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Section:

15. Numerical Analysis and Scientific Computing

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Bifurcation of Kolmogorov flows with an emphasis on singular limit

Keywords and Phrases: Kolmogorov flows in 2D tori, incompressible fluid, bifurcation, singular perturbation, internal layer, inviscid limit.
We consider a family of stationary Navier-Stokes flows in 2D tori. The flow is driven by an outer force which is of the form $(\sin y, 0)$. Varying the Reynolds number and the aspect ratio of the torus, we numerically compute bifurcating solutions by a path-continuation method. Folds and cusps are obtained in the range where the Reynolds number is < 100. Some solutions are computed until the Reynolds number becomes 10,000. Although every solution is known to be smooth (analytic actually), the vorticity tends, as the Reynolds number $\to \infty$, to a function which is at most C^1. In other words, smooth solutions tend to functions with a finite number of differentiability as the Reynolds number tends to infinity.
From our numerical computation, we can guess some interesting asymptotic behaviors as the Reynolds number tends to infinity. Since the Navier-Stokes equations are defined in a two-dimensional torus, there can not be a boundary layer. However, we can observe the appearance of some internal layers. The layer yields an energy spectrum of k^{-r}, where r is between -7 and -4, depending on the aspect ratio. Analysis as the aspect ratio $\alpha \to 0$ is also given.