It is already clear that the background places significant limits on the number counts of quasars whether they are local or cosmological. Rees emphasized the need to get a bivariate (X-ray+optical) luminosity function to enable one to make realistic estimates of the contribution of X-ray quasars to the X-ray background. Rees also discussed the probable future use of the X-ray background data as a probe of the large scale inhomogeneities of the universe.

There were several contributions which extend the hope that infrared astronomy will help filling in important gaps in our knowledge of the extragalactic space. One example is the possible identification of infrared sources in the 'empty' fields, as was discussed by G. Rieke. M. Lebofsky indicated how infrared magnitudes in the H and K bands can be used to determine the Hubble's constant and the deceleration parameter, showing results based on the data for 6 galaxies. Incidentally, the largest galaxy redshift of 0.947 for the elliptical galaxy 1305+2952 was also included the list of six galaxies.

The IUE data on the spectrum of galaxies in the ultraviolet was discussed by M. Penston. The drop in intensity over 2000Å—3000Å range for normal galaxies is as expected, although there is a rise at wavelengths shorter than 2000Å. In some cases the spectra have been extended to 1150Å. This information is important to cosmologists in estimating the K-corrections to the magnitudes of high redshift galaxies. Two high redshift quasars of 17 magnitude were detected with a rest frame wavelength of 300Å. The spectrum of 3C-273 does not show any ultraviolet absorption lines except those in our own Galaxy ?

The final session of the symposium was on the cosmic microwave background. The departure from the Planckian form was discussed by D. Woody and P. Richards. The departure is significant and needs an explanation in order to sustain the usual interpretation of the origin of the background in a big bang. The speakers pointed out that so far only one explanation has been advanced, that by Segal in his chronometric cosmology. P.E. Boynton discussed small scale anisotropy. In the discussion that followed, it turned out that theoreticians still disagree on the level of small scale anisotropy at which inhomogeneities in the structure of the universe can be detected. G. Smoot reviewed large scale anisotropy, pointing out that the apparent discrepancy between the directions and magnitudes of the background anisotropy and the anisotropy of the Hubble flow (the Rubin-Ford Effect) still remains to be explained.

It was a well organized and stimulating symposium which ended with a barbeque on Mt Wilson. This informal gastronomical occasion (instead of a formal conference dinner) not only provided the delegates with opportunities to carry on their (often heated !) discussions but also demonstrated the powerful local background radiation and large optical depth which have driven the observers away from Mt Wilson.

J. V. Narlikar

Tata Institute of Fundamental Research
Bombay 400 005

THE 16TH INTERNATIONAL COSMIC RAY CONFERENCE

The 16th International Cosmic Ray Conference was held at Kyoto, Japan between August 6-18, 1979 and was attended by about 570 participants of whom 300 were from Japan. The Conference papers, comprising of 11 volumes, were distributed to the participants at the time of registration. They included original contributions in the areas of (i) cosmic ray composition, origin, sources, acceleration and propagation, (ii) modulation of cosmic rays in the solar system, (iii) geophysical effects on cosmic rays, (iv) solar particles, (v) high energy physics at energies greater than about a TeV, (vi) extensive air showers produced by cosmic rays in the Earth's atmosphere, (vii) cosmic ray muons and neutrinos, and (ix) techniques. In the present article I will attempt to summarise important contributions of interest to astronomers.

1. Gama Ray (GR) Astronomy

(a) COS-B RESULTS : The Gamma Ray Experiment in the European Space Agency's satellite COS-B launched in 1975 has yielded very rich dividends. Some of the important results are the following :

(i) Sources :—From the latest analysis of the data, 30 peaks consistent with their being discrete sources have been detected. Of these, 29 are seen at energies in excess of 100 MeV and include 25 which have galactic latitudes b less than $\pm$ 5°. The mean value $|b|$ is 1.7°. The identified sources are the Crab and Vela pulsars, 3C 273 and ρ Oph. The remaining peaks are yet unidentified. 3C273 has a spectral shape

$$\frac{dN}{dE} = 2.7 \times 10^{-8}\ E^{-2.7}\ \text{ph. cm}^{-2}\ s^{-1}\ \text{GeV}^{-1}$$

and has a luminosity above 50 MeV of $L = 2\times 10^{48}$ ergs s^{-1} (assuming d = 790 Mpc).

