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Research Paper

Experimental Study of Phases of Moon For Observing Variation of Secondary Cosmic Gamma Ray Flux, Energy and X-Ray Flux in the Month of September 2000 at Udaipur, India

Astronomy

KEYWORDS : Position of moon, Solar magnetic field & interplanetary magnetic field, GCR, SEP, emission of Gamma ray from limbs of Moon

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ABSTRACT

An experimental study of Phases of Moon was conducted to observe systematic variation in secondary cosmic ray and SEP (Solar cosmic ray) flux mostly gamma rays, energy and X-ray flux using lead shielded scintillation counter for the month of September 2000. The scintillation counter pointing towards Moon detected secondary cosmic ray flux and SEP (Solar cosmic ray) mostly gamma rays and X-ray approaching on surface of the Earth. We observed variation in secondary cosmic gamma ray flux (SCGR flux), X- ray flux and variation of secondary cosmic gamma ray flux at some energy in energy spectrum. During the passage of Moon through background of Uranus and Capricornus constellation we observed abrupt change in energy spectra on 9th and 10th September, 2000. In the course of observation two prominent peaks in energy spectrum showed systematic variation in position from 1.18 MeV to 3.34 MeV and in count rate from 40 to 150-counts/ 30 min. During Phases of moon experimental study these results of variation of SCGR flux, energy and X Ray flux can be explained by different relative location of Moon with regards to the Sun, X- ray flux from moon surface, Combined effect of strong magnetic field of the sun and the interplanetary magnetic field bent the galactic cosmic ray (GCR), SEP resulting gamma ray emission from limbs of Moon by hard hitting of SEP and bent GCR, gravitational lensing effect.

1. Introduction

Phases of Moon [1] studies have been planned to observe the different relative location of Moon with regards to the Sun, different background, constellations in the sky, gravitational lensing, interaction of cosmic rays, SEP with combined effect of the Sun and the interplanetary magnetic field. These effects collectively modulate cosmic rays, SEP, which are measured on the surface of the Earth in terms of Secondary flux. From all directions high-energy charged particles named as cosmic rays is travel nearly the speed of light having the nuclei of atoms include high-energy electrons, positrons, and other subatomic particles. About 89% of the nuclei are protons, 10% helium, and 1% heavier elements in cosmic ray composition and known as Galactic cosmic rays (GCR) [2]. Galactic cosmic rays (GCR) originate outside the solar system, distributed throughout our galaxy. Other classes of energetic particles including nuclei and electrons accelerated from the Sun called solar energetic particles (SEP), (Solar cosmic ray). Phases of Moon study will provide additional information regarding the GCR, SEP modulation at the time of new Moon and different phases of the Moon with different background and constellation in the sky. The different Phases information of Moon in the month September, 2000 is as given Table 3. During Lunar phase different relative location of Moon with regards to the Sun due to this intensity of cosmic ray coming towards earth changes and causes variation of secondary flux at the surface of the earth. Table 1 shows variation of X-ray flux of counts/30 minutes and Table 2 shows variation of counts/30 minutes of secondary flux and energy of first and second peak.

On 29th June, 1990 with help of ROSAT, X ray satellite image of Moon was taken and it is observed that X - rays are coming from moon illuminated part by the sun. The moon acts as the reflector of X- ray from the sun. In our experimental study for the month of September, 2000 during different Phases of Moon the Moon passes different relative location with regards to the Sun and moon illuminated parts by the sun are different cause variations of X- ray flux as we observed during phases of moon.

During the new Moon the moon passes between the Earth and the Sun and due to this during new moon we can understand Variation of cosmic ray flux and energy in SCGR flux and energy with the phenomena of Shadowing/focusing of cosmic rays by the Sun strong magnetic field and the interplanetary magnetic field. We conducted also experimental study of solar eclipse [3] and lunar eclipse [4] and we observed during solar eclipse the variation of secondary cosmic gamma ray flux and energy. During the solar eclipse the sun, moon and earth comes in straight line position. During new moon the condition is not same as that of solar eclipse but moon passes between the Earth and the Sun. Due to this Shadowing/focusing of cosmic rays by the sun and the interplanetary magnetic field the GCR and SEP bent towards moon surface and resulting gamma ray emission from moon surface near limbs of Moon [5], [6], [7] by hard hitting of SEP and bent GCR. First time Clark (1957) [8] suggested Shadowing/focusing of cosmic rays by the Sun and Moon. Latter on several groups Alexandreas et al., 1991[9]; Pomarede, D. et al., 2001[10], Amenomori et al., (1993 a, b) [11], [12] given evidence of Shadowing/focusing of cosmic rays by magnetic field. Emitted gamma rays impinge on the atmosphere of the earth causing variation of secondary emission of gamma ray and energy.

