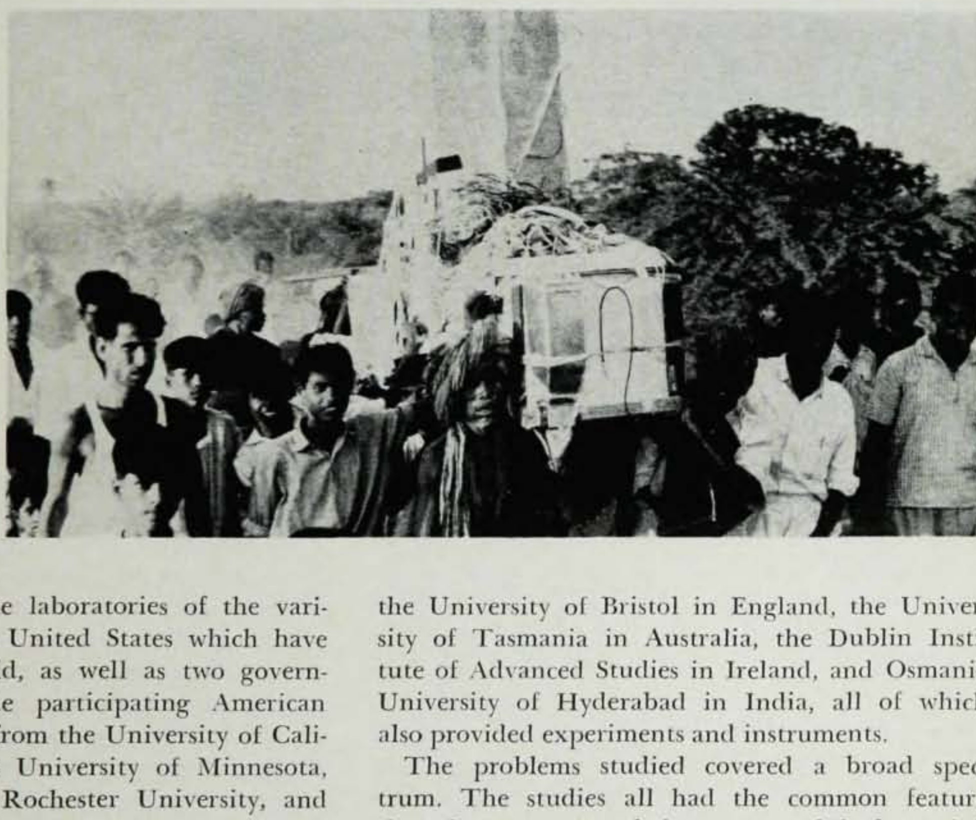
Since we are at present in a period close to the minimum of solar activity, as exemplified by the International Years of the Quiet Sun (the IQSY), it has seemed desirable to make a set of observations at this epoch which might be compared to observations made closer to sunspot maximum. Plans were accordingly made for a joint Indo-American IQSY equatorial expedition for cosmic-ray balloon launching (known as "EQEX"), to be undertaken in the spring of 1965. The project was proposed by the Cosmic-Ray Panel of the United States IQSY Committee of the National Academy of Sciences. Bertram Stiller of the National Center for Atmospheric Research was in charge of the scientific coordination of the expedition, and Robert Kubara, also of NCAR, served as project manager. Stiller was responsible for the various instrument packages attached to the balloons and for liaison with the scientific groups; Kubara was responsible for the ballooning. The principal support came from the National Science Foundation, with additional financing from the National Aeronautics and Space Administration, the Office of Naval Research, and the Air Force Office of Scientific Research.

Representatives of about a dozen groups interested in cosmic ballooning accepted invitations to participate in the expedition. These groups

The author is professor of physics and head of the Cosmic-Ray Group at New York University.



Balloon and instrument package for one of the EQEX flights. The package, shown here loaded on a hand truck just before launching, contains several experiments and associated recording equipment. Below, the same package, recovered after flight, is brought in by some of the local inhabitants. (Photos, including the one appearing on this month's cover, are by W. Sandie, Y. Zeira, and S. A. Korff.)



represented some of the laboratories of the various universities in the United States which have been active in this field, as well as two government laboratories. The participating American university groups were from the University of California at Berkeley, the University of Minnesota, New York University, Rochester University, and the Southwest Graduate Research Center. The government groups were from the Air Force Cambridge Research Laboratory and the Naval Research Laboratory. Several flights were combinations, in that several packages were carried by one balloon. Additional participation by groups from other countries was represented by the Tata Institute for Fundamental Research in Bombay, India, the University of Bristol in England, the University of Tasmania in Australia, the Dublin Institute of Advanced Studies in Ireland, and Osmania University of Hyderabad in India, all of which also provided experiments and instruments.

