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A model for origin of self-rotation in a protoplanetary cloud under action of exterior periodic force

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This work investigates condition for origin of increasing rotational disturbance in a gas-liquid protoplanetary cloud under action of a periodic force. The model (based on Reynolds equations [1]) describing self-organization of rotational disturbance of viscous gas-liquid substance into a protoplanetary cloud is proposed. The Reynolds equations as well as continuity equation in cylindrical frame of reference (r, e, z) as basis relations for this analytical model are used. The mean velocity is supposed to be equal to zero from the beginning action of an exterior periodic force. The Reynolds' tensor of turbulent strain of velocity disturbances in a becoming fluid flow is sought for (besides, z-component of velocity disturbance is supposed to be equal to zero). In assumption that z-components of turbulent strains are equal to zero, the (r, e)-turbulent strain components are found. After all considerations the Reynolds equations and continuity one (in the cylindrical coordinate system) are reduced to the system of two differential equations in partial derivatives relatively to (r, e)-cylindrical components of turbulent strain of velocity disturbance.

A common solution of these two equations permits us to reduce this task to solution of one differential equation relatively to (r, e)-turbulent strain. This homogeneous differential equation is solved with usage of the variables separation method. As a result, a superposition of two cosine's and sine's waves gives us (r, e)-turbulent strain wave with an elliptic (or circular) polarization. Moreover, this paper shows that amplitude of cosine-wave as well as sine-wave is an increasing function as r**(n**2-2). This paper finds that oscillations are intensified with growing a frequency of becoming oscillations.

The computational experiments based on STAR-CD package [2] confirm the main analytical statements of the proposed model for becoming self-rotation in a gas-liquid protoplanetary cloud. This work develops also the nonlinear analysis of an attractor describing hydrodynamic state of rotating flows based on the matrix decomposition [3]. This analysis permits to estimate the values of characteristic parameters (including control one) of the attractor and predict its evolution in time analogously to the stated in [4].

References:

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