In an interesting paper to understand these peaks, Montmerle of France reported that he has found a strong correlation between the unidentified GR sources and supernova remnants that are associated physically with H II regions and OB associations; such objects are given the name of SNOB. Some of the interesting consequences of this correlation have also been pointed out.

(ii) Galactic diffuse emission:—Compared to the US gamma ray satellite SAS-2 which recorded a total of 14,000 photons, COS-B has already recorded 64,000. In Fig. 1 is shown at the middle the sky map at energies between 70 MeV and 5 GeV. Additional information on the longitudinal and latitudinal distribution are given in the curves at the top and bottom of this figure. This is only the foreunner of what GR astronomy is likely to bring out in the future with better statistics and improved angular resolution; the latter is only about 1° at present. Very little interpretative work has been so far carried out with these data.

(b) GAMMA RAY BURSTS (GRB) : In a collaborative experiment between French and Soviet scientists, they have mounted identical GR detectors in two Venus

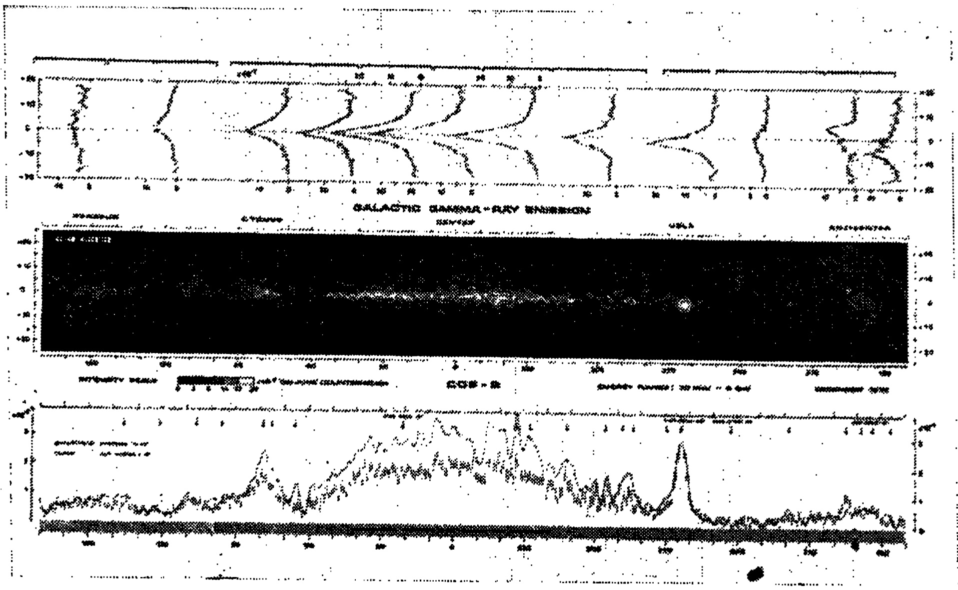

Fig. 1 : In the middle is shown a sky map in Gamma Rays. At the top is given the latitudinal distribution at various longitudinal intervals. At the bottom is shown the data points for the longitudinal distribution for $b = \pm 5°$; the curve is a cut along $b=0$.

probes, Venera 11 and 12, and an eccentric earth statellite Prognoz-7. During the period September 1978 to March 1979, a total of 16 GRBs have been recorded. Of these 11 were also seen by other satellites. The time structure of these bursts is very interesting as seen in Fig. 2 for an event recorded on November 19, 1978 in all three satellites. Notice the narrow spikes are seen in all the three detectors which cover the energy range 80-1000 keV. One GRB that occurred on March 5, 1979 was recorded in 9 satellites thereby enabling by triangulation an error box of $1' \times 1'$ within which lies the supernova remnant N49 in LMC. If this identification is correct the energy release is about 10^{44} ergs. No other identification has yet been possible though so far a little more than 100 GRB's have been well recorded. In this situation the first tentative identification of a GRB in a nearby extragalactic object is very interesting particularly in view of the large energies involved. Otherwise the GRB is still a mystery and we know next to nothing about them at the present time. May be we will have some real surprises in the near future.

