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Experimental Study of Variation of Secondary Cosmic Gamma Ray Flux during Total Lunar Eclipse April 4, 1996 and July 16, 2000

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Abstract

We report the observations of variation of secondary cosmic gamma ray flux near 2.57 MeV energy during April 4, 1996 Total Lunar Eclipse and energies near 1.31 MeV, 1.618 MeV, 2.57 MeV during July 16, 2000 Total Lunar Eclipse. For our experimental studies, we used scintillation counter to detect secondary cosmic gamma ray flux in the energy range of 10 keV to 5 MeV. We interpret the variation of secondary cosmic gamma ray flux at some energies on the basis of phenomenon of bending primary cosmic ray and solar energetic particle by magnetic field of the Sun and the interplanetary magnetic field, combined gravitational leasing effect of Sun and Earth, may cause strong impact on the air less surface of the Moon and produced secondary particle flux from bared surface of the Moon (mostly gamma ray, high energy photo electron, hard x-rays, muons, Protons, neutrons) may be regarded as back scattering form the Moon surface and energy of backscattered Secondary flux is so large enough that gives such variation during Lunar eclipse observation. Also the bent primary cosmic ray and solar energetic particle impinges deep inside the atmosphere of the Earth which produces shower of secondary cosmic ray particles. These collectively effects gave variation of secondary cosmic gamma ray flux at near 2.57 MeV energy during April 4, 1996 Total Lunar Eclipse and energies near 1.31 MeV, 1.618 MeV, 2.57 MeV during July 16, 2000 Total Lunar Eclipse.

Keywords: Lunar eclipse, solar magnetic field, interplanetary magnetic field, combined gravitational leasing effect of Sun and Earth, bending of primary cosmic ray and solar energetic particle, Secondary emission form the Moon surface, back scattering form the Moon surface, interaction of cosmic rays with Earth Atmosphere.

Introduction

Cosmic rays are high-energy charged particles that travel at nearly the speed of light and isotropically strike the earth from all directions. About 89% of these nuclei are of hydrogen (protons), 10% of helium, and about 1% of others heavier elements[1]. Sources of cosmic rays outside the solar system, distributed throughout the Milky Way galaxy. Energetic particles that are associated with energetic events on the sun, also known as solar energetic particles (SEP) and are accelerated in interplanetary space. We found that the characteristics of GCR and SEP are modulated and manifested in the ground based spectrum observed for the terrestrial secondary cosmic gamma rays (SCGR) flux. These SCGR measured by efficient scintillation detectors. Cosmic rays are almost isotropically distributed charged particles and propagate through interplanetary space while arriving on the Earth[2]. If these particles have energies of the order of 10 TeV or lower then will bend under the influence of solar and interplanetary magnetic field[3]. It is believed that the bending of cosmic flux becomes significant when the Moon is in the line joining the centers of the Sun and the Earth during the Eclipse[3,4,5,6]. Bending of cosmic flux specifically becomes important when the moon is in the line joining the centers of the sun and the earth during the eclipse[7, 8].

Rays of light or other electromagnetic radiation passing near a massive object bends due to gravitational field of the object is called the gravitational leasing. In fact due to combined effect of solar and interplanetary magnetic field and gravitational leasing the strong impact of primary high-energy solar and bent cosmic ray flux on surface of the Moon produces secondary emission from moon surface[9,10,11] (mostly gamma ray, high energy photo electron, hard x-rays, muons, Protons, neutrons) and may be regarded as back scattering form the Moon surface in the range of several hundred keV to MeV and energy of backscattered Secondary flux is so large enough that gives such variation during Lunar eclipse observation. As shown in figure-1 below Moon with Back scattered Secondary flux:

