Process of transitions between exited atom states IN GAS discharge plasma of inert gases

B.M. Smirnov, D.A. Zhilyaev

Joint Institute for High Temperatures of RAS, 13 Izhorskaya str., Moscow, 125412, Russia

A gas discharge plasma is a plasma which is supported by an external electric field. It is necessary for its existence a sufficient ionization rate, so that a typical electron energy is ~1eV. Therefore, a gas discharge plasma is a nonequilibrium system which properties are determined by processes inside it and this determines a large number of regimes for a gas discharge [1, 2]. We analyze a gas discharge plasma of inert gases, where excited atoms give a remarkable contribution to ionization, and the ionization process has a stepwise character. The main contribution to ionization in a gas discharge plasma of inert gas give excited atoms which have an electron shell *np*5(*n +*1)*s*. Usually decay of these atoms leads to their excitation in state group with the electron shell *np*5(*n +*1)*p*. There are other channels for decay of excited inert gas atoms, and the first one among them is emission of resonantly excited atoms. The lifetimes of resonantly excited atoms of inert gases in a gas discharge plasma are evaluated on the basis of the Veklenko theory with taking into account reabsorption [3]. Under typical conditions, these lifetimes exceed those for isolated atoms by two-three orders of magnitude.

Another process in decay of excited states of the group *np*5(*n +*1)*s* consists in mixing of states of this group as a result of collisions of these atoms with electrons. Taking these transitions to be resulted from the exchange electron-atom collisions, we use the following scheme of this process

e↓ + A[np5(n+1)s↑] → e↑ + A[np5(n+1)s↓]

Where arrows indicate spin directions for free and valence electrons. Some measured processes of mixing of excited atom states within the framework of the Phelps method [4] are analyze on the basis of the above scheme. We analyzed the character of decay of excited atoms in a gas discharge plasma of inert gases with using the indicated processes. In spite of level nearness for a group *np*5(*n +*1)*s* in the mixing process, usually the cross sections of mixing are less than the cross section of transitions in states of the group *np*5(*n +*1)*p*, i.e. evolution of each state of the group *np*5(*n +*1)*s* proceeds independently of other states of this group. Nevertheless, various regimes of evolution of excited atoms in a gas discharge plasma of inert gases are realized depending on the electron concentration, and these regimes are analyzed.

References

1. Y.P.Raizer.Gas Discharge Physics.(Berlin, Springer, 1991)
2. B.M.Smirnov. *Phys.Usp*. **52**, 519(2009)
3. B.M.Smirnov. Theory of Gas Discharge Plasma. (Berlin, Springer, 2015)
4. A.V.Phelps. *Phys.Rev.* **114**, 1011(1959)