The problems studied covered a broad spectrum. The studies all had the common feature that the parameters being measured had a minimum of complications added by solar activity, which is the basic point of the IQSY set of measurements. This was probably the only common feature. The NYU group, for example, was studying the number of fast neutrons produced in the atmosphere by the cosmic radiation. This program is a part of the overall study by that group

GMD (Ground Meteorological Detector) was used to track balloons during flight and sometimes to receive radiosonded telemetering of data. Balloons were also tracked by recovery plane which followed them in flight. The antennas shown here were installed on the roof of the physics building at Osmania University in Hyderabad.

of the neutron balance in the atmosphere, which hopefully will lead to an understanding of how many neutrons are produced at each latitude and altitude, in what energy interval, and what happens to them. Many unanticipated but interesting results have come from this study. Something over half of the neutrons are, in due course, captured by nitrogen to form radiocarbon, which in turn is a product of interest to archaeologists and Pleistocene geologists, among others. Measurements of the rates of neutron production as made with boron-trifluoride counters were for a long time in disagreement with measurements of neutrons inferred from radiocarbon data until it was realized that some fast neutrons were captured by resonance processes before they were slowed down into the energy ranges in which the boron-trifluoride detectors operate. Hence they did not appear in the BF_3 measurements. While this particular problem has been cleared up, there remain many others which also have interesting implications. Not all of the neutrons end up forming radiocarbon. Some form tritium, some diffuse upward from the top of the atmosphere and are lost in the so-called "albedo" (a term that causes astronomers to shudder), and some go into still other processes and end-products. There remains much to be done to complete our understanding, and the present set of flights is just one in a series intended to help fill our knowledge.

Another field which was represented in the EQEX flight program was the study of gamma rays or x rays from outer space. This field is very much in its infancy, with many experiments remaining to be done and most questions still unanswered. Today, we know very little about sources of high-energy photons, so that practically every observation brings us some news of interest. There are many possible sources of such radiation, including bremsstrahlung generated by the impact of fast electrons on interstellar matter, possible synchrotron radiation, gamma rays originating from various nuclear sources, and others, all needing much study and interpretation. Several of the groups and flights had apparatus for these studies in the EQEX program. Because of the high geomagnetic cutoff, the ambient cosmic-ray background in India is far lower than in the United States, and India is thus a good place for such work.

High-energy photons have another characteristic which is important. They travel in straight lines and are not deflected by the earth's magnetic field, the magnetic fields in space, or the magnetic field generated by the moving interplanetary plasma. Therefore, the arrival directions are of importance, in contrast to the direction-scrambling suffered by all charged particles.

Another set of experiments in which various groups participated during the expedition was the study, involving several different types of experiments, of the heavy primaries. In India, with the 15-GeV cutoff, it is possible to study the high-energy portion of the heavy primary spectrum, and to find out if the mass spectrum is or is not a function of the energy. Many of the heavy primaries are thought to be fragments of still heavier particles, produced by collisions with interstellar matter. Studies are currently under way to explore the fragmentation processes and parameters, which in due course will throw light on the amounts of interstellar matter traversed, and perhaps also on the composition of the matter which is fed into the original "ion source" of the original acceleration mechanism. Thus we may hope to learn, from these flights, a little more about the origin of the radiation and the characteristics of the space through which it has passed.

Various instrument packages, using a number of detection instruments ranging from neutron detectors, through gamma-ray scintillators, to spark chambers and photographic emulsions, all were flown in this series of tests. Indeed, one of the big sets weighed as much as 2000 pounds and had to have an enormous parachute, but most of the flight sets were a good deal lighter. Most flights carried more than one experiment.

In this type of ballooning it is possible to float the balloon at any desired altitude up to about 145 000 feet, which is close to the top record of balloon altitudes today. Even at 120 000 feet, readily attainable by balloons, only one-half of one percent of the atmosphere remains above the instrument. The duration of the flight (or the time at a given altitude) is determined by the requirements of the experiment and can range from an hour to twenty hours or even more. Two different considerations may determine the duration. One is the length of time needed to get the desired data, and the second is the possibility that the balloon will drift out over the ocean to some other undesired region. In either case, two alternative flight-termination procedures are available—the regular time cutdown and a radio command cutdown for use in the second contingency. Continuous tracking of the balloon is carried out at all times, a small beacon attached below the instrument package providing the signal, and a directional receiving antenna the azimuth angle. A homing antenna in the recovery plane tells the pilot the direction of the flight. Indeed, it is usually possible for the recovery plane to stay nearly below the balloon, thus keeping it in view.

When the flight is terminated, the load is separated from the balloon and descends on a parachute. This chute comes down very fast for the first half of the flight. At some 40 000 to 50 000 feet the chute begins to become effective and the descent decelerates. As the chute and package comes below 20 000 feet, it can often be seen from the plane, which then circles around it and watches the landing. Communication by walkie-talkie with a recovery vehicle then directs its crew to the package on the ground. Reward labels on the instrument package encourage any finder to telephone the location of the set, in case the recovery plane misses it. The entire operation runs with precision since the personnel have made many flights and are familiar with the details and procedures.

The data obtained on such a flight can in some cases be telemetered, making recovery not vital. Still, there are two reasons for wanting recovery in all possible cases. These are (a) the cost of the apparatus, which often can be flown a second or a third time, and (b) the question of recalibration. If an instrument can be calibrated before a flight and then recalibrated after the flight, the confidence in the data is greatly increased. Hence, recovery is attempted in all cases. This is especially true for EQEX, as only three of fifteen flights were telemetered.

Any such ballooning operation involves a set of special problems, produced by the locality. In the case of flights in India, there are two factors which differ from, for example, flights in the continental United States. First, in India there is not the network of good roads and telephones that can be found throughout the United States, so the strategic placement of the recovery vehicle is more complicated. The second is that mechanical facilities are less readily available. Thus, for example, it took some time and effort to locate a crane in Hyderabad capable of hoisting the helium cylinders onto the truck that took them out to the inflating field. Nonetheless, such problems could be and were solved, and indeed give an atmosphere of challenge to the entire operation. By the time our NYU group left India, the first three flights had been successfully carried out, and preparations for the next ones were well along. A group of intelligent people working on such a problem rapidly develops competence. In this case a smoothly working group was welded together by Stiller and Kubara. They did an excellent job, and made for a very successful and satisfactory operation.