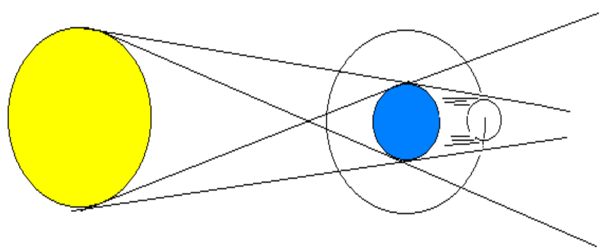


Figure 1
Moon with Back scattered Secondary flux

Also the bent primary cosmic ray and solar energetic particle impinges deep inside the atmosphere of the Earth which produces shower of secondary cosmic ray particles and can be measured using appropriate detector on ground[12,13]. We conducted experiments for observing unusual variation of secondary cosmic gamma ray flux near energy 2.57 MeV during April 4, 1996 and energies near 1.31 MeV, 1.618 MeV, 2.57 MeV during July 16, 2000 Lunar Total Eclipse as compared to normal days.

Methodology

Experimental setup and observations: For Lunar eclipse 4th April 1996 we used scintillation detector to detect the secondary cosmic gamma ray flux in the energy range of 10 keV to 5 MeV. The radiations were allowed to enter in the NaI (Tl) crystal of 50 mm thick and 44.5 mm in diameter optically coupled with photo multiplier tube (PMT) RCA 8575. This integral line was connected to a high tension voltage supply of 1100 volts DC. The negative signal of about 0.5 Volts was amplified to 5 Volts positive pulse using negative polarity of spectroscopic amplifier ORTEC model 451. This signal was fed to analog to digital counter (ADC) model 917 to provide appropriate input to ADCAM 100 ORTEC for data acquisition and analysis in ADCAM multichannel Buffer. Scintillation counter kept open to collect the counts as a function of time so as to make our case study more precise as compared to short duration collection of counts. The energy calibration was observed to be 4.54 KeV per channel using standard radioactive sources Co^{60}.

Experimental set up was consisted highly shielded scintillation counter coupled with photomultiplier tube and data acquisition system. This setup was brought up at top of the building of department of Physics, College of Science, M.L. Sukhadia University, and Udaipur. On 4th April, 1996, smoothly we chased lunar eclipse pointing the detector exactly towards and along the line of sight of Dark red Moon. Sufficient data were collected on 4th April 1996 for entire time period of totality of lunar eclipse over channels of multichannel analyzer. To compare this valuable data (totality) with normal days, we have taken enough data using same apparatus on 28th, 29th, 30th and 31st March, 1996 and well before Lunar eclipse with same time period. The Total Lunar Eclipse began at 28:56 IST. Earlier Lunar study on 4th April, 1996 revealed different unique features and we decided to confirm them with another scintillation detector of still higher resolution of 3.3 KeV/Channel using standard radioactive sources Co^{60} on next total Lunar Eclipse of 16th July, 2000. For this purpose we used integral line of scintillation counter ECIL, India make which had better resolution than that of earlier used on 4th April, 1996. Scintillation counter with photomultiplier tube plus potential divider with preamplifier were integrated in one rigid metallic cylinder and output connectors had been given only to connect H.T., L.T. pulses cables only. This compact unit of scintillation counter has least noise, high-energy resolution (3.3 KeV/channel) Co^{60} source. H.T. value was about 870 Volt and L.T. with +12,-12 volt and output negative pulse was around 0.5 volt. It was fed to linear spectroscopic amplifier to make final pulse of approximately 10Volt with positive polarity. This pulse was fed to multi channel analyzer MCA SMS ECIL make to collect data as a function of energy scale of incoming Secondary cosmic flux at ground level. The output of SMS-MVA was coupled to data acquisition system comprising computer. Valuable data were acquired Lunar Eclipse days i.e. 16th July, 2000 data files have been created after every 15 minutes duration from 18:35 hours to 19:50 hours including eclipse time proceed.. Also valuable data were acquired on normal day i.e 18th. During normal day 18th July, 2000 data files have been created after every 15minutes duration from 18:35 hours to 19:50 Hours on the same times as taken on 16th July (eclipse day). The total Lunar Eclipse began at 18:32 IST. This setup was brought up at top of the building of department of Physics, College of Science, and M.L. Sukhadia University.