2. Discovery of Antiprotons in Cosmic Rays :

The first evidence for the presence of antiprotons in cosmic rays was presented from a balloon experiement using a superconducting magnet spectrometer in conjunction with multiwire proportional chambers for trajectory determination and a 7 radiation length shower counter below. The results were reported by R.L. Golden of the New Mexico State University jointly with other authors including two from TIFR. After corecting for the effect due to the residual air, the flux of antiprotons in the primary cosmic rays is $5.2, \pm 1.5 \times 10^{-4}$ of the proton flux in the rigidity range of 5.6. to 12.5 GV/c.

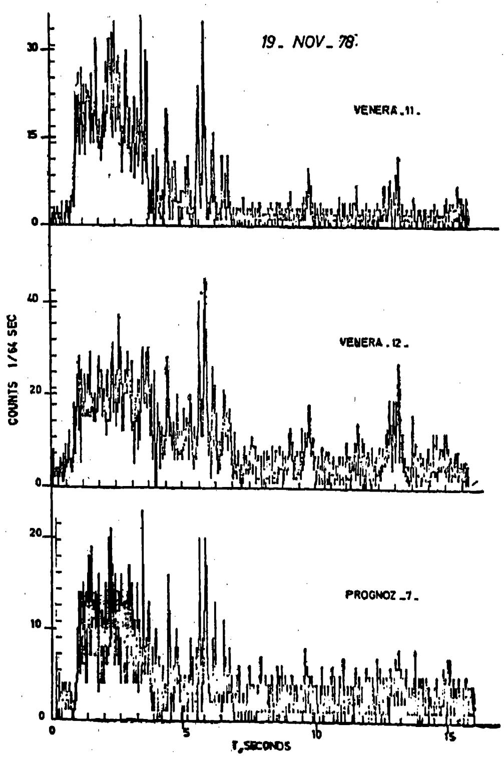

Fig.2 : Time structure of a GRB detected in Venera 11 and 12 and Prognoz 7 on November 19, 1978.

The error associated with the flux measurement is such that the presently determined value is consistent with that expected to be produced as secondaries of $(1\text{-}4) \times 10^{-4}$ in interstellar space by the primary cosmic rays traversing the 5 g cm^{-2} of matter as determined from the abundance of cosmic ray Li, Be, B nuclei. More accurate measurements and calculations will be needed to say whether there is any excess of antiprotons over those produced as secondaries in space. It also means that the life time of antiprotons is at least as long as about 10^7 years which is also roughly the cosmic ray life time.

3. Very Low Energy Cosmic Ray Nuclei :

The study of heavy nuclei of energy above a few MeV and upto about 50 MeV has brought about a number of interesting anomalies in the composition which is clearly different from that of high energy cosmic rays. For example the ratio of oxygen to carbon is about 4.5. The TIFR Group has proposed a model to understand this observation. In this, particles in partially ionised states originating in nearby steller sources with energies of about 100 KeV/amu are accelerated to energies of about 10 MeV/amu in the heliosphere boundary by turbulent magnetic fields. Some interesting observational method of testing this model is also proposed by them. The model evoked considerable interest among a section of the delegates.

4. Ultra Heavy Nuclei :

The Bristol University Group from the United Kingdom has launched on May 24, 1979 the UK-6 satellite dedicated for a study of nuclei heavier than iron in cosmic rays. The detector system which incorporates a number of interesting features is working very satisfactorily and preliminary data from the first 43 days of its operation were reported. The charge resolution of the instrument $\Delta Z/Z \approx 4\%$ FWHM for $Z > 45$. Based on 374 events with $Z \geqslant 37$, corresponding to 63 m^2 sr days, they find clear peaks at $Z = 38, 52, 56$ and possibly 62; the platinum peak at $Z = 78$ is also quite pronounced. The highest charge recorded is 98.7 ± 2. The flux values obtained are $6.5 \times 10^{-5} / m^2$ sr. s for $Z \geqslant 37$ (374 events), 1.3×10^{-5} for $Z \geqslant 50$ (72 events) and 3×10^{-6} for $Z \geqslant 70$ (17 events). There is every indication that in an year's normal operation this satellite will bring forth a statistically significant chemical composition that will enable us to say a great deal about the origin and history of cosmic rays.

