

Experimental Study of Emission of X - Ray and Variation of Secondary Cosmic Ray Flux at Some Energy During Appearance of Comet Hyakutake March, 1996



Physics

KEYWORDS : Comet Hyakutake, X-rays emission, primary cosmic ray and solar energetic particle, emission of light nuclei,

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ABSTRACT

Comet study has been planned to see the role of comet in the sky on observing X - ray and variation secondary cosmic rays flux. For this experimental study was conducted by scintillation counter with lead shield in the energy range of 10 keV to 5 MeV and ADCAM 100 ORTEC system for data acquisition. Ground based observations of Comet Hyakutake were conducted of the day's 28th, 29th, 30th, 31st March 1996, pointing our detector towards Comet Hyakutake and also observed background after two hours on above dates when comet set below horizon (comet disappeared from the sky and was not visible in the sky).

Analyses showed large amount of X-rays is observed from comet and unusual variation and enhancement of secondary cosmic flux in energy spectrum of specific energies of about 1.127 MeV, 2.29 MeV and 3.66 MeV. This was unique and astonishing result we observed in the study of Comet. The results have been interpreted on the basis of Production of unexpected X-rays from comet may be due to absorption of X-ray from the sun by a cloud of gases water molecule surrounding the nuclei of the comet and then remitted by the molecules in a process of fluorescence. Another possible explanation is that the X-rays are produced from the violent collision between the comet material and supersonic wind of plasma and high energy particles streaming away from the Sun. Unusual variation and enhancement of secondary cosmic flux at some energy can be understand on the basis of due to high energy cosmic ray (GCR) and solar energetic particle (SEP) collision with comet nuclei which undergo fragmentation followed by the emission of light nuclei (p , n , π , α) with high energy. These energetic particles impinge deep inside the atmosphere of the Earth which produces shower of secondary cosmic ray particles.

1. Introduction:

A comet contains of ice and dust. Comet can be divided into three part Nucleus, Coma and Tail. Comet nucleus is a surface described as a black crust, nucleus black crust helps the comet absorb heat, causes the ices to turn into gas. Coma enveloping nucleus its size depend on distance from the sun and the size of the nucleus. It has gas and dust. Comet tail is of two types (gas tail and dust tail). Gas tail has charged gases and remains away from the sun due to solar wind. It pushes away from the sun. The dust tail is immersed by photons coming from the Sun. Orbit of Comet around the sun is elliptical. Yuji Hyakutake in Japan discovered a new comet. The comet was designated Comet C/1996 B2 (Hyakutake). Comet Hyakutake was the Great Comet of 1996. The comet would pass as close as 0.10 AU (9.3 million miles) from the Earth on March 25, 1996. The comet had become a bright naked-eye object and remained so in March, April and May in 1996. Comet Discovered: January 30, 1996 Earth Closest Approach: March 25, 1996 07:00 UT (0.10 AU) Sun Closest Approach: May 1, 1996 09:31 UT (0.23 AU) 1 AU = 93 Million Miles = 150 Million Kilometers = 150x10 meters [1]. The most abundant gas in the entire coma of the comet was hydrogen. They are produced when solar ultraviolet light divides molecules of water, the major constituent of the nucleus of the comet. Teams of U.S. and German astrophysicists first detected of X-rays coming from a comet Hyakutake using Germany's orbiting ROSAT satellite [2] and Glanz [3] also observed X ray. With help of EUVE satellite from this comet Extreme ultraviolet (EUV) emission was detected [4]. Mumma, M.J. et al. [5], Peterson, K.[6] and Huebner, W.F. [7] reported from Comet Hyakutake large quantities of the gases ethane and methane, Co and water in icy form.

Cosmic rays (GCR) are charged particles about 89% of these nuclei are of hydrogen, 10% of helium, and about 1% of others heavier elements [8] Energetic particles that are associated with the sun, known as solar energetic particles (SEP).

