THE KINETIC MODEL OF PHOTOCHEMISTRY AND DYNAMICS OF THE COMETARY INNER COMA. M.Ya.Marov, Keldysh Institute of Applied Mathematics; D.V.Bisikalo, V.I.Shematovich, Astronomical Council UssR Academy of Sciences

The inner coma (referred usually as a region within about 10^3 km from the nucleus for a routine comet at a geliocentric distance I a.u. and with the average gas production ~ 10^{29}-10^{30} mol/sek) is especially intriguing in terms of theoretical simulation of the physico-chemical processess which principally determine the chemical composition, dynamics and energetics of the cometary atmosphere because just within this relatively small region the most numerous collisions occur . This problem is however a rather complicated because of strong gradients in the gas flow and mainly non-equilibrium character of the collisional processess (I).

For the treatment of the problem in kinetic approach two essentially non-equilibrium (by their thermal states) parts of flow are to be evaluated:

- near-surface (boundary) layer where the collisional relaxation of semispherical Maxwell distribution by velocities of sublimated gas particles occur (2);
- transient (from collisional to free molecular flow) layer where the frequency of the elastic collisions of particles due to gas expansion fell to sustain the local thermal equilibrium.

For the non-equilibrium state of gas flow in the inner coma the photochemical reactions are also responsible. High-energy particles are produced in the inner coma mainly due to photolysis of water vapors by the solar UV radiation. The interaction between high-energy particles produced in these reactions and parent molecules results in the disturbance of thermal state of the latter, whereas the daughter components exhibit explicitly non-Maxwellian distribution by velocities because of permanent input of fresh energetic particles and non-effective collisional energy exchange.

Photochemistry and dynamics of the rarefied cometary gas expansion in the inner coma influenced by the stationary solar UV flux can be described by the Boltzman type equation with the source term (I).

To evaluate the system of kinetic evaluations the modified procedure of the direct stochastic simulation was utilized. The procedure includes the following (I):

- splitting by physical processes for photolytic and impact photoelectronic interactions and then collisional photochemical relaxation and collisionless expansion;
- statistical simulation of the kinetic of the photochemical system using Monte-Carlo algorythms.

From the solution of the kinetic equations one can deduce most accurately the boundary conditions in the near-surface layer and the rate of photochemical heating of the gas expanding further into ambient space. It is worth to note that the kinetic approach is especially pertinent in case of the treatment of the more complex problem incorporating admixtures which could contribute to the photochemistry because the functions of distribution for the daughter components differ remarkably from Maxwellian distribution in the inner coma due to nonequilibrium character of their ground states and non-complete thermalization.

The kinetic approach to the study of the cometary gas flow showed that nonequilibrium processes in the inner coma noticeably influence the distribution of macroparameters (I,2). The profiles of mass-averaged velocities and number densities of the daughter components seems closer to reality when non-thermalized particles are taken into account. Rather elaborative study of the processes of thermalization of the products of photochemical reactions revealed also lower effectivness of heating principal (parent) gas component - water vapor molecules - and thus argue for the lower temperatures in the inner coma. It was found that within several tens kilometers from the nucleus surface a thermal equilibrium gas components can be violated and it thus place constrains for the choice of a model to describe the flow.

References: (I) Marov M.Ya., Shematovich V.I., Bisikalo V.D. (I990). Kinetic simulation of rarefied gas in aeronomy. Moscow, 250. (2) Bisikalo D.V., Marov M.Ya. Shematovich V.I. The flow of the subliming gas in the near-nuclear (Knudsen) layer of the cometary coma. Adv.Space Res. (I989), vol.9, No.3, (3)53-(3)58.