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The development of attractor description of non-linear phenomena in boundary layer and their analysis based on matrix series into state-space

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This paper deals with the derivation a new attractor describing the dynamical behavior of aerohydrodynamic processes in a boundary layer [1] on the basis of nonlinear dynamics methods into the state-space (on particular, on matrix decomposition method [2], [3]). We consider a behavior of the perturbations in Reynolds number's region close to number corresponding with flow change to turbulent form, therefore we suppose that the perturbation velocity components are large enough, and their quadratic terms would not be neglected [4]. Using a cylindrical coordinate system $(r$, *fi*, $z)$, this paper shows how the system of partial differential equations (describing Goertler's whirlwinds [1] in the boundary layers) is reduced to the system of ordinary differential equations based on the Galerkin's method [4]. Then we apply a matrix decomposition [2] to a vector function describing the obtained attractor in a state-space of nonlinear system of ordinary differential equations. Using the matrix notation [2], [3] we show that a change of this vector function can be approximated by only linear and quadratic terms of matrix series. Then we develop nonlinear analysis of the obtained attractor based on matrix decomposition. Because in the general case the attractor's model is non-integrable, its solutions can be found by means of numerical methods if system parameters a, b and c are fixed. First of all, we study stationary solutions: in such a case they are Goertler's whirlwind flows [1]. This paper shows that a value meeting the condition *a = 2sqrt (b)* corresponds to Goertler's whirlwind mode. When the parameter a becomes greater than *2sqrt (b)* we obtain not stationary solution leading to a chaotic dynamics mode.

Using the results of matrix decomposition we can carry out the numerical analysis

of this attractor on the basis of linear and quadratic terms of matrix series. Because the values of the first and second order derivatives can be calculated by means of numerical methods (for example, based on Runge-Kutta method) we can estimate a change of this vector function from a computational experiment. In result, we can estimate the values of parameters a, b and c for the obtained attractor.

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