Results and Discussion

Analysis and Results: Shown in Figure 2 sufficient data were collected on 4th April 1996 (Eclipse day) for entire time period of totality of lunar eclipse. For this study, calibration was kept 4.545 KeV/Channel using standard sources of Co^{60}.

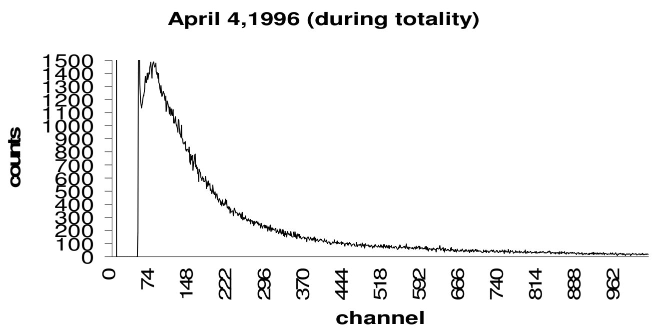
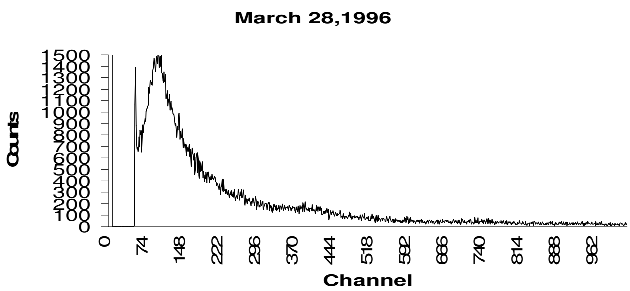


Figure-2
Spectrum of SCGR flux on eclipse day

To compare this valuable data (totality) with normal days, we have taken enough data using same apparatus on 28th, 29th, 30th and 31st March, 1996 and well before lunar eclipse with the same time about as depicted in the panels of figure-3 and figure 4 below:



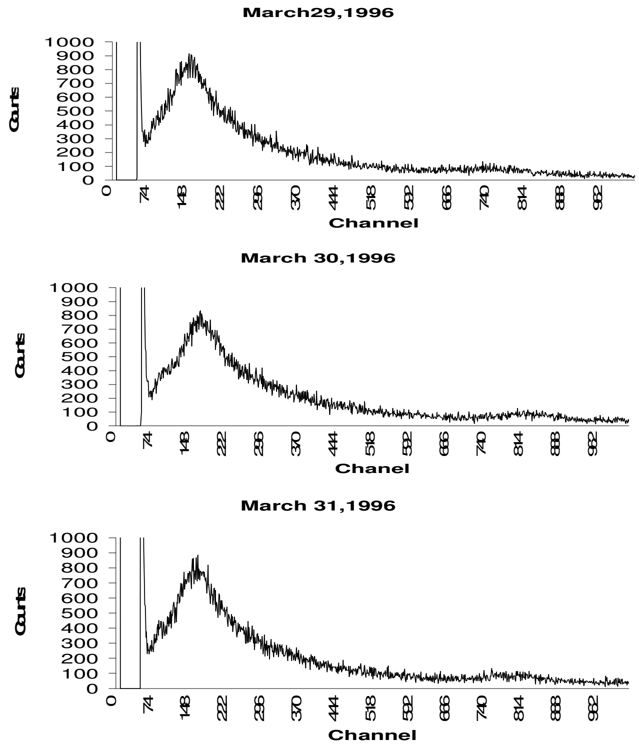


Figure-3
Panels of spectrum of SCGR flux on pre eclipse days

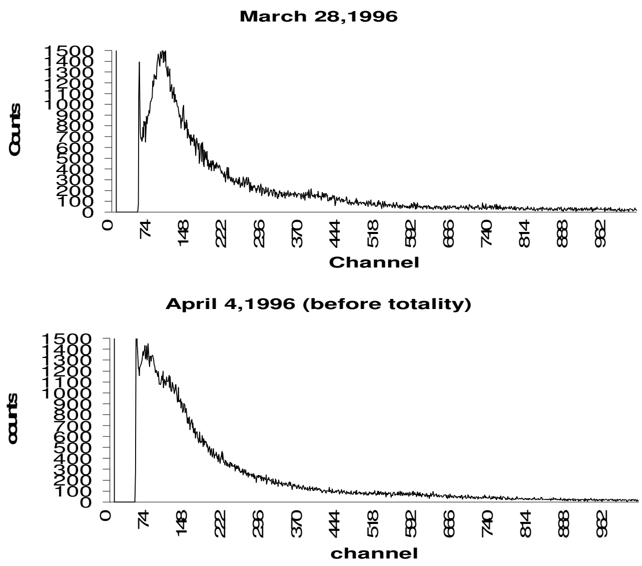


Figure 4
Spectrum of SCGR flux before totality

For better information we took ratio (comparison) of eclipse day 4 April, 1996 (totality) to normal days 28th, 29th, 30th, 31st March and before totality 4 April, 1996 Panels of figure 5 and 6 below:

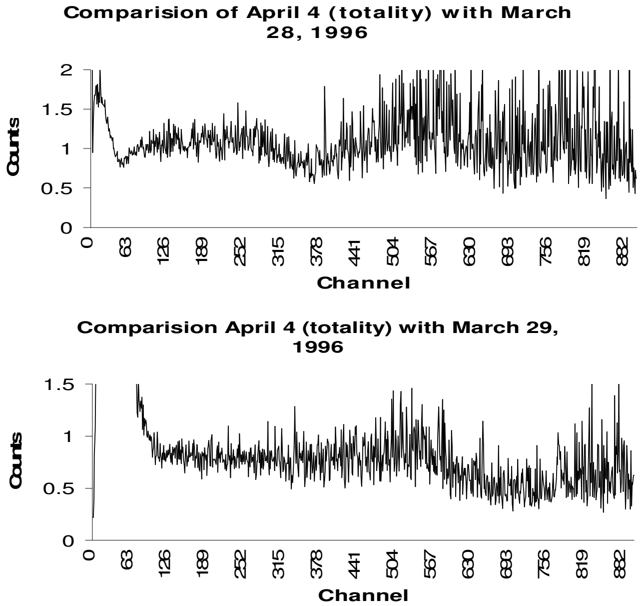


Figure 5
Panels of count ratios of SCGR flux between l eclipse day with Pre eclipse days

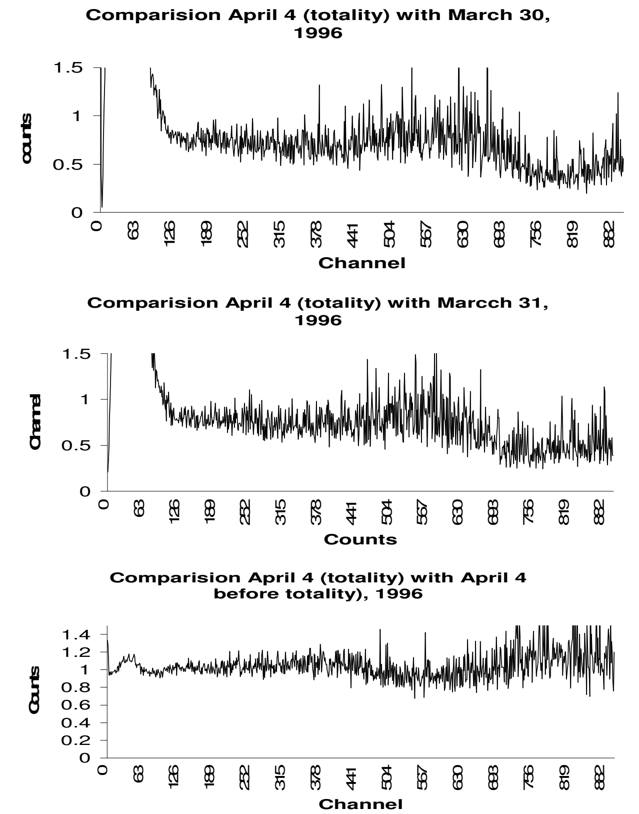


Figure 6
Panels of count ratio of SCGR flux between l eclipse day with Pre eclipse days and between totality with before totality

