Final Report

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13. SUPPLEMENTARY NOTES
This grant to JNU was initiated to setup SEVAN station in Indian location with help from Armenian Professor Ashot Chillingarian, Yerevan Physics Institute (YerPhI), Alikhanyan Brothers 2, Yerevan 0036, Armenia. Scientific data could not be reported at the time of concluding this project due to schedule slippage in the delivery and installation of the detector at JNU. PI plans to continue the project at his cost.

14. ABSTRACT
Influence of Sun and other cosmic factors on the Environment of the earth is a new concept in Sun-earth connection studies. Space weather phenomena affecting environment of the earth including aircraft and spacecraft communication will be studied. During the Coronal mass ejection (CME) from the Sun the impact on the Galactic Cosmic rays (GCR) will be observed. Particle detector is vital for measuring the modulation effects the sun poses on the ambient population of the Galactic Cosmic Rays (GCR). The known agents of these modulation effects are Solar Flares (SF), Coronal Mass Ejections (CME) and Interplanetary CMEs (ISME).

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PI: Professor Saumitra Mukherjee, Jawaharlal Nehru University

Objectives

As per the MOU (Ref: AOARD-07-4096) the following was the objective:

The P.I. will install a new particle detector that will monitor various species of secondary cosmic rays with different energy thresholds at JNU Delhi (India) to investigate:

1) Detailed simulation of the traversal of cosmic rays through atmosphere and precise calculation of the detector response function
2) Development of new statistical methods of enhancing signal to noise ratio for the reliable estimation of energy spectra above 10 GeV, where background of the Galactic Cosmic rays is much higher compared to exposed fluxes of Solar cosmic rays;
3) Installation and operation of new type of hybrid detector at JNU observatory;
4) The correlation of earth orbiting satellite data (IRS,ENVISAT, Quickbird) with sun orbiting satellite data (SOHO) with cosmic variation; and
5) Establishment of Cosmic-Sun-earth connection to develop early warning system

(3) Status of effort

Based on the drawings of the Cosmic Ray Detector (designed by Cosmic Ray Division, Armenia) the final structure of the detector has been constructed. In this work the Tata Institute of Fundamental Research helped initially for the preparation of the new particle detector. Later the work was completed in the Remote sensing Applications Laboratory School of Environmental Sciences, Jawaharlal Nehru University, under the supervision of PI (Professor Saumitra Mukherjee). The metallic stands were prepared and assembled to hold different parts of the particle detector, which has been constructed as per the dimension designed at Cosmic Ray Division, Armenia.. The detector height and width is 1meterX 1 Meter which can hold the scintillator slabs and photomultiplier. The cosmic ray detector has been covered by 100 pieces of Lead bricks for accuracy of the reading of galactic and cosmic rays.

Photomultiplier and scintillator slabs have been manufactured in Armenia. These parts will be sending by Dr.Ashot Chillingarian along with the Electronics items.

(4) Abstract:

Influence of Sun and other cosmic factors on the Environment of the earth is a new concept in Sun-earth connection studies. Space weather phenomena affecting environment of the earth including aircraft and spacecraft communication will be studied. During the Coronal mass ejection (CME) from the Sun the impact on the Galactic Cosmic rays (GCR) will be observed. Particle detector is vital for measuring the modulation effects the sun poses on the ambient population of the Galactic Cosmic Rays (GCR). The known agents of these modulation effects are Solar Flares (SF), Coronal Mass Ejections (CME) and Interplanetary CMEs (ISME).

Introduction

Detected at earth surface, changing fluxes of the secondary cosmic rays (mostly muons, electrons, neutrons and gammas) can provide highly cost-effective information on the key characteristics of the interplanetary disturbances and on the operation of solar accelerators. Several theories have been formulated in the past to explain the origin of killer electrons, and many uncoordinated observations have already been performed. Recently, scientists got a boost in their understanding of this hazardous phenomenon. This was possible thanks to a unique set of data, collected simultaneously, by a global armada of ground and space observatories during the recovery phase of a large geomagnetic storm. Main modulation effects consist in:

1. Abrupt enhancement of the intensity of secondary fluxes, called Ground Level enhancement (GLE) due to additional Solar Cosmic Ray (SCR) protons and ions incident on the terrestrial atmosphere. Those particles should be energetic enough to produce secondary particles reaching earth surface. GLEs are a small fraction of more frequent events called Solar Energetic Particles (SEP), detected by the space-born spectrometers and do not producing GLEs due to lower energies;
2. Forbush decreases, significant reduction in cosmic ray flux, due to screening effect of the huge magnetize cloud (so called Interplanetary Coronal Mass Ejection – ICME) arrived at Earth;
3. Reduction of the cut off rigidity triggered by arrived shock wave and ICME in interactions with magnetosphere.

