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On the advection in the flow field generated by near stationary structures of three vorticies in a two-layer rotating fluid

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In a two-layer quasi-geostrophic model, the evolution of a symmetric baroclinic tripole, composed of a central vortex with strength $\mu\kappa$ in the upper layer, and *two* satellites with strength κ in the lower layer, is studied. The equation

$$F(B,\, R;\, \mu) = \frac{1}{2R} + \frac{2R(1+\mu)}{B(2R-B)} + K_1(2R) + \quad \frac{(2R+B\mu)K_1(2R-B) - [2R(1+\mu)-B\mu]K_1(B)}{2(R-B)} = 0,$$

give a uniform rotation of this collinear configuration with a constant angular velocity

$$\omega = \frac{\gamma\kappa(\mu+2)}{4\pi(2R+B\mu)}\left[\frac{B+2R\mu}{2BR} - \mu K_1(B) + K_1(2R)\right]$$

with respect to the center of vorticity with coordinates

$$(X_c,\, Y_c) = (2(R-B)/(\mu+2),\, 0).$$

Here the B is distance from one lower layer vortex to upper layer vortex and $2R$ is distance between lower layer vortexes. At $\mu = -2$ the angular velocity has identically zero value, the center of vorticity X_c shifts to the infinitely remote point, and the equation takes a form

$$F(B,R) = \frac{B^2 - 2BR + 4R^2}{2BR(2R-B)} - K_1(B) - K_1(2R-B) - K_1(2R) = 0,$$

and the collinear vortex structure performs a rectilinear motion with a constant velocity

$$V = \frac{\kappa\gamma}{4\pi}\left[\frac{2(R-B)}{B(2R-B)} - K_1(B) + K_1(2R-B)\right]$$

in the direction, normal to the axis x.

In our work, we discuss the problem of the advection of fluid particles in the velocity field induced by these three-vortex two-layer stationary structures. More detailed analysis of the phase portraits of water motion, induced by collinear structures, and the analysis of the perturbed motion and the conditions of the chaotic regime appearance will be given in the talk. For analysis of chaotic regime appearance condition we will use method of unperturbed rotation frequency and nonlinear resonances investigation proposed in work *Koshel K.V., Sokolovskiy M.A., Davies P.A.,* 2008. Chaotic advection and nonlinear resonances in a periodic flow above submerged obstacle. Fluid dynamics research, **40**, 695–736.