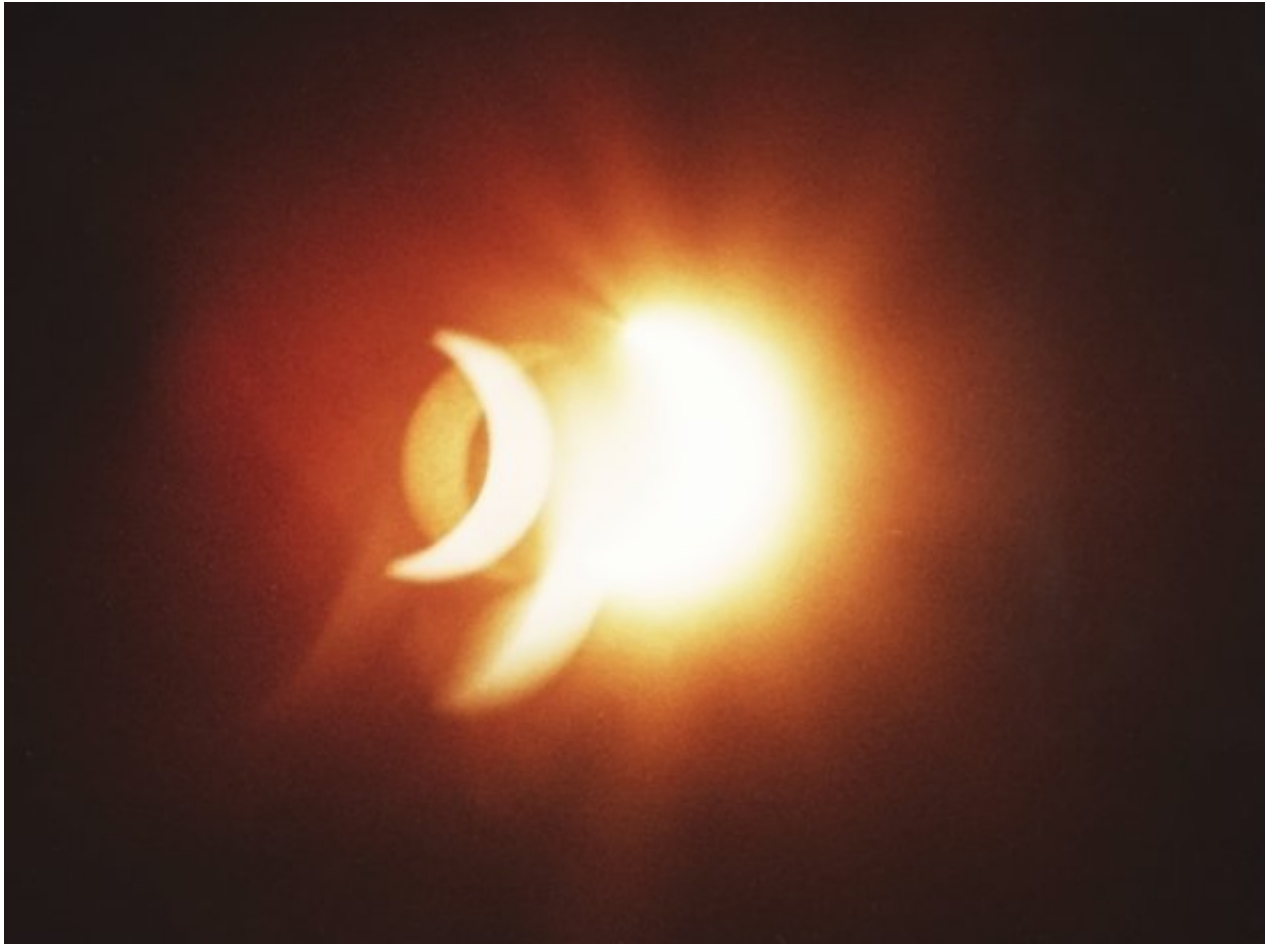


RECOGNIZING THE THREATS

Solar Storm

Jarosław Zarzycki



The Sun is not only the center of a planetary system and a source of life-giving energy. Its structure and the processes occurring there can cause a huge threat for human civilization.

