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Numerical Model of Semirestricted Vortex Flows With Peninsula-Shaped Boundary

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Research of vortex patches and fronts evolution of the most attractive area of study in ocean and geophysical fluid dynamics. The numerical simulation of vortex flows in semirestricted region is under consideration. The method of contour dynamics numerical model is proposed to simulate evolution of vortex patches in semirestricted region with peninsula-like boundary. It is shown that we investigate flow evolution observing the changes in vortex patches boundaries.

Contour dynamics, vortex flow, ideal incompressible fluid, numerical simulation. Let's consider plane vortex flow of an ideal incompressible fluid induced by the domain $D(t)$ of unit vorticity ω_0 (vortex patch). The flow streamfunction may be written in the form

$$\Psi(x, y) = \omega_0 \iint_{D(t)} G(x, y; \xi, \eta) d\xi d\eta \quad (1)$$

$$G(x, y; \xi, \eta) = \frac{1}{4\pi} \left[\ln \frac{(\xi - x)^2 + (\eta - y)^2}{(\xi - x)^2 + (\eta + y)^2} - \ln \frac{\left(\frac{a^2 \xi}{\xi^2 + \eta^2} - x\right)^2 + \left(\frac{a^2 \eta}{\xi^2 + \eta^2} - y\right)^2}{\left(\frac{a^2 \xi}{\xi^2 + \eta^2} - x\right)^2 + \left(\frac{a^2 \eta}{\xi^2 + \eta^2} + y\right)^2} \right] \quad (3)$$



Fig. 1. Computation domain of the flow and streamfunction the function

$$\Psi(x, y) = \int G[x, y; x + (\xi - x)z, y + (\eta - y)z] \omega_0 d\xi d\eta \quad (4)$$

where $(x, y), (\xi, \eta)$ are coordinates of observation point and integration point respectively, $G(x, y; \xi, \eta)$ - Green function for the Laplace equation. The velocity vector components u and v may be found from (1) by well known relations

$$u = -\Psi_y, v = \Psi_x \quad (2)$$

To construct effective numerical procedure of temporal flow exploration one must rewrite (1) using contour integrating instead of double integrating. In the case of unbounded flow it is easy to make using Green function symmetry with respect to observation and integration points and the Stokes theorem. This paper is dedicated to make contour dynamics algorithm to explore vortex flows in region with peninsula-like boundary (fig. 1). In this case Green function may be written in form where a is the radius of peninsula.

satisfying the identity

$$G = [(\xi - x)F]_\xi + [(\eta - y)F]_\eta \quad (5)$$

Using (5) and the Stokes theorem one can obtain from (1)

$$\Psi(x, y, t) = \omega_0 \int_{C(t)} F[(\xi - x)d\eta - (\eta - y)d\xi] \quad (6)$$

where $C(t)$ is the vortex boundary.

Substituting (3) into (4) and integrating it one can find after some algebra where we used the notation