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Astronomical & Astrophysical Transactions

The Journal of the Eurasian Astronomical Society

Publication details, including instructions for authors and subscription information:
<http://www.informaworld.com/smpp/title~content=t713453505>

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Online Publication Date: 01 January 2003
To cite this Article: Murtazov (2003) 'Ecology and circumterrestrial space',
Astronomical & Astrophysical Transactions, 22:4, 651 - 655
To link to this article: DOI: 10.1080/10556790310001609098
URL: <http://dx.doi.org/10.1080/10556790310001609098>

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ECOLOGY AND CIRCUMTERRESTRIAL SPACE

A. K. MURTAZOV

The Essenin Ryazan State Teachers' University, Svobody Street, 46, Ryazan 390000, Russia

(Received September 10, 2002)

Circumterrestrial space is the environment's global component providing the connection between the terrestrial biosphere and the Universe and protecting the planet's nature from harmful influences at the same time.

Human civilization activities have sharply increased the technogenic influence on the circumterrestrial space, which has started to affect biospherical processes.

This paper tackles problems related to the changes in physical processes in circumterrestrial space due to the technogenic influence and contamination of the circumterrestrial space by technogenic waste products, and the influence of circumterrestrial space thus taken out of its natural state in the biosphere.

Problems of optical monitoring of the circumterrestrial space in order to control continuously its degree of contamination as well as to develop evaluation criteria for critical parameters of its technogenic contamination and the danger of its influence on terrestrial ecosystems are surveyed in details.

Keywords: Circumterrestrial space; Ecology; Near-Earth astronomy

Vernadsky's (1991) doctrine on the biosphere is based on the general philosophical principles of natural science on the whole, biospherical and cosmic picture of the world. The Earth's biosphere is viewed as an indivisible global ecosystem. It is natural that the circumterrestrial space is the environment for such a system.

Today we are on the threshold of the biosphere's transition to the new state, namely the noosphere, when its evolution is going to be determined not so much by natural stochastic processes as by the guiding activities of man.

It is possible to observe directly the results of this transition exactly in the environment surrounding the biosphere (circumterrestrial space) in which the consequences of anthropogenic activities were quite evident in the last decades of the twentieth century.

It is quite clear now that circumterrestrial space is a particular mechanism of the interrelation of space with natural ecosystems and human civilization proper. On the other hand it protects the nature of the planet from all the Universe's influences which may destroy the nature.

The objectives of circumterrestrial space ecology may possibly be defined as follows.

- (i) Physical processes in circumterrestrial space, the technogenic influence on processes occurring in circumterrestrial space and the interaction of circumterrestrial space with the processes in biosphere and some Earth ecosystems need to be investigated.

- (ii) In this connection, monitoring of the circumterrestrial space status acquires decisive importance including observation of both the physical interactions and the mechanisms of the contamination of circumterrestrial space with technogenic waste.
- (iii) Measures for protecting the circumterrestrial space against anthropogenic influences and the Earth nature from space hazard should be developed.
- (iv) It is necessary to develop measures for the rational use of circumterrestrial space in the process of further extension of civilization's ecological niche.

If we determine circumterrestrial space as an area with a radius equal to the celestial orbit radius, then it might include the following:

- (i) high atmospheric layers, about 100 km;
- (ii) ionosphere;
- (iii) magnetosphere (average distance, about $(60-70) \times 10^3$ km at the subsolar point) and Van Allen belts.

These zones are plunged into the geomagnetic and interplanetary fields and include the following:

- (i) protons and electrons of the solar (quiet and high-speed) wind;
- (ii) charged particles of solar events, galactic cosmic rays;
- (iii) interplanetary gas and dust;
- (iv) anthropogenic fields and technogenic objects and their waste.

Interaction of circumterrestrial space with nature arises in several ways.