5. Isotopes :

The advances in resolving with reliability isotopes of cosmic ray nuclei have now reached a stage where, one can go upto Fe nuclei for energies upto 1000 MeV/amu. Special mention may be made of the Caltech Heavy Isotope Spectrometer Telescope which was launched in ISEE-3 in August 1978. The first results which were reported at this Conference from this experiment revealed the excellent resolution it possesses for nuclei lighter than Fe at energies of 5-250 MeV/amu. We will now consider some of the new results reported at this Conference.

(i) Fe Isotopes: Earlier measurements had indicatedthat Fe^{58} is more abundant than Fe^{56} incosmic rays. In this Conference a number of investigators reported results from ballon and satellite measurements which conclusively show that Fe^{56} is the dominant sotope. It is found that at the sourc Fe^{56} accounts for about 85% of the Fe nuclei whereas Fe^{54} accounts for about 5-10% while Fe^{58} is less than 5%. Thus the Fe isotopes in cosmic rays are converging towards solar system abundance of 6%, 92% and 0.3% for the 54, 56 and 58 isotopes respectively.

(ii) Ne Isotopes: Results reported by three experimenters on Ne isotopes convincingly revealed that the ratio Ne^{22} / Ne^{20} has a value lying between 0.3 and 0.4 when extrapolated to the source region as seen in Figure 3. Compared to this, solar system material (lunar fines, meteorites, solar wind and solar flares) have values

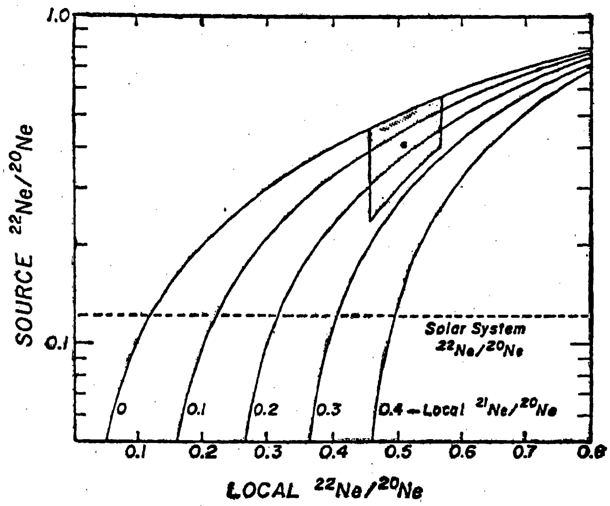

Fig. 3 : The ratio Ne^{22} / Ne^{20} in cosmic rays measured in interplanetary space is plotted against its extrapolated value at the source. The error box in the experimental value extrapolated to the source is shown. The dotted line represents the value of the ratio in the solar system.

between .07—.15. The experimental errors are such that the results strongly suggest that Ne^{22} is significantly in excess in cosmic ray sources compared to what is expected for solar system material. This is the first clear case of cosmic ray source composition significantly different from solar system composition. Since a number of different processes can contribute to the synthesis of Ne isotopes, it is not yet clear how this difference is to be interpreted. However speculations are already on the way. Since Ne^{22} is thought to be sysnthesised primarily in helium burning, two possibilities have been pointed out. In the first, the Ne^{22} enhancement may be due to repeated nucleo-synthesis during galactic evolution since cosmic rays are relatively much younger than the solar system. However, this suggestion will have difficulties in explaining the observed isotopic abundance of magnesium in cosmic rays. In the second possibility Ne^{20} and Ne^{22} are produced in different burning processes in differnet zones of a massive star; consequently the ratio Ne^{22} / Ne^{20} might be a variation in the relative contribution of these zones. Observations of other s-process nuclei might test this possibility.