For most observable feature found in comparison of spectra of 4th April with normal days 28th, 29th and 30th and 31st March 1996 background is variation of secondary cosmic gamma ray flux and little enhancement (as good as one and half) near 2.57 MeV energy during lunar Eclipse. To confirm the unusual finding during total Lunar eclipse, experimental study was repeated during 16th July 2000. For this study, calibration was kept 3.3 KeV/Channel using standard sources of Co^{60}. During eclipse day 16th July, 2000 data files have been created after every 15minutes duration from 18:35 hours to 19:50 hours including eclipse time proceed. The energy spectrums of individual days have been given in panels of figure-7 and figure 8 below:

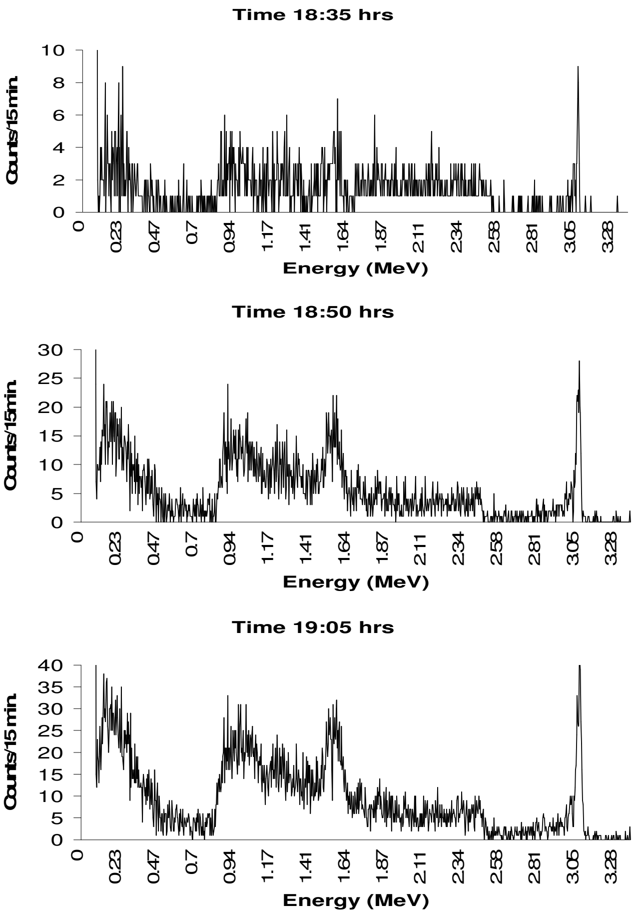


Figure 7
Panels of energy spectrum of SCGR flux on eclipse day 16th July, 2000

Also valuable data were acquired on normal day i.e 18th. During normal day 18th July, 2000 data files have been created after every 15minutes duration from 18:35 hours to 19:50 Hours on the same times as taken on 16th July (eclipse day). The energy spectrums of individual days have been given in panels of figure-9 and figure10 below:

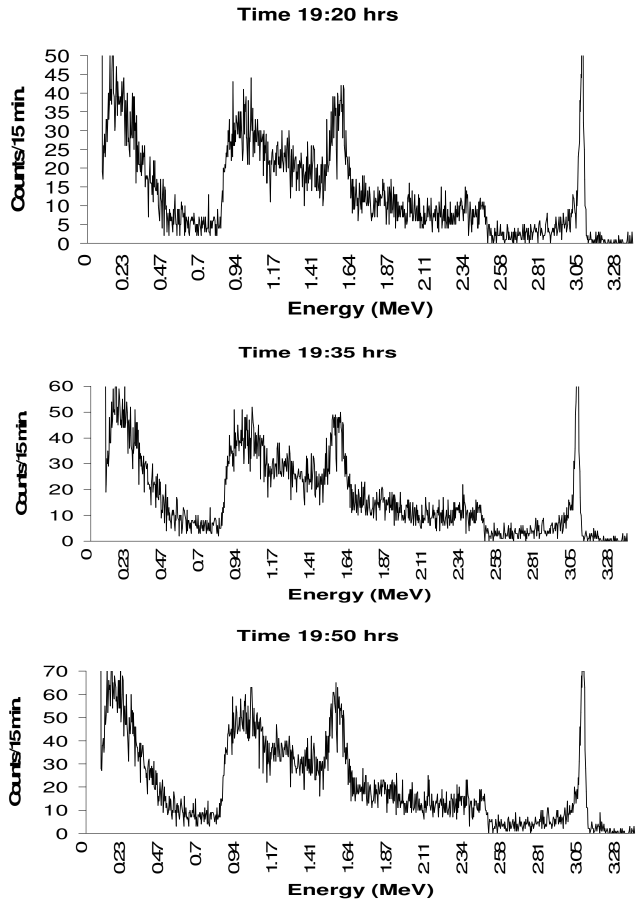
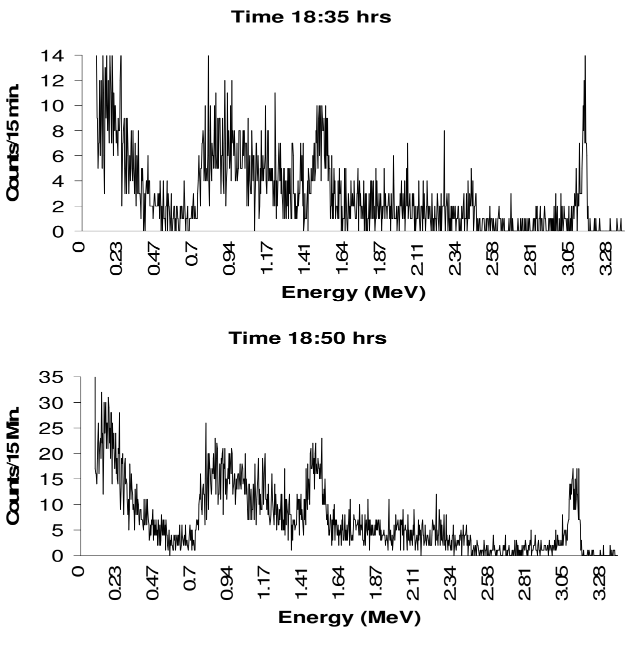