All the threats posed to humans and their environment can be divided into: natural, technological, military, social, economic, political threats, mass diseases of humans, animals and plants, mass biological threats (e.g. plague of insects or rodents), uncontrolled trans-border migration, overexploitation of natural resources, terrorism and organized crime. Natural and technological threats are the domain of rescue services and organizations. The cause and effect relationship specifies the relations between some of the threats mentioned above. In such cases we speak about so-called associated threats – caused by other threats. For instance, a flood can cause destruction of a bridge, a failure of a hydro-technical construction, inundation of a drinking water intake, sewage treatment plant, dumping ground or industrial

waste heaps, and an excessive amount of greenhouse gases in the atmosphere can cause an increase of the global temperature and have an influence on the formation of extreme weather phenomena, e.g. intense rainfall in one region and drought in another area.

Among the natural threats, apart from geological threats (e.g. seismic shocks, volcano eruptions, landslides or avalanches), threats connected with weather (e.g. lightnings, heavy winds, long-term extreme temperatures, intense rainfall or snowfall), there are also space threats, like meteorite or comet falls as well as solar storms, which can cause magnetic storms on Earth.

The Sun is the center of the planetary system called the Solar System. It is supposed to have formed almost 5 billion years ago. Currently it is in the half of its lifetime. Its radius has increased by several percent since its formation and its luminosity by almost 30 percent. The Sun is a star and is much larger than nine planets of the Solar System orbiting it. Currently its diameter is 1,392 km long – this means that the radius of the Sun is 109 times longer than the radius of Earth. In comparison with other stars, the Sun is not distinguished by any special features. Its size and luminosity are not great. As much as 75 percent of the mass of our central star is hydrogen, helium constitutes over 24 percent, and the rest (1 percent) is composed of traces of coal, oxygen, sodium, calcium, iron, sulphur and silicon. The Sun is the main source of energy reaching Earth in the form of warmth and light. The temperature on its surface, called photosphere, comes to about 6,000 centigrade. Both the gas pressure and the temperature increase inward the Sun. In its core, under the temperature of 15 million centigrade, the nuclear reactions take place – enormous energy is released when hydrogen is converted into helium. Out of all the energy produced by the Sun, 95 percent is created in the core, 40 percent of which is made of hydrogen now (at the beginning it was about 73 percent). The remaining 5 percent of the energy is produced in the layers located directly over the core, where the pace of nuclear reactions as well as the temperature is a bit lower. Only an inconsiderable amount of the energy reaches the Earth, which is about 150 million kilometer away from the Sun. Almost half of the energy is reflected, dispersed and absorbed in the Earth's atmosphere.

The Sun is a magnetically variable star. Almost every 11 years (exactly 10.96) there is a time of increased solar activity – the activity increase phase lasts for 4.26 years (the energy production grows) and the decrease phase lasts for 6.7 years (the energy production falls). In the period of maximum solar activity, when the energy production inside the Sun is the greatest, there appear sunspots on the surface of the Sun – areas of the photosphere of lower temperature connected with the existence of strong magnetic fields. The lifetime of a sunspot

depends on its size. The smallest ones exist for several hours, the largest – even for a few months. In the most outer layer of the Sun atmosphere, called corona, there are also huge explosions, observed from Earth as so-called Coronal Mass Ejections (CME). They are usually accompanied by solar flares (sudden explosion). These phenomena are called a solar storm – an eruption in the Sun's atmosphere. In the period of the solar minimum activity the CMEs occur usually once a week; in the solar maximum they may happen at least twice every 24 hours. Billions of tones of the solar matter ejected in the flare points produce particle radiation known as solar wind, which, in the form of streams of totally ionised molecules, positive ions and negative electrons with high energy, is accelerated to hundreds of kilometers per second. The flares produce electromagnetic radiation in the form of visible light, infrared radiation, ultraviolet, radio, gamma and X-radiation. Both types of radiation (particle and electromagnetic) reaches Earth in a short time. The solar wind takes the form of a drop of water, flowing round the invisible cocoon of Earth's magnetic field – like rivers flow round islands. The chemical composition of solar wind is the same as of the atmosphere of the Sun; its intensity changes depending on the activity of the star. Solar wind is responsible also for deflection of comets' tails. Produced as a result of a solar storm, heavy solar wind hits Earth several times a year and in most cases it does not pose any bigger threat. On its way to Earth it encounters some barriers, like the Sun's magnetic field, magnetic field of the galaxy, galactic wind and the Earth's magnetic field called magnetosphere. During the clash the Earth's magnetic field is disturbed to a significant extent showing increased variability, it pulsates (the phenomenon of a strong pulsation of the Earth's magnetic field is called electromagnetic storm) and is pushed down from the height of over 60,000 km to about 30,000 km. The solar wind striking the magnetosphere induces another storm, called a magnetic storm on Earth, which can last even several hours. The Earth's magnetosphere deflects the course of those molecules, sometimes, however, the radiation can penetrate through the magnetic field of our planet and reach its surface in the area of the poles, where the Earth's atmosphere (mainly atoms and molecules of oxygen and nitrogen) are the only barrier. This induces also the change of the atmosphere ionization and colourful phenomena called active auroras, which occur dozens of kilometers above the Earth's surface even at latitudes remote from the poles. During such a phenomenon the absorbed electric energy is released in the form of light and the colour of the aurora depends on the type of gases and the height, where the collision took place. Usually the red and green light of an aurora is visible in the upper layers of the atmosphere, while blue and violet light – in the lower layers. When the sunspots appear it is more probable to see also an aurora, which can be even over 100 km long.