Objective

1. The first second and third modulation effect unleashed Radiation Storm (RAS), fluctuation in Planetary Indices (Kp), Electron Flux (Eflux) and Proton Flux (Pflux) and its correlation with the GCR will be studied in Indian peninsula.
2. Effect of fluctuation of GCR will be correlated with GPS navigation.
3. Effect of CME and GCR on other extra terrestrial phenomenon like release of killer electrons which are potential threat to the telecommunications satellites and to the astronauts.
4. Effect of GCR variation on CME and on the communication blackout.
5. Prediction of Sunspots by long term GCR variations.
6. Because GCR are fast and have large scattering mean free paths in the solar wind, the modulation effects can be detected hours before the start of GMS and, usually, some tens minutes before RAS and, thus, are useful for space weather forecasting.

Taking into account that only few of solar energetic events produce dangerous consequences, it is not only critical to alert clients about the arrival of the severe storms, but also to minimize the number of false alarms against events which are not severe enough to cause damage.

Reliable and timely information on the characteristics of approaching CME or/and SEP event will help to deduce the possible effects of approaching storms on the geospace (i.e. on magnetosphere, ionosphere, atmosphere and lithosphere) and estimate the geoeffectiveness of the event.

The information about primary ion type and energy is mostly smeared during its successive interactions with atmospheric nuclei, therefore, only coherent measurements of all secondary

fluxes (neutrons, muons, and electrons), along with their correlations, can help to make unambiguous forecasts and estimations of the energy spectra of upcoming dangerous flux and its influence on the environment of the earth.

Also we have to specify important parameters of ICME (size, “frozen” magnetic field, speed) and develop the methodologies of their estimation by modulation effects these phenomena pose on uniform and isotropic population of GCR in vicinity of Earth.

For reliable solving of inverse problems of cosmic ray and its influence on the Space weather we shall develop new type of correlation with the SOHO satellite data and particle detector hybrid detection system, measuring neutral and charged fluxes simultaneously and plan to install these not only on high altitude of Aravalli Delhi in India, but it will function as International Cosmic and Remote Sensing Correlation Centre for GCR and CME

Expected Results.

New particle detectors (To be installed by Cosmic Ray Division, Armenia) will perform monitoring of various species of secondary cosmic rays with different energy thresholds at Delhi to

- Perform detailed simulation of the traversal of cosmic rays through atmosphere and precise calculation of the detector response function;
- Develop new statistical methods of enhancing signal-to-noise ratio for the reliable estimation of energy spectra above 10 GeV, where background of the Galactic Cosmic rays is much higher comparing with expected fluxes of Solar Cosmic Rays.

- To install and operate new type “basic” modules of hybrid detector in JNU New Delhi India (JNU observatory) as an examples for the further expansion of the new type of detectors.
- To correlate GPS data with extra terrestrial satellite data (SOHO) and cosmic variation.
- To predict the possibilities on communication blackout.
- To estimate the possibility of fluctuation of killer electrons from the space.
- To establish “Cosmic-Space weather connection to develop early warning system”

Although frequency of the energetic solar events was t low during 2007-08-09 and expected to be very high during 2011-12 on the rising phase of new 24-th cycle, it is very important to understand the influence of extraterrestrial particles and forces on the Space weather.

We can research the modulation effects due to single CME expanding in the non-disturb interplanetary space, thus we will be able to isolate and characterize “pure” cases of modulation. During active sun years, the solar energetic events are coming in long lasting consequences and new CME is expanding in the interplanetary space already disturbed by the previous one and modulation effects are overlapping and correlated.

SOHO satellite data shows changes in heliophysical parameters in every 15 minutes interval. It has been observed that the fluctuation of Kp, Eflux and Pflux (which are the important heliophysical parameters), has some correlation with the Space weather. It has been observed that earth directed coronal mass ejection from the Sun along with the cosmic influence has the potential to change the space environment temporarily. The changes in the Electron flux and planetary indices have been observed before the Galactic cosmic ray variation. Cosmic

influence of the sun needed to be observed on continuous basis on the Sun as well as on the earth and other planets of the solar system. Correlation of changes in sunspots, star spots with the heliophysical, sun-earth environment and other cosmic activities and its influence on space weather are being studied since several years. It has been observed that some geo-physical parameter eg, Kp (planetary indices) and Eflux (electron flux) changes after the coronal mass ejection from the outer periphery of the sunspots. When the Kp (planetary indices) and Eflux (electron flux) changes suddenly it affects the space weather. This phenomenon changes communication in the aircraft and spacecrafts temporarily. The response of the magnetosphere to interplanetary shocks or pressure pulses can result in sudden injections of energetic particles into the inner magnetosphere.