- (i) The natural factors of the circumterrestrial parameter changes influence ecosystems with their counter-action.
- (ii) Technogenic factors influence the circumterrestrial space with its counter-influence upon the ionosphere. Mankind is already capable of changing the natural parameters of circumterrestrial space by creating artificial radiation belts, provoking aurorae, generating low-frequency radiations and changing ionospheric properties.
- (iii) Technogenic waste influences circumterrestrial space and this effect is monotonously increasing.

While choosing the parameters characterizing anthropogenic phenomena, one can single out two groups. The first includes the concentration of components directly contaminating the neighbouring space. These components arrive in circumterrestrial space as a result of man's production activities (chlorofluorocarbons, nitrogen oxides, chlorine, radioactive element isotopes, etc.), as well as resulting from launching rocket and space systems. Electromagnetic radiations of technogenic origin changing the status of the Earth's ionosphere and magnetosphere also belong in this group. The second group includes the parameters characterizing the status of the top atmosphere, ionosphere and magnetosphere undergoing considerable changes resulting from technogenic influence, which influences the planet's nature as caused by feedback.

Circumterrestrial space monitoring means observations and continuous control of the natural and anthropogenic contamination; methods need to be developed for evaluating the physical status of circumterrestrial space as part of the natural environment. The prognosis of the possible consequences of the growing anthropogenic influence upon the circumterrestrial space targeted at both its protection and prevention of its negative effect upon the Earth biosphere also need to be developed.

Development and coordination of the circumterrestrial space global monitoring is carried out within the framework of the United Nations and the World Meteorological Organization (WMO).

The main objectives of the programme are as follows:

- (i) organizing an extended warning system about the threat to human health;
- (ii) evaluating the influence of the atmosphere's global contamination upon the climate;
- (iii) evaluating the amount and distribution of contaminations in biospherical systems, especially in food chains;
- (iv) evaluating critical problems occurring as a result of agricultural activities and land use;
- (v) evaluating the response of ground ecosystems to the influence of the environment;
- (vi) evaluating the ocean's contamination and the influence of contamination upon sea ecosystems;
- (vii) developing a system of warning about natural calamities on an international scale.

The author of this paper believes that it is quite necessary to include the following point related to circumterrestrial monitoring in the development of the environment global monitoring project: evaluation of characteristics of circumterrestrial space processes related both to its natural state and to the technogenic influence upon it in order to forecast the further influence upon the biosphere of circumterrestrial space.

As circumterrestrial space is a complicated system in which components interact owing both to different internal reasons and to a great extent under some external influence, circumterrestrial space monitoring can be divided into the monitoring of its state proper and the monitoring of natural and technogenic contamination.

Physical monitoring of circumterrestrial space includes in the first place forecasting 'space weather' the parameters of which are as follows:

- (i) temperature and low-temperature plasma component concentration (ions, electrons and neutral particles);
- (ii) magnetic and electric fields and currents;
- (iii) energy spectra of charged particles and spectral structure of electromagnetic radiations.

Energy processes in circumterrestrial space influence the operation of both space apparatus and ground ecological systems, expose human life to danger and can affect the social and economic life of people.

Another very important topic is ecological low-frequency electromagnetic monitoring which investigates the following:

- (i) the roles of electromagnetic radiation generation and energy mechanisms in the processes of transfer and transformation of solar wind energy in the ionosphere and top atmosphere of the Earth;
- (ii) the anthropogenic and electromagnetic influence upon the circumterrestrial space (radiations from electricity transmission lines, and heating of ionosphere by ground transmitter radiation) and the latter's feedback;
- (iii) medical and biological problems of the influence of natural and anthropogenic electromagnetic fields;
- (iv) correlation of radiations recorded by space apparatus with extremal phenomena and processes on the Earth's surface, atmosphere and lithosphere (typhoons, earthquakes, powerful blows, energy catastrophes, etc.).