(iii) ISOTOPES OF C, N AND O: Isotope measurements on these nuclei have now reached a high degree of resolution and reliability and results were reported by a number of Groups. It is found that in cosmic rays recorded in interplanetary space (a) C^{13} constitutes about 5-8% of Carbon, the rest being C^{12} (b) N^{15} constitute about 45-50% of all nitrogen, the rest being almost entirely N^{14}; and (c) 90 to 95% of oxygen is O^{16}, the rest being O^{18} and O^{17}; if any is less than about 2%. When these data are extrapolated to the source, it is seen that all O^{13} and O^{18} can be accounted as produced as secondaries in collision of heavier nuclei in interstellar space; that is to say that at the source all carbon is C^{12} and all oxygen O^{16}. As for nitrogen, the elemental abundance itself is low compared to C and O and the uncertainties in the production cross sections of N^{15} are large such that no reliable conclusion can be drawn at present about the abundance of N^{15} at the source. However, it seems that one can extrapolate more reliably the ratio of N/O to the source, which suggests a value of 1 to 6%. This may be compared to the value of 17% for the solar system abundance of nitrogen compared to oxygen. However, it is too soon to draw any inference from this.

6. Cosmic Rays in the Outer Heliosphere

Voyagers 1 and 2 have already encountered Jupiter and are proceeding beyond 5 AU toward encounters with Saturn. Pioneer 11 launched in 1973 is now about to encounter Saturn at about 10 AU. Pioneer 10 has passed the 20 AU mark after a 7 year journey. All cosmic ray instruments on these space crafts are still functioning quite well. Hopefully, they will be tracked for several more years to provide data upto and beyond 30 AU. We summarise below some of the new and interesting results from these missions that are reported at this Conference.

(i) SOLAR MODULATION EFFECTS ON GALACTIC COSMIC RAYS: The following are the important results. (a) A study of the heliocentric radial intensity gradient of low energy cosmic rays of extrasolar origin will give important information on the sphere of influence—the modulating region—of the sun. Pioneer 10 and 11 data show that the flux of protons of energy greater than 60 MeV increases outwards from the Sun at the rate of about 3% per AU upto about 16 AU. (b) Extrapolating the radial gradients, it is inferred that the solar modulating boundary may be somewhere between 35 and 50 AU. (c) Observations on protons of energy less than 60 MeV show that the radial gradients are much larger and have values of 7—15% per AU. (d) While studying long term variations of proton intensities as a function of distance from the sun, the onset times of the events at various locations propagate with a velocity of about 400 km s^{-1}—the typical solar wind speed. This shows the dynamic interaction between solar wind and galactic cosmic rays.

(ii) SOLAR COSMIC RAYS: Unlike galactic cosmic rays which enter the heliosphere from outside and thereby get modulated, solar cosmic rays emitted by the sun at times of intense activity will be propagated outwards and can also be used as a powerful tool to probe interplanetary medium. Several papers were presented at this Conference in which energetic particles emitted from large solar events were traced out to 14 AU. From earlier work it was well known that upto 5 AU the propagation of energetic solar particles is consistent with a diffusive—convective model with a diffusion coefficient $K_r = K_o r^{\beta}$. Upto about 5 AU, $\beta \simeq 0$. Papers presented at this Conference show that at large radial distances r, the event takes almost a month to reach the mximum intensity of particles associated with the solar flares and the high intensity persists for over a month indicating that the azimuthal distribution is much less dependent on solar connecting features than at 1 AU. The average value of β obtained from these events is-0.3. A distinct change in interplanetary phenomena seems to take place in the 10-15 AU range to a quieter, more azimuthally uniform and less temporally varying situation occasionally influenced by longlived incursions of solar cosmic rays.

(iii) THE ANOMALOUS COMPONENTS: The very low energy He and O nuclei show anomalous intensities compared to the other nuclei (see Section 3). It is found that the 10-20 MeV He nuclei show a positive gradient of about 15% per AU upto 16 AU compared to protons which have a value of 5-10% per AU at this energy. The O nuclei on the other hand have even a larger gradient of about 20% upto 6 AU whereafter they start decreasing to 10% at 16 AU. This is a most puzzling observation and there is as yet no satisfactory explanation.

A joint IUPAP/IAU Symposium on "The Origin of Cosmic Rays" will be held at Bologna, Italy, during June 11-14, 1980. The 17th International Cosmic Ray Conference will be held in Paris in July-August 1981.

R. R. Daniel

Tata Institute of Fundamental Research
Bombay 400 005