As technology progresses, there is also an increase in the level of knowledge of the Sun's atmosphere and the phenomena occurring there, especially the sources and causes of the changes on the surface of the Sun. For many years the scientists have been observing attentively the phenomena on the surface of the Sun and measuring their intensity with the use of specialist tools installed in probes. All of these is done to prevent negative effects of the phenomena and to prevent disasters on our planet. The devices installed in the probes measure the energy of molecules originating from the Sun. Detecting electrons, which come at first, they warn us about coming ions, which are slower but far more dangerous. In the solar maximum period, which lasts for about 2.5 years there can be many interferences and damages in the communication and energy systems. The interference can affect electronic devices of spacecrafts, geostationary satellites orbiting the Earth at the height of about 36,000 km, GPS systems, communications satellite systems; in particular there may also occur a blackout – electricity supply is cut off because of destruction or damage of insulators, transformers and long power transmission lines as a result of increased electric induction. The largest blackout caused by solar wind took place in March 1989; as a result of a damage of main power transformer in a border region of the USA and Canada, 6 million people lost electrical power for 9 hours. Solar wind can also pose a threat to electronic devices of cellular network, in airplanes flying high in polar regions and to electronic devices on ships or in railway transport. During a solar storm high-energy radiation doses are received especially by astronauts, airplane pilots and passengers, and smaller doses are received also by people on Earth, especially living in the polar regions. It is also probable that birds using the direction of the Earth's magnetic field can lose the sense of direction for some time.

The largest solar storm of the 20th century took place in 1958, when many electric appliances were damaged. In 1987 in North America a solar storm forced the power plants to switch the power supply off and damaged numerous electric appliances; the damage was estimated at about 100 million dollars. The next – 24th Sun activity cycle (solar maximum) will start at the end of 2011 or beginning of 2012 and the auroras can be visible than even in Europe. The beginning of energy production, i.e. of the increased cycle lasting for 4.26 years will start soon.

A solar storm can lead to many associated disasters – chain reaction disasters. From the point of view of safety it is one of the fundamental tasks of a state to create conditions for population to survive in extreme situations. The entities responsible for the protection of life, health, property and environment will be the first entities which will have to face in a relatively short time the removal of the effects of numerous fires, failures, accidents and

disasters resulting from a solar storm. Blackout lasting for several hours or even days, which would result from a destructive overload of power networks, especially in large agglomerations can lead to chaos because of lack of water, light, warmth and food. The functioning of many public institutions may be seriously interfered than. Therefore, all the systems and their components – functional establishments of the critical infrastructure should be protected against the consequences of such a threat. This concerns especially power and fuel supply systems as well as food and water supply systems, communication systems, ICT systems, transport systems, systems assuring the continuity of public administration, systems of production, storage, maintenance and usage of chemical and radioactive substances, including pipelines carrying dangerous substances, financial systems, rescue systems (in Poland mainly national rescue and firefighting system) and health care systems (mainly National Emergency Medical Service). Such a threat requires also a review of rescue schemes, including medical rescue protection schemes, crisis management schemes, critical infrastructure protection schemes as well as preparation of different variants of actions in crisis situations, recreation of critical infrastructure and restoring its original nature and national reserves (possible resources). Such an analysis will allow us to plan an optimal use of available rescue resources and to support their actions, especially using unit and subunits of Polish Armed Forces.

*Junior Brigadier Jarosław Zarzycki Ph.D. of the Faculty of Fire Safety Engineering of the
Main School of Fire Service in Warsaw*