Technogenic contamination of circumterrestrial space had reached quite a high level by the beginning of the twenty-first century, which resulted in setting up a service of monitoring the

technogenic space situation by direct co-hitting sensors to the ground and cosmic observation means. The same service also makes it possible to monitor natural space debris in circumterrestrial space. As the space debris fragments drift in their orbits under the influence of gravitation field irregularities, solar wind and magnetic storms it is necessary to renew information continuously on space debris to keep a continuously corrected data bank on it. There has been no bank like that of artificial Earth satellites until now.

It is natural that the technogenic status of circumterrestrial space conditioned by space apparatus and space activity waste available in it is related to its physical state.

Over the last decades of the twentieth century a new field in the science of the Universe was formed: near-Earth astronomy.

The main problems that near-Earth astronomy is dealing with are problems of circumterrestrial monitoring, which are the basis for investigations in the sphere of its ecology, development of protection measures and rational use of the following problems: observations, making up catalogues, simulating situations in different spheres of circumterrestrial space with respect to the Earth's passing through numerous meteor flows and monitoring the most dangerous trends that occur when natural space objects come into circumterrestrial space.

The active apparatus functioning in space needs to be controlled; the form, orientation and other characteristics of launched apparatus needs to be determined in order to identify their purpose and development of control mechanisms of the peaceful use of space.

Because of the great and continuously growing amount of technogenic waste in circumterrestrial space it is impossible to provide full monitoring. Therefore the pressing investigation trends of the further circumterrestrial space contamination are the following:

- (i) improvement of methods of simulating small technogenic and natural waste fragments in space based on the coordination of model parameters with observation data;
- (ii) investigation of the general appropriateness of substance migration processes in the solar system, sources of complementing objects approaching the Earth, identification of these objects and constructing catalogues;
- (iii) observations of representational selections of artificial and natural objects populating circumterrestrial space, paying special attention to the investigation of blown-up objects;
- (iv) keeping selective control of some objects through photometry.

The balance of circumterrestrial space, like that of any physical system, is characterized by sustainability of any of its parameters. The disturbance of any parameter causes, as shown above, compensating processes bringing circumterrestrial space back to its balanced state (the Le Chatelier principle, observed in physical, biological and ecological systems). However, after considerable disturbances that are often related to technogenic influences, circumterrestrial space may not even return to its original state (or pass on to another stationary state) with a natural counter-influence on ecosystems. What will this influence be like? What general technogenic influence is necessary to take the circumterrestrial space out of its rather unstable balanced state for a long time? What will the new circumterrestrial space parameters be like after its returns to the stationary state?

An international association has already started to develop agreements targeted at protecting circumterrestrial space as a global component of the environment. Thus, two of the points of the Vienna declaration on investigation state the following uses of space for peaceful purposes (UNISPACE-III):

- (i) extension of scientific knowledge about neighbouring and deep space through developing cooperation in such spheres as astronomy, space biology and medicine, cosmic physics; studying of the circumterrestrial space objects and investigation of other planets;

- (ii) improvement of the neighbouring and remote space environment protection through intensification of investigations in the field of taking measures for decreasing space contamination and practical implementation of these measures.

It also stresses the necessity to develop investigations related to space debris including measuring methods, mathematical simulation of contamination and methods of decreasing the hazard created by space debris.

Development of the measures of protection and use of circumterrestrial space may become one of the most important scientific, technical and ethical problems of the third century. Here, according to the present author, a number of issues can be singled out:

- (i) These methods must not use technologies that harm to circumterrestrial space and biosphere.
- (ii) They should be targeted at decreasing contamination of both circumterrestrial space and the biosphere.
- (iii) Methods of protection and rational use of circumterrestrial space to be used in the future energywise should not exceed the limit above which circumterrestrial space will not be able to return to its original sustainable state (or to any state sustainable at all but different from that of the original state).

In connection with the above, the objective of determining the maximum possible level of influencing circumterrestrial space may become the main objective for investigations for the coming decade. It is extremely pressing with respect to anthropogenic influences of all kinds, and its quickest achievement will both determine the further development of man's cosmic activities and ensure the existence of modern civilization in the transition era towards a noosphere.

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