Mellier,Y, 1998 [13], Narayan, R. and Bartelmann, M. 1996 [14] pointed that when electromagnetic radiation and rays of light passing near a massive object bends due to gravitational field of the object it is known as gravitational lensing effect. On this basis we can understand abrupt change in energy spectra is noticed on 9th and 10th September, 2000. On 9th and 10th September, 2000. On these dates Uranus was only three lunar diameters above the location of the Moon in the constellation of Capricornus therefore gravitational lensing effect produced by Uranus and Capricornus constellation on 9th and 10th September causes bending of GCR and bent GCR enter in the atmosphere of the earth produce abrupt change in energy spectra is noticed on 9th and 10th September, 2000. On 9th and 10th September, 2000 SCRs flux which is detected using appropriate scintillation detector on ground [15], [16].

2. Experimental setup and observation for Phases of Moon in the Month of September, 2000:

During observations detector was kept always pointing towards the Moon under different phases in the month of September, 2000. The Moon traveled around the Earth through different constellation and different background producing little modulated flux of cosmic ray and SEP due to Sun and interplanetary magnetic field and gravitational lensing. We used integral line of scintillation counter ECIL, India make Scintillation counter system (photomultiplier tube plus potential divider with preamplifier) output connectors had been given only to connect H.T., L.T. pulses cables only. This compact unit of scintillation counter has high-energy resolution (3.3 KeV/channel) was obtained. About 870 Volt H.T. value and L.T. with +12,-12 volt. Output negative pulse around 0.5 volts was fed to linear spectroscopic amplifier to make final pulse of approximately 10Volt with positive polarity and then this pulse was fed to 1024 multi channel analyzer MCA SMS ECIL make. Experimental set up of scintillation counter employed in the study of secondary flux and energy on the ground during the Phases of the Moon in the month of Sep-

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tember, 2000 with fine gain of Linear Spectroscopic amplifier, resolution was 3.3KeV/Channel using standard source Co^{60} as shown in Figure 1. This setup was brought up at top of the building of department of Physics, College of Science, M.L. Sukhadia University Udaipur (Rajasthan, India).

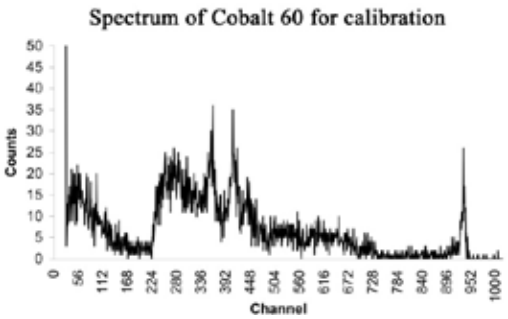


Figure 1

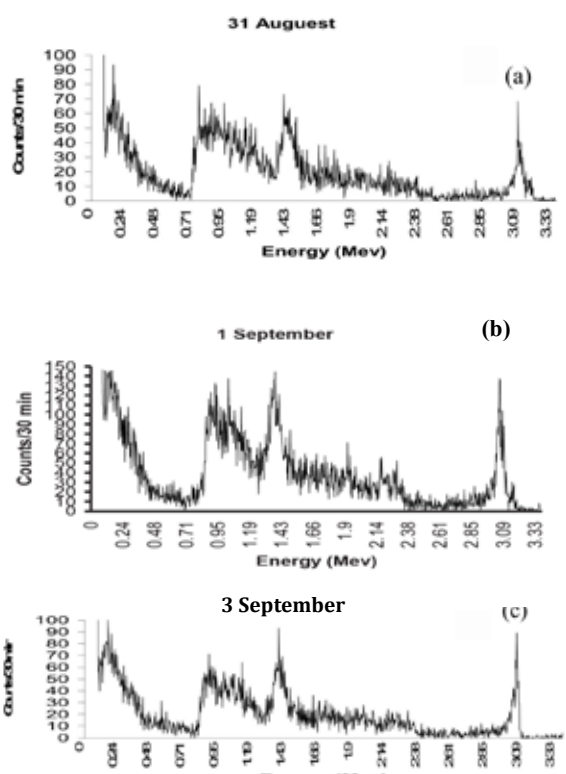
3. Results and Discussions:

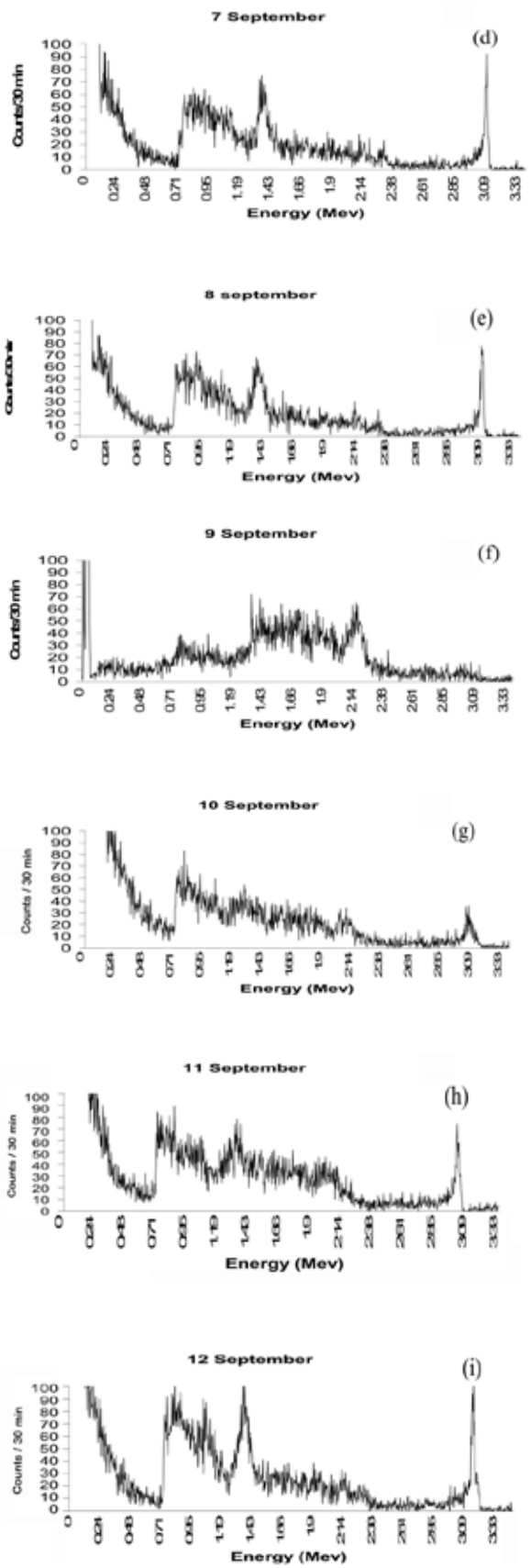
During observations detector was kept always pointing towards the Moon under different phases of Moon to observe some changes in Secondary flux at some energies in the month of September, 2000. The Moon traveled around the Earth through different constellation and background also Moon passes different relative location with regards to the Sun ensuing little modulated flux of cosmic ray and SEP at some energies, variation of X-ray flux on the surface of the earth as we observed in our energy spectrum given in Figure 2 (21 nos.) below:

Energy spectrum of secondary flux during –

Phases of Moon in the month of September, 2000

Calibration: 3.3 Kev per channel





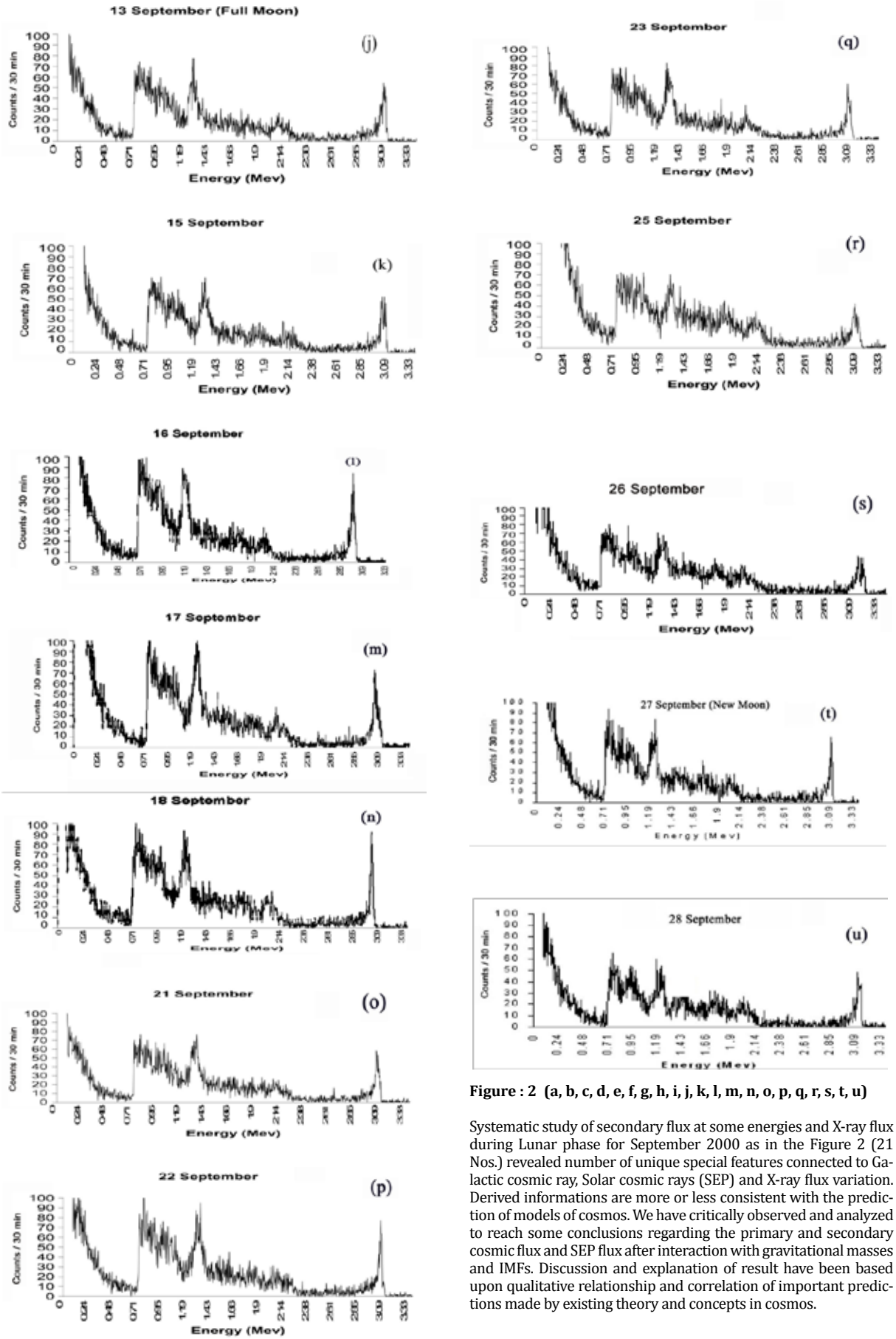


Figure : 2 (a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u)

Systematic study of secondary flux at some energies and X-ray flux during Lunar phase for September 2000 as in the Figure 2 (21 Nos.) revealed number of unique special features connected to Galactic cosmic ray, Solar cosmic rays (SEP) and X-ray flux variation. Derived informations are more or less consistent with the prediction of models of cosmos. We have critically observed and analyzed to reach some conclusions regarding the primary and secondary cosmic flux and SEP flux after interaction with gravitational masses and IMFs. Discussion and explanation of result have been based upon qualitative relationship and correlation of important predictions made by existing theory and concepts in cosmos.