Figure 8
Panels of energy spectrum of SCGR flux on eclipse day 16th July, 2000



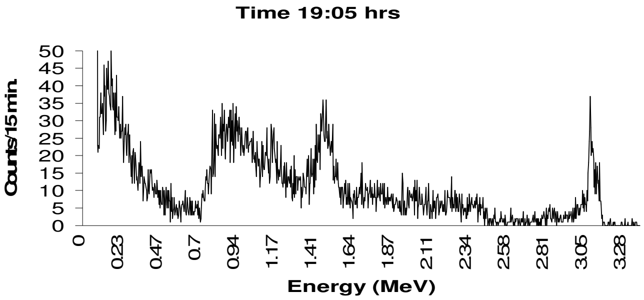


Figure-9
Panels of energy spectrum of SCGR flux on normal day 18th July, 2000

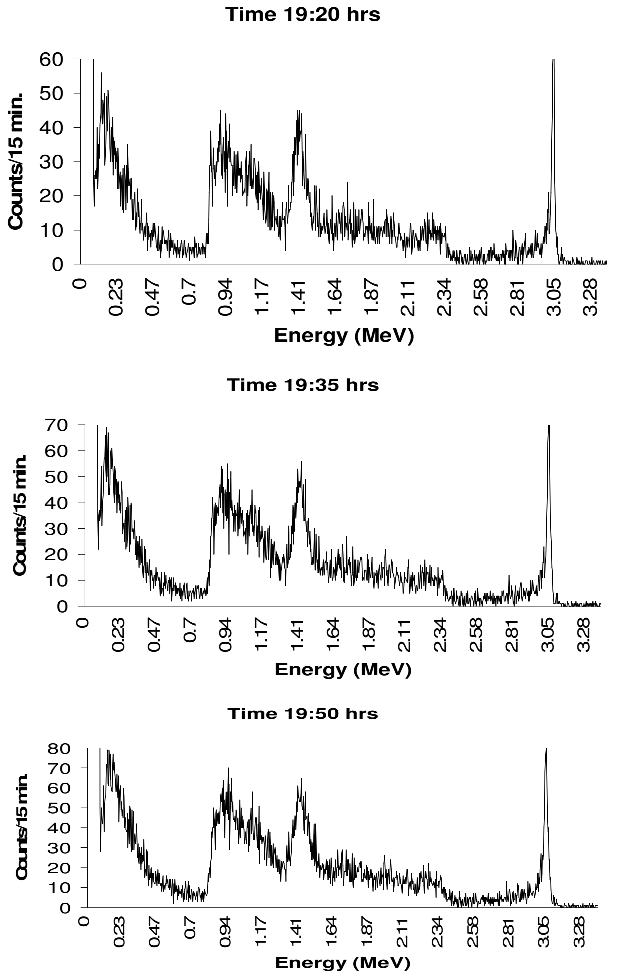


Figure-10
Panels of energy spectrum of SCGR flux on normal day 18th July, 2000

For better information we took ratio of eclipse day 16 to normal days and 18. Results have been plotted in Panels of figure 11 and 12 below:

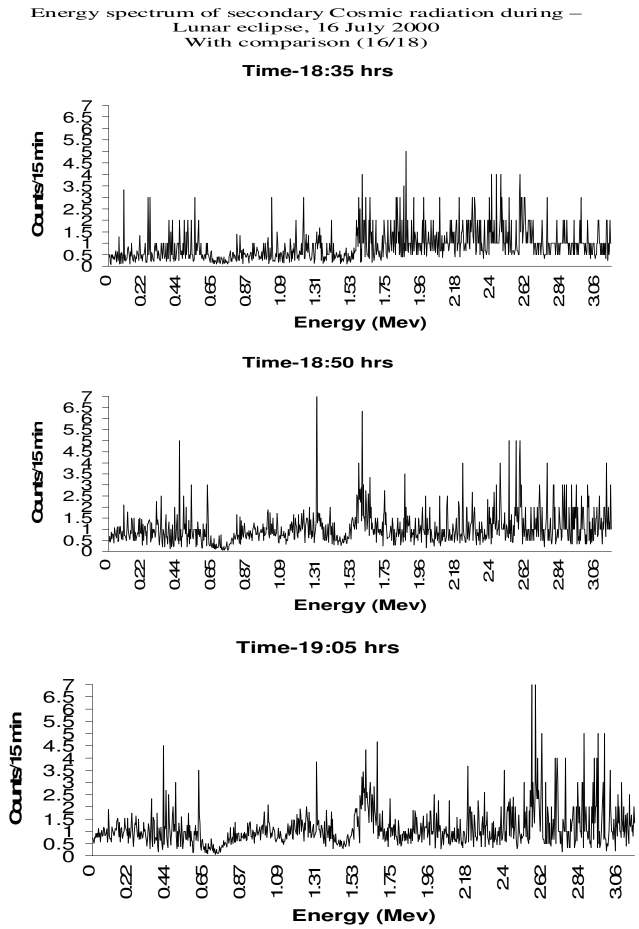
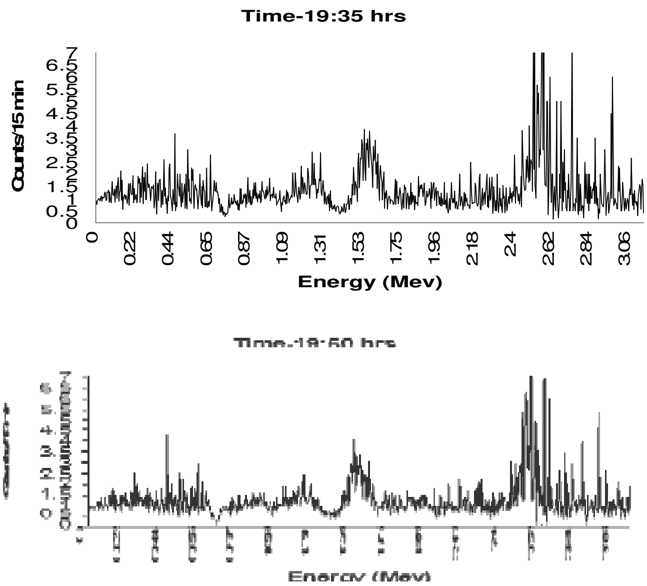


