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The problems of solar-terrestrial coupling and new processes introduced to the physics of the ionosphere from the physics of atomic collisions

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Further progress in research of solar-terrestrial coupling requires better understanding of solar variability influence on the ionosphere. The most powerful manifestations of solar variability are solar flares and geomagnetic storms. During a flare EUV/X-ray irradiations are completely absorbed in the ionosphere producing SID. During geomagnetic storms precipitations of electrons with energy of several keV (and to a lesser extent protons precipitations) from radiation belts and geomagnetosphere produce additional ionization and low latitude auroras.
Considering the physics of ionosphere during the last several decades we have been taking into account three novel processes well known in the physics of atomic collisions. These are Auger effect [S. V. Avakyan, The consideration of Auger processes in the upper atmosphere of Earth. In Abstracts of paper presented at the Tenth scien. and techn. Conf. of young specialists of S.I. Vavilov State Optical Institute, 1974, 29-31.], multiple photoionization of upper, valence shell [S.V. Avakyan, The source of O++ ions in the upper atmosphere, 1979, Cosmic Res, 17, 942 - 943] and Rydberg excitation of all the components of upper atmosphere [S.V. Avakyan, The new factor in the physics of solar - terrestrial relations - Rydberg atomic and molecules states. Conf. on Physics of solar-terrestrial relationships, 1994, Almaty, 3 - 5]. In the present paper the results of bringing these new processes in the ionospheric physics are discussed and also its possible role in the physics of solar-terrestrial coupling is considered.
Involving these processes to the model estimations allowed us for the first time to come to the following important conclusions:
- Auger electrons play the determinant role at the formation of energy spectrum of photoelectrons and secondary auroral electrons at the range above 150 eV;
- double photoionization of the outer shell of the oxygen atom (by a single photon) plays a dominant role in the formation of ionospheric doubly charged positive ions, and Auger effect mainly determines the formation of double- and triple charged ions in the low ionosphere of planets and also comets;
- transitions in the Rydberg excited ionospheric atoms and molecules play the main role in generation of new type of upper atmospheric emission - microwave characteristic radiation.
The ionospheric O++ ions fill the magnetosphere after geomagnetic storms. These ions scatter the solar radiation in one of the most intense lines with a wavelength of 30.4 nm (He+) and also in the 50.7-, 70.3-, 83.3-83.5-nm lines in geocorona to the nocturnal side, giving rise to additional ionization and optical excitation in the F-region.
The first calculations of the excitation rate of Rydberg states by photoelectrons and by auroral electrons (including Auger electrons) were carried out. It was shown that such process can generate the microwave ionospheric radioemission. Such emissions were observed during solar flares and in auroras. We suggest that Rydberg microwave radioemissions which take place during ionospheric disturbances produced by the solar flares and geomagnetic storms can be considered as an agent of influence of solar-geomagnetic activity on the biosphere and also as a factor of Sun-weather-climate links
All these results obtained experimental confirmation in space investigations and in some ground-based measurements carried out with radiophysical and optical methods. The new processes which we introduced to the physics of upper atmosphere and ionosphere are now widely used in the ionospheric science for interpretation of spacecraft measurement data (the spacecrafts ISIS, GEOS-1, IMAGE, the satellites DE-1,-B, EXOS-D (AKEBOHO), FAST, Intercosmos-19, -24, -25, the orbital stations "Salut", "Mir"). There is a Russian patent on the method of remote registration of radioactive atmospheric clouds and nuclear weapon tests over the atmosphere by means of optical fluorescence which is based on Auger processes.