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Revolution of Moon around the Earth represents different Lunar Phase with regards to the Sun and different location of the Moon during its journey may be a subject of study of cosmic rays, SEP and X-Ray. We shall discuss the observed facts in this unique study of Phases of Moon. Specific features in daily energy spectrum of secondary flux have been observed as follows:

1. Continuous spectrum of X -ray were observed in secondary flux. X-ray flux variation shown in Figure 3, in the month of September, 2000 and its data Table 1 is given at end of this study during our observation for Phases of Moon.

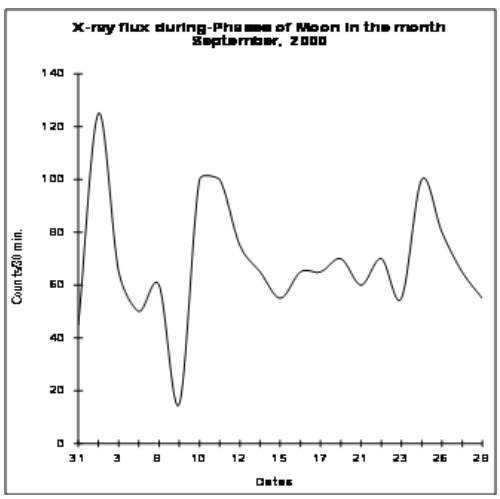

Figure 3

2. In the range of 900 KeV to 1200 KeV of Secondary cosmic ray and SEP flux in energy spectra appears to be content of closely spaced peak but during new Moon period one peak register its presence between energy range 900 KeV to 1200 KeV little distinctly. In our observation between energy range of 1.45 MeV to 2.14 MeV we observed three distinct energy peaks of 1.45, 1.70 and 2.10 MeV with low flux and they do not exhibit themselves clearly from 1st September to 23rd September but these peaks register their presence only after 25th September to 28th September during new Moon period as shown in figure 2.
3. A very prominent peak of energy 1.43 MeV is distinctly observed in every energy spectrum. Intensively (40 to 150 counts/30min) and position of (1.18MeV-1.43 MeV) of, 1.43 MeV peak is detected changing in our observation as shown in Figure 2. Also 3 MeV energy, a prominent energy peak of large intensity flux was observed (30 to 140 counts/ 30 Min.) It showed its unique character of distinct resolution. It also changes its position from 2.99 MeV to 3.138 MeV or beyond detection limit of our detector (3.35 MeV) as shown in Figure 2.
4. As shown in Figure 2 in the month of September 2000 from 2.14 MeV to 2.9 MeV energy range in energy spectrum we did not observe any peak but lowest secondary cosmic flux on the ground.
5. Suddenly abrupt change in energy spectrum during our regular observation for lunar phases in the month of September 2000 was recorded on 9th Sept. 2000. Level of continuous soft and hard x rays and gamma rays flux in the beginning part of spectrum drooped from 100 to 10 and showed energy capacity opaqueness of Secondary cosmic ray flux. Also flux of prominent peak of 1.43 and 3MeV vanished. Here we observed sufficient enhancement of energy peaks of 1.45 MeV, 1.70 MeV and 2.10 MeV. Later this abrupt change in spectrum gradually got normalized in the successive days of 10th to 11th Sep. 2000. Initial part of energy spectrum of soft and hard X-rays and Gamma rays was recovered on 10th September but portion of energy spectrum beyond 0.171 MeV came into original shape in net two days 11th and 12th September, 2000.

4. Conclusions:

From above results and discussions now we can understand the variation of secondary cosmic flux, energy and x ray flux as:

1. Variation of X -ray in the month of September 2000 during our observation for lunar phases may be explained on the basis during phases of Moon different relative location of Moon with regards to Sun and different parts of moon illuminated during phases of Moon. The moon acts as the reflector of X ray from the sun therefore due to this we observed X- ray flux variation during phases of moon.
2. During new Moon period the moon in our observation one peak register its presence between energy range 900 KeV to 1200 KeV and also we observed three distinct energy peaks of 1.45, 1.70 and 2.10 MeV with low flux of secondary cosmic gamma ray. We can understand above happening with help of the phenomena of Shadowing/focusing of cosmic rays by the Sun strong magnetic field and the interplanetary magnetic field. Due to this Shadowing/focusing of cosmic rays by the sun and the interplanetary magnetic field the GCR and SEP bent towards moon surface and resulting gamma ray emission from moon surface near limbs of Moon by hard hitting of SEP and bent GCR. Emitted gamma rays impinge on the atmosphere of the earth causing variation of secondary cosmic gamma ray flux at some energies.
3. Prominent peaks of energy 1.43MeV and 3 MeV in each spectrum may be the result of gravitational lensing of primary cosmic rays during Phases of Moon. Moon is atmosphere less gravitational body and strong impact of high energy cosmic rays on Moon surface may produce secondary emission from surface of the Moon that gives such prominent peaks of energy 1.43MeV and 3 MeV.
4. In energy spectrum the energy range 2.14 MeV to 2.9 MeV we did not observe it may refer to energy opacity and terrestrial activity of Primary cosmic radiation in the energy range is almost negligible. It might be possible that Primary cosmic radiation of this energy range is not approaching on the surface of the Earth.
5. We can understand abrupt change in energy spectra on 9th and 10th September, 2000 with help of phenomena of gravitational lensing. On these dates Uranus was only three lunar diameters above the location of the Moon in the constellation of Capricornus therefore gravitational lensing effect produced by Uranus and Capricornus constellation on 9th and 10th September causes bending of GCR and bent GCR enter in the atmosphere of the earth produce abrupt change in energy spectra is noticed on 9th and 10th September, 2000 and we observed sufficient enhancement of energy peaks of 1.45 MeV, 1.70 MeV and 2.10 MeV.

   This is a unique and new observation first time we reported in the present study during Phases of Moon for the month of September, 2000 using lead shielded scintillation counter and such experimental study of Phases of Moon may be conducted in detail with more statistics for two or three whole months.

5. Acknowledgments:

The authors wish to thank anonymous referee.

6. Figure captions:

- Figure 1 Graph of source Co^{60} for Calibration.
- Figure: 2 (a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u) Panels of spectrum of Secondary flux on the surface of the Earth during Phases of Moon.
- Figure 3. Observed X-ray varying flux during Phases of Moon.

Date	Counts/30 min.
31 August	45
1 September	125
3 September	65
7 September	50
8 September	60
9 September	15
10 September	100
11 September	100
12 September	75

13 September	65
15 September	55
16 September	65
17 September	65
18 September	70
21 September	60
22 September	70
23 September	55
25 September	100
26 September	80
27 September	65
28 September	55

Table 1 (Variation of X-ray flux)

Table 2 shows variation of counts/30 minutes of secondary cosmic flux and energy of first, second peak as given in Figure 2.

	First Peak		Second Peak	
Date	Energy (MeV)	Counts /30 min.	Energy (Mev)	Counts/30 min.
31 August	1.43	60	3.09	70
1 Sept.	1.35	150	3.066	140
3 Sept.	1.32	90	3.042	90
7 Sept.	1.30	70	3.037	92
8 Sept.	1.30	60	3.08	78
9 Sept.	1.43	50	3.37	140
10 Sept.	1.30	40	3.06	35
11 Sept.	1.35	70	3.066	72
12 Sept.	1.31	100	3.08	100
13Sept. (Full Moon)	1.27	80	3.066	55
15 Sept.	1.25	70	3.042	55
16 Sept.	1.23	80	3.02	85
17 Sept.	1.20	100	3.01	72
18 Sept.	1.18	90	2.99	92
21 Sept.	1.35	70	3.054	60
22 Sept.	1.35	80	3.066	75
23 Sept.	1.27	80	3.09	60
25 Sept.	1.25	60	3.1	42
26 Sept.	1.31	60	3.138	42
27Sept. (New Moon)	1.20	70	3.114	68
28 Sept.	1.20	50	3.126	50

Table 3 The different Phases information of Moon in the month September, 2000 is as given below:

	New Moon	First Quarter	Full Moon	Last Quarter*
January	6	14	20	28
February	5	12	19	26
March	5	12	19	27
April	4	11	18	26
May	3	10	18	26
June	2	8	16	24
July	1 & 30	8	16	24
August	29	6	14	22
September	27	5	13	20
October	27	5	13	20
November	25	4	11	18
December	25	3	11	17

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