Periodic changes in the parameters of finite coagulating systems with sources and sinks at steady state regime approach

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As is known, finite coagulating systems with sources and sinks could reach steady state regimes. At the stage, when a system is approaching such regime, its parameters are not necessarily change smoothly; some periodic changes (McGrow, and Saunders (1984), Badger, and Dryden (1939)) could occur along the transition period. Smoluchowski equation could be written to account for these fluctuations:

$$\frac{\partial c_1}{\partial t} = I - \sum_{n=1}^{G} K_{1n} c_1 c_n , \qquad (1)$$

$$\frac{\partial c_g}{\partial t} = \frac{1}{2}\sum_{n=1}^{g} K_{n,g-n} c_n c_{g-n} - c_g \sum_{n=1}^{G} K_{g,n} c_n , \qquad (2)$$

where c_g – particle concentration, $K_{g,n}$ – frequency of collisions of particles consisting g and n monomers with resulting formation of particle with $(g+n)$ monomers, I – speed of monomer supply from the source to the atmosphere per unit of time and unit of volume, and G is a maximum particle size produced in the system.

Particles larger than G are removed from the system and do not further participate in the system evolution. Some stationary particle size distribution is possible in such systems. If $G \to \infty$, time required to reach such distribution becomes indefinitely long. Direct integration of this system of differential equations provides the results clearly showing parameters' oscillations during steady state regime approach. Detailed information about periodic changes may be obtained by asymptotic properties of the equation system. To this end let us linearize the system near steady state point and find eigen values of the matrix. Its real parts give damping decrement of time dependence curve and image parts give oscillation frequencies, which linear combination shows deviations of time dependence from asymptotic line.

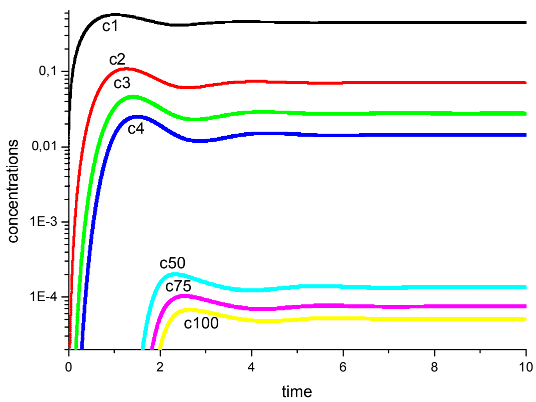

Figure 1. Oscillations of concentration of particles consisting of different numbers of monomers c_1 – c_4 and c_{50} –c_{100} (superscripts represent numbers of monomers) for $K_{ij}=i+j$; G =100 and dimensionless time.

The method was applied to equation system (1). Such estimates were made for model nuclei (K_{ij}=1; $K_{ij} = i+j$) and free molecular regime.

The results demonstrated that complex solutions of the abovementioned algebraic equations correspond to oscillation attenuation and frequencies, which are observed in solutions of the corresponding differential equation.

To extend the suggested approach enabling it to cover larger sizes, a model with coincidence of linear and logarithmic size scales has been built. This procedure was proven to be capable of modeling real processes occurring in the atmosphere.

McGrow, R. and Saunders J. H. (1984). *Aerosol Sci. Tech*. **4**, 367 – 380.
Badger, T.H.M. and Dryden, I.G.C. (1939). *Trans. Faraday Soc*. **35**, 607.