Production of unexpected X-rays from comet in our experimental study may be due to absorption of X-ray from the sun by a cloud of gases water molecule surrounding the nuclei of the comet and then remitted by the molecules in a process of Fluorescence. Another possible explanation is that the X-rays are produced from the violent collision between the comet material and supersonic wind of plasma and high energy particles [9, 10] Variation secondary cosmic rays flux may be due to When GCR,

SEP collides with comet nuclei so as to give rise secondary radiation and also GCR, SEP undergo fragmentation followed by the emission of light nuclei (p , n , π , α) with high energy. These energetic particles impinge deep inside the atmosphere of the Earth which produces shower of secondary cosmic particles. These secondary cosmic rays SCR flux can be measured during ground based experimental observation by efficient scintillation detectors on ground [11, 12]

2. Experimental setup and observation of comet Hyakutake:

We used scintillation detector for detection of X ray flux and secondary cosmic ray flux in the energy range of 10 keV to 5 MeV. Photo multiplier tube (PMT) RCA 8575 optically coupled with NaI (Tl) crystal of 50 mm thick and 44.5 mm in diameter. This integral line was connected to a high tension voltage supply of 1100 volts DC. Spectroscopic amplifier ORTEC model 451 used for amplification of negative signal of about 0.5 Volts to 5 Volts positive pulse. Then this signal was given to analog to digital counter model 917 so that appropriate input can be provided to ADCAM 100 ORTEC for data acquisition and analysis in ADCAM multichannel Buffer. Counts as a function of time collected as to make our case study more precise. 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. Our experimental set up and continued our observation on the terrace of the Building of Physics Department of College of science, Mohan Lal Sukhadia University, Udaipur.

3. Analysis and Results: We took observation on 28th, 29th, 30th and 31st March 1996, pointing our detector towards Comet Hyakutake and also observed background after two hours on above dates when comet set below Horizon (comet disappeared from the sky and was not visible in the sky). The time dependent spectra of secondary radiation flux detectable on the ground as shown Figure 1 and Figure 2 below:

Spectrum of Secondary radiation of Hykutake Comet in March, 1996 With Comet and Background

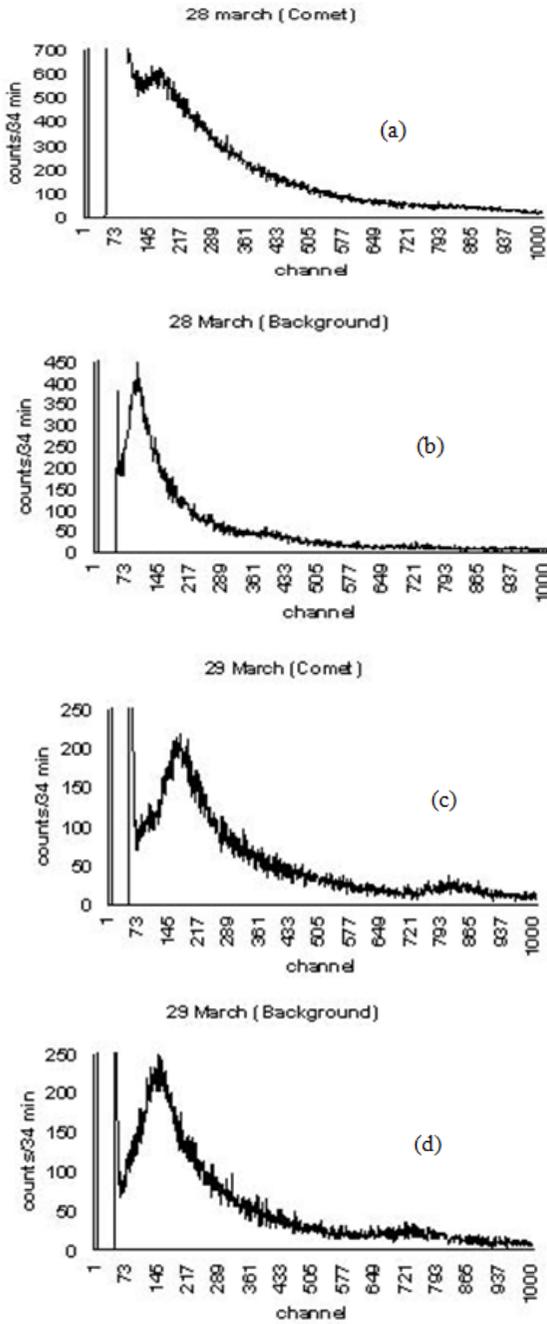


Figure 1 (a, b, c, d)