(5) Personnel Supported

Following personnel have supported in the project:

1. Professor Saumitra Mukherjee , Professor , School of Environmental Sciences, Jawaharlal Nehru University, New delhi-110067, India
2. Professor Ashot Chillingarian Yerevan Physics Institute (YerPhI), Alikhanyan Brothers 2, Yerevan 0036, Armenia
3. Mr.Amit Singh, Research Scholar, School of Environmental Sciences, Jawaharlal Nehru University, New delhi-110067, India
4. Mr.Ravi Prakash Singh Research Scholar School of Environmental Sciences, Jawaharlal Nehru University, New Delhi-110067, India
5. Mr.Dayaram Yadav , Laboratory Assistant School of Environmental Sciences, Jawaharlal Nehru University, New Delhi-110067, India

6. Dr.Anita Mukherjee, Lecturer & Head of Department, Institute of Public Health & Hygiene, Mahipalpur, New delhi-110067, India
7. Professor S.K.Gupta, Tata Institute of Fundamental Research , Mumbai, India
8. Dr.S.Krishnaswamy, KOVAI CNC Applications, Coimbatore,Tamilnadu India
9. Mr. Deepak Arora, Midas India Limited, New Delhi

(6)Publications. Following publications were made:

1Mukherjee,S. (2009). Sun-Earth-cosmic connection to understand early Warning of Earthquakes. Journal Earth Science India Vol.2 (II), April, 2009, pp. 83 - 93 http://www.earthscienceindia.info/

2. Mukherjee Saumitra. (2008).Cosmic Influence on Sun-Earth Environment. Sensors 2008, 8, 7736-7752; DOI: 10.3390/s8127736 www.mdpi.com/journal/sensors

3.Mukherjee, S. (2007). Changes in Heliophysical parameter influence on Environment of the Earth. Bull.Astr.Soc.India (2007) 35, 1-7

(7) Interactions

(a) Participation/presentations at meetings, conferences, seminars, etc

1. Mukherjee, S. (2009). Electron flux and Cosmic Ray anomaly to predict Atmosphere of the Earth. NASA Sounder Science Team Meeting Proceeding , October 13-16,2009, Marriott, Greenbelt, USA (Remote Presentation)

(b) Describe cases where knowledge resulting from your effort is used, or will be used, in a technology application

Based on the concept of Sun-Earth-Cosmic connection the publications were made and more scientific understanding is being developed with Department of Science & Technology, Government of India.

(8) Inventions None

(9) Honors/Awards None

(10)Archival Documentation

The Deliverables at the end of the project will be fully operational SEVAN detector(to be collaborated in network by CRD Armenia) (Figure.1) at JNU observatory, the calculations of the expected Cosmic-Space weather relation for the development of early warning system in India. Further a final report and refereed journal publications on the results from the project will be produced.

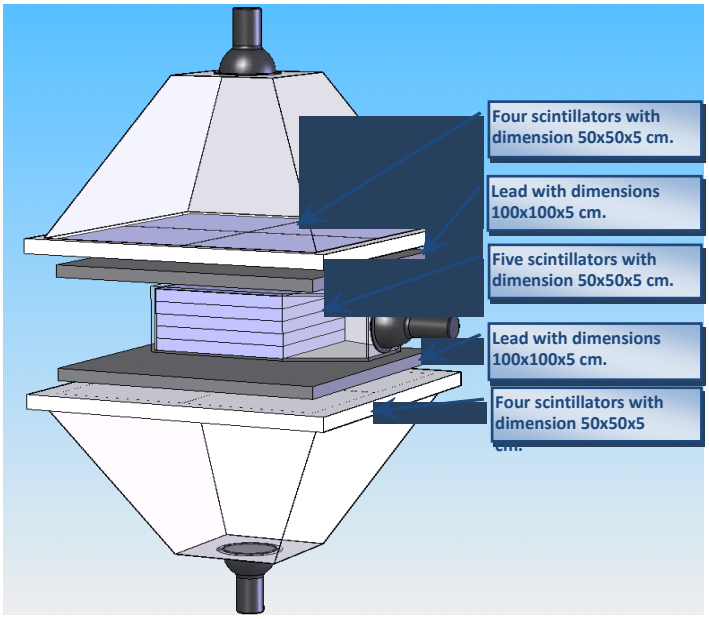

Figure.1. Cosmic ray detecting module of the SEVAN* network

***(Space Environmental Viewing and Analysis Network)**

(11) Software and/or Hardware (if they are specified in the contract as part of final deliverables): Include source code, brief installation and user guides.

The Hardware has been installed in Remote sensing Applications Laboratory JNU. Scintillator slab, Photomultiplier and Electronics along with accessories will be installed soon bu Cosmic Ray Division, Armenia.