Figure-11
Panels of count ratios of SCGR flux between l eclipse day 16th July, 2000 with normal day 18th July, 2000



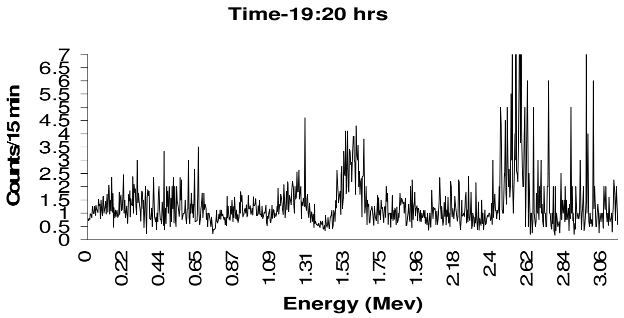


Figure 12
Panels of count ratios of SCGR flux between l eclipse day 16th July, 2000 with normal day 18th July, 2000

As compared to last lunar eclipse 4th April, 1996 due to better resolution we observed very prominence peaks of cosmic rays of near about 1.31 MeV, 1.618 MeV, and 2.57 MeV, but one of peak of about 0.9 MeV, with less prominence.

Discussions: The results of the experiments conducted by us that observed variation of secondary cosmic gamma ray flux near 2.57 MeV energy during April 4, 1996 lunar Eclipse and energies near 1.31 MeV,1.618 MeV, 2.57 MeV during July 16, 2000 Lunar eclipse may be understood in the light of information by the following reason: i. Under the influence of strong solar and interplanetary magnetic field and due to gravitational lensing the strong impact of primary high-energy solar and bent cosmic ray flux strikes on surface of the Moon produces secondary emission from moon surface (mostly gamma ray, high energy photo electron, hard x-rays, muons, Protons, neutrons) and may be regarded as back scattering form the Moon surface in the range of several hundred keV to MeV . Energy of backscattered Secondary flux is so large enough that gives such variation during Lunar eclipse observation. ii. Also the bent primary cosmic ray and solar energetic particle impinges deep inside the atmosphere of the Earth which produces shower of secondary cosmic ray particles so large enough that gives such variation during Lunar eclipse observation.

Conclusion

Above collectively effects (1) and (2) gave unusual variation of secondary cosmic gamma ray flux at energies 2.57 MeV during Total Lunar Eclipse April 4, 1996 and near energies 1.31 MeV, 1.618 MeV, 2.57 MeV during Total Lunar Eclipses July 16, 2000 on the Earth.

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