Spectrum of Secondary radiation of Hykutake Comet in March, 1996 With Comet and Background

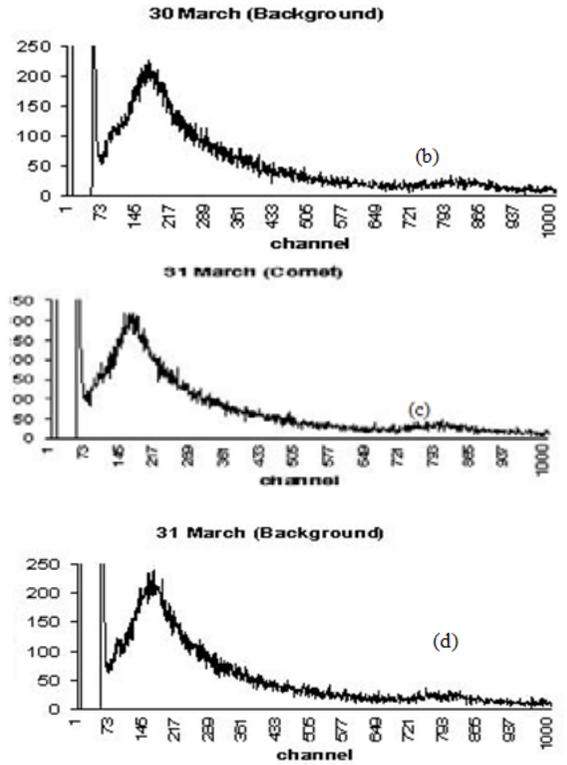
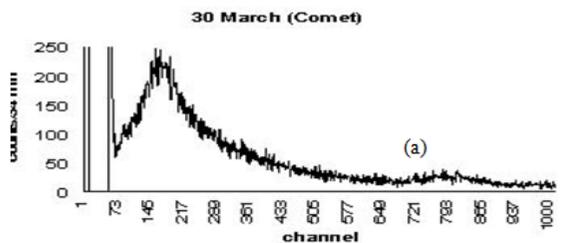


Figure 2 (a, b, c, d)

Later ratio of data of Hyakutake and background of same day was obtained. The count ratio enables us to determine unambiguously the presence of the peaks as shown in Figure 3 below

Spectrum of secondary radiation of Hykutake Comet in March, 1996 Comparison with Comet and background

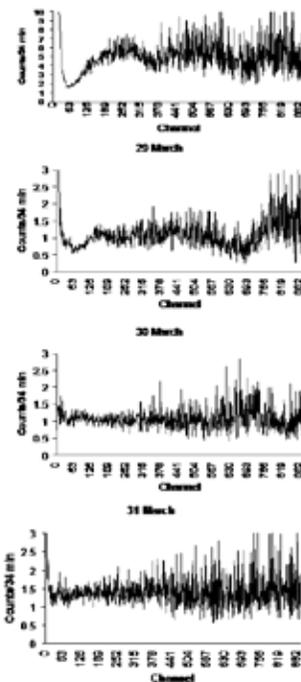


Figure 3 (a, b, c, d)

Spectrum of Secondary radiation flux of Hyakutake in March, 1996 gave very special feature as follows:

1. Large amount of soft X-rays flux is observed more than 10 times as compared to background and double the Hard X-rays of energy about 281.79 KeV on 28th March. On contrary, on 29th March hard X-Rays were totally absent, but soft X-rays flux declared to about 3 Times of background. But on 30th and 31st march nothing like X-rays were observed except high-energy secondary flux of about 1.5 times of background.

2. Some specific prominent peaks of energies about 1.127 MeV, 2.29 MeV and 3.66 MeV have been observed on 28th March with the enhancement in flux on an average 7 to 10 times of background flux. This was unique and astonishing result we observed first time in the study of Comet. It may be due to high energy cosmic rays (GCR) and solar energetic particle (SEP) collision with comet nuclei so as to give rise secondary radiation and also GCR, SEP which undergo fragmentation followed by the emission of light nuclei (p, n, π , α) with high energy.

3 On 29th March 1996, Comet went away from the Earth at a larger distance as compared to 28th March. Due to large oblique distance, radiation of high energy either from Comet or Galactic cosmic rays produced little less secondary flux such that energy about 1.127 MeV vanished but energies about 2.29 MeV and 3.666 MeV are subsidized to just about double of background.

4. On 30th march 1996 comet went to still large oblique distance from the Earth and able to produce only energy about 3.18 MeV peak energy with flux enhancement of 2 times of the background. Other energy peaks disappeared.

5. On 31st March almost all peaks vanished and uniform enhancement of above 1.5 times of background was observed. Position of comet on 31st was almost on Horizon.

4. Discussion on results of Hyakutake:

We have observed very surprising results in the study of comet Hyakutake in March 1996 on 28th march and on successive day's 29th, 30th and 31st march 1996.

1. Soft and hard x rays in energy spectra of 28th and 29th and almost negligible in 30th and 31st March with exponential decrease in flux indicate absorption effect and large oblique distance covered by radiation in atmosphere as comet receded after 25th March from closest approach to the earth. Production of unexpected X-rays from comet may be due to absorption of X-ray from the sun by a cloud of gases water molecule surrounding the nuclei of the comet and then remitted by the molecules in a process of Fluorescence. Another possible explanation is that the X-rays are produced from the violent collision between the comet material and supersonic wind of plasma and high energy particles streaming away from the Sun. Still Scientists are trying to learn about Hyakutake structure and composition for these unique X-rays images.

2. Another surprising result was unique and prominent peaks in energy spectra of 28th, 29th and 30th March 1996 observa-

tion of Hyakutake comet. Probably it could be attributed to the strong impact of high energy Galactic cosmic ray (GCR) and solar energetic particle (SEP) on the nucleus of comet containing water, Methane, Ethane and other gases. As a result of these strong impacts, there would be production of secondary cosmic radiation flux consisting mainly proton, neutron mesons and electrons and may be directed to the Earth for further secondary flux production in our atmosphere. The charged particles, if they do not undergo nuclear reaction, interact with atomic and molecular electrons losing energy by ionization and excitation. From these interactions basically pions come with strange particle like Kaysons.

3. Gradual fall in flux of each peak suggest further secondary flux production during high energy cosmic rays impact on molecules of Methane, Ethane and water. As comet receded away from the Earth obliquely, flux intensity would have been reduced to produce same effect

4. Secondary flux intensity should have been further reduced on 30th March 1996 so as to produce only 3.18 MeV energy flux of two times of background. Of course 3.18 MeV energy peak is not apparently prominent on 28th and 29th March but becomes clear on 30th March when other energies peaks are subdued.

5. On 31st March energy spectrum is almost straight without any apparent prominent peak and suggest that Comet had gone far away from the Earth at horizon producing diffused secondary flux in atmosphere of the Earth with approximately 1.25 times of uniform background cosmic flux.

5. Conclusion:

Results of our experimental studies of Comet Hyakutake are another signature of emission of X - Ray. It indicates that Cosmic rays and solar energy particles rays interact strongly with Hyakutake material molecules and produce fluorescence. Some specific prominent peaks of energies 1.127 MeV, 2.29 MeV and 3.66 MeV have been observed. This was unique and astonishing result we observed first time in the study of Comet. It may be due to high energy cosmic rays (GCR) and solar energetic particle (SEP) collision with comet nuclei so as to give rise secondary radiation and also GCR, SEP which undergo fragmentation followed by the emission of light nuclei (p, n, π , α) with high energy. Prominent energy peak of 3.18 MeV is a big surprise in the study of Comet. It would be interesting to observe in future during next celestial event of Comet.

6. Acknowledgments:

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7. Figure captions:

Figure 1 (a,b,c,d) Panels of spectrum of secondary radiation flux
Figure 2 (a,b,c,d) Panels of spectrum of secondary radiation flux
Figure 3 (a,b,c,d) Panels of spectrum of count ratios